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AGRIBALYSE® 3.2

THE FRENCH LCI DATABASE ON AGRICULTURE AND FOOD

Methodological report on food products

FINAL REPORT

Nov. 2024

EXPERTISES

QUOTE FROM THIS REPORT

Cornelus M., Ceccaldi M., Doucet M., Vasselon H., Wolff H. 2024. AGRIBALYSE® 3.2: Methodological report on food products. Ed ADEME, Angers, France. 80 p.

For previous versions of AGRIBALYSE® see previous reports:

Asselin-Balençon A., Broekema R., Teulon H., Gastaldi G., Houssier J., Moutia A., Rousseau, V., Wermeille A., Colomb V., Cornelus M., Ceccaldi M., Doucet M., Vasselon H., 2022. AGRIBALYSE 3.1: the French LCI database on Agriculture and Food. Methodology for the food products. Initial report Agribalyse3.0-2020, update Agribalyse3.1 - 2022 Ed. ADEME

Asselin-Balençon A., Broekema R., Teulon H., Gastaldi G., Houssier J., Moutia A., Rousseau, V., Wermeille A., Colomb V. 2020. AGRIBALYSE v3.0: the French LCI database on Agriculture and Food. Methodology for the food products. Ed. ADEME 2020

This publication is available online at www.AGRIBALYSE®.fr and at www.ademe.fr/mediatheque

ACKNOWLEDGEMENTS

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ABSTRACT

AGRIBALYSE® , is a French agricultural and food consumption Life Cycle Inventory (LCI) database. It is produced in the frame of the AGRIBALYSE® program, which has been running since 2009 lead by ADEME and INRAE, with the support of numerous organisations and experts.

AGRIBALYSE® provides a large number of LCIs of French agricultural products, described in another report (Auberger & Cornelus, 2022024). This report describes the methodology used to develop AGRIBALYSE® 3 food LCIs.

AGRIBALYSE® is providing LCIs for more than 2500 food items registered in CIQUAL, the national nutritional database (ANSES, 2017)with similar ID number and boundaries, enabling consistent connections between nutritional and environmental properties.

This version is by its scope and ambition an innovative and challenging project. The priority has been to establish a robust infrastructure for the database and to focus on hotspots in order to be able to reach a suitable quality level for publication. The work was built mainly on existing LCI: combining existing agriculture (AGRIBALYSE® v1.4, Ecoinvent, WFLDB,), food processes (ACYVIA, WFLDB) and logistic LCIs. Extensive documentation, use of "Unit processes" and Data Quality Ratio (DQR) are the basis for transparency. The methodology is in line with main international LCA guidelines: ISO 14040; LEAP and PEF.

The database is available in two formats:

- For experts: A Life Cycle Inventory Database with modular, unit processes, cradle to plate. With a wide diversity of agricultural products for France (organic, no till cropping etc.), imported products, processing and logistic data, combined into 2500 average food products. This format can be adjusted (ex: switch to organic product) and is especially suitable for eco-design work but requires expert users. This database is available in LCA software, under the user licence agreement of ecoinvent®.
- For non-experts: Life Cycle Impact Assessment for 2500 food products: aggregated indicators at the product level, freely available on the program webpage (http://www.agribalyse.ademe.fr). Impacts are also provided by production stages and ingredients. It is especially suitable for hot spot analysis, can contribute to environmental information and eco-scores and can be used by non-experts.

Complementary documentation and tools are available on the website https://doc.agribalyse.fr/documentation-en and on AGRIBALYSE® dataverse and in particular in the dataset: Cornelus, Mélissa; Auberger, Julie; Rimbaud, Audrey; Ceccaldi, Mathilde, 2024, "AGRIBALYSE® version 3.2", https://doi.org/10.57745/XTENSJ.

The update to 3.2 was performed by EVEA S.A Coopérative, mandated by ADEME, and in relation with GIS REVALIM.

1. Background and objectives

1.1. Description of AGRIBALYSE®

AGRIBALYSE® is a Life Cycle Inventory (LCI) database representing the French agricultural and food sector. Since 2009, a partnership has been in place between ADEME, INRAE and the French technical institutes, and it is in this context that AGRIBALYSE® database was developed.

AGRIBALYSE® provides a large number of life cycle inventories for French agricultural products. The methodology of these LCIs is described in a separate report (Auberger et al., 2024).

This report describes the methodology used to create AGRIBALYSE® food LCIs.

Prior to version 3.0 (published in 2020), AGRIBALYSE® program focused mainly on French agricultural production (Peter Koch & Salou, 2016). Following on from this work, this program includes the development of the database but also updates linked to methodological projects (OLCA Pest, AGRIBALYSE® Water etc.).

Since version 3.0, the scope of application has been extended to include French food consumption. Its aim is to provide LCIs for all foodstuffs present in CIQUAL, the national nutritional database (ANSES, 2020), with a similar identification number and limits.

Subsequent versions continue to improve the quality of the data, thanks to the work of GIS REVALIM's approved members and external contributors. Each time the database is updated, additional data is added, data is updated or corrected and methodological improvements are incorporated. All changes are listed in a specific change report (CECCALDI, et al., 2024).

AGRIBALYSE® database is built with unit processes, corresponding to a disaggregated LCI database, and is also available in aggregate format (system processes).

The database is available in two versions :

- The expert version : This is a life cycle inventory database made up of modular and unitary processes from "cradle to plate". It includes a wide variety of French agricultural products (organic, no-till, etc.) as well as imported products, processing and logistics data, which when combined form 2,500 average food products. This format allows for adaptations (changes to use an organic product, for example), making it particularly suitable for eco-design work. It does, however, require expert users. This database is available in the various LCA software packages under the ecoinvent® licence.
- General public version : This includes environmental impact indicators for the life cycle of 2,500 food products. These indicators are aggregated for the final product. They are available free of charge on the AGRIBALYSE® programme web page (https://agribalyse.ademe.fr/). Impacts are also provided by life cycle stage and by ingredient. This makes it particularly suitable for analysing hotspots in the value chain. For example, it can contribute to environmental information and eco-scores. It is aimed at a non-expert audience.

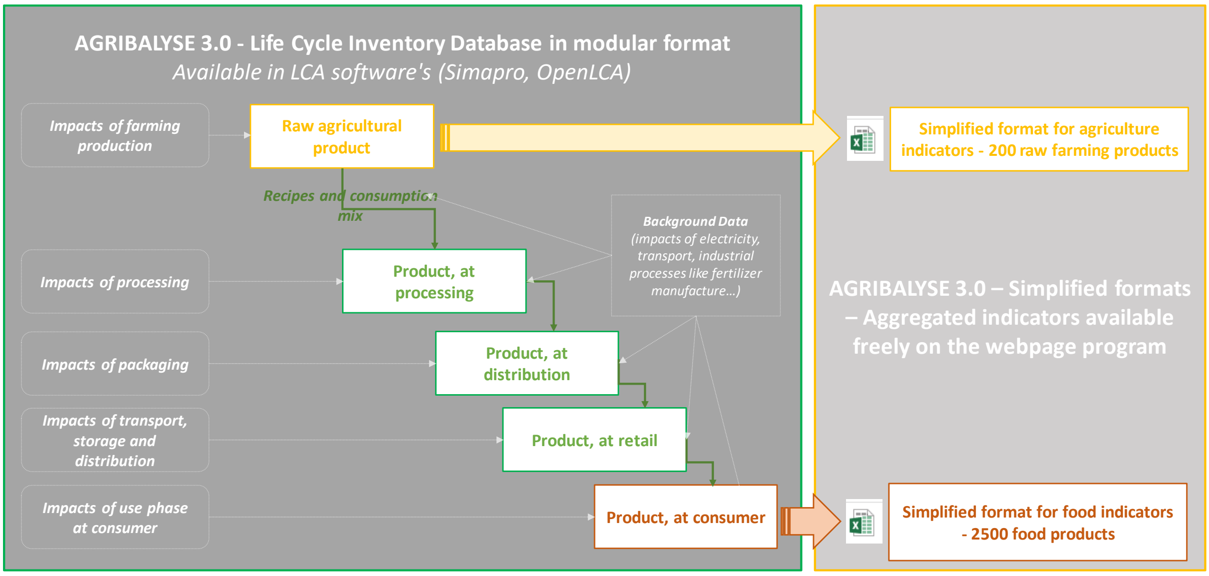


Figure 1 : Overview of AGRIBALYSE® access options

ZOOM : CIQUAL database

CIQUAL provides the nutritional composition of foods consumed in France, whether prepackaged (industrial source) or not (e.g. "Apple, pulp and skin, raw", "Tap water"). In its 2020 version, CIQUAL contains 3186 foods and provides, for each of them, their content in 61 nutritional components per 100g edible portion. The foods are classified by group, sub-group and sub-sub-group. This database is managed and maintained by ANSES (Agence Nationale de Sécurité Sanitaire des Aliments, de l'Environnement et du Travail). It can be downloaded free of charge from the CIQUAL website, in French and English. It is used by ANSES, in particular for nutritional risk assessment. Other users include government departments, researchers, nutritionists, food companies and consumers.

1.2. AGRIBALYSE® database goals and scope

1.2.1.General information

AGRIBALYSE® is a farm-to-fork LCA database for France. AGRIBALYSE® links the food products in the French CIQUAL 2020 nutritional database to environmental impacts using the same limits and identifiers. This makes it possible to link environmental and nutritional information on food products consumed in France. The linking of CIQUAL and AGRIBALYSE® is seen as a basis for studies and decision-making tools concerning the food transition in France. The data is not intended to be used for comparisons between very different products with varying nutritional properties.

The users of AGRIBALYSE® datasets are diverse. LCA experts will be able to use the value chains as described in AGRIBALYSE® and update them according to their own specificities. Food professionals (managers, product developers, R&D teams) and the general public (NGOs, consumers) are also a target audience for the use of environmental impacts. It is recommended to read the "User Guide" (15 pages only), which contains the key information in a way that is accessible to all users.

The history of AGRIBALYSE® versions is as follows:

- 2013: First publication of AGRIBALYSE® 1.0 (agricultural scope)
- 2014-2016-2018 : AGRIBALYSE® 1.1 to 1.4
- 2020 : AGRIBALYSE® 3.0 (with ecoinvent® 3.5 and WFLDB® 3.1 in the background)
- 2022 : AGRIBALYSE® 3.1 and 3.1.1 (in the background ecoinvent® 3.8 and WFLDB® 3.5)
- 2024: AGRIBALYSE® 3.2 (with ecoinvent® 3.9.1 and WFLDB® 3.5 in the background)

1.2.2. Goal

AGRIBALYSE® is the "mirror" environmental database of CIQUAL database, which describes the nutritional properties of over 3,000 foodstuffs consumed in France. AGRIBALYSE® therefore aims to be the French LCA database for these same foods, making it possible to describe the corresponding environmental properties.

1.2.3. Functional unit, system limits and allocations

Food products have been modelled for 1 kilogram of prepared product, but individual processes in the value chain can be modelled for other functional units.

AGRIBALYSE® database is provided in the form of unit processes, following the value chain of food products from the production of raw materials through processing, assembly, distribution, retailing and storage to preparation at the consumer end. Transport between each stage of the value chain is included, with the exception of transport between the retail outlet and consumer's home. Food waste and losses are accounted for at the various stages of the life cycle, except at consumer's home.

The allocations used throughout the database are essentially economic allocations, in line with the existing processes used (ACYVIA, ecoinvent, etc.).

Exceptions on benefits :

Products/inventories concerned	Type of allocation chosen	Comments
Dairy farming	biophysical allocation	
Cheese production	dry mass allocation	
Edible part processing	100% attributed to the edible part (simplifying assumption)	Processes used to obtain the edible part of the product (such as peeling, pitting, shelling, filleting fish).

If in doubt, the user should refer to the allocation procedures described in the documentation for each database.

1.2.4. Inventory and impact analysis method.

The impact assessment method used is the Environmental Footprint (EF) method version 3.1[1] . It proposes 16 midpoint indicators and a single score (European Commission, 2018). AGRIBALYSE® is used to calculate and display the impacts of CIQUAL foods and the quality of this assessment. This data can be accessed on the Agribalyse documentation website.

1.2.5. Type of data, ressources and nomenclature

AGRIBALYSE® aims to bring together different databases of unit processes that have been developed in parallel using similar methodological rules:

- previous versions of AGRIBALYSE® have been updated (v1.3 - v.1.4/unpublished, v3.0 and v3.1) (French production of agricultural raw materials and food products),
- ACYVIA (French food industry process),
- Ecoinvent 3.9.1 (imports of raw materials and food processes)
- World Food LCA database v3.5 (food processes) - note that the WFLDB 3.5 background has been updated to call data copied from Ecoinvent 3.9.1

AGRIBALYSE® is largely based on the rules of PEF, which is mainly reflected in the modelling of the stages of the life cycle, from distribution to the plate.

[1] https://eplca.jrc.ec.europa.eu/permalink/EF3_1/EF-v3.1.zip

Since AGRIBALYSE® is largely based on existing unit process databases, the nomenclature of AGRIBALYSE® follows that of the original existing processes. "At-consumer" data sets include the corresponding CIQUAL 2020 ID in their name.

1.2.6. DQR and critical review

At the consumption stage ("at consumer"), AGRIBALYSE® includes a quality indicator, the "Data Quality Ratio" (DQR), based on the temporal and technological representativeness, accuracy and geographical specificity of the entire value chain; in line with the PEF methodology (European Commission, 2020).

The assessment of the RDI of each food product is aligned with the "objective and scope" of the database.

A food product aligned with the objective and scope of the database has the following characteristics:

- It is representative of French food consumption,
- It describes consumption mixes for "raw" agricultural products with a coverage of at least 70%,
- Data from French trade statistics are no more than 3 years old,
- Food processing uses representative technology with verified data for mass balances, energy consumption and water consumption wherever possible,
- The recipes cover at least 95% of the mass in terms of ingredients, and
- A representative primary packaging is used for the food product.

Critical reviews of the database were carried out:

- 2020 : AGRIBALYSE® 3.0 has been reviewed by RIVM and GreenDelta. RIVM reviewed the data used, the modelling and the impact assessment, while GreenDelta reviewed the methodology and the DQR rating. AGRIBALYSE® 3.0 was also commented on by the French technical institutes (led by ACTA and ACTIA). "Peter Koch Consulting carried out a final critical review before publication, making further improvements and corrections.
- 2022 : AGRIBALYSE® 3.1 includes methodological improvements, improvements in data quality, corrections and the addition of supplementary data. These improvements have been made by EVEA S.A.S Coopérative in conjunction with the members and accredited members of GIS REVALIM: ADEME, ITERG, ACTALIA as well as CIRAD, GINGKO21 and the Association nationale de la meunerie française (ANMF). This version has been reviewed by the GIS REVALIM.
- 2024 : AGRIBALYSE® 3.2 also includes methodological improvements and added data, compiled by EVEA S.A in conjunction with the members and approved adherents of GIS REVALIM: please refer to the change report. This version has been reviewed by the members of GIS REVALIM.

1.2.7. Limitations of the database

Firstly, it has been **compiled from several existing databases**, which are similar in terms of dataset scope, data collection and methodological rules for creating inventories (emission models, allocation rules, etc.), but which are not always 100% consistent. The original dataset is mentioned in the metadata and documentation of the AGRIBALYSE® database. Users should refer to it if they have any questions. For example, equipment is not necessarily covered in all existing datasets. Some inventory items related to methodological issues "still in progress" have not been harmonised across all databases. This is particularly the case with agricultural inventories for data relating to carbon storage, land use change and plant protection.

The **allocation rule** (economic, biophysical, etc.) is defined in each original dataset (AGRIBALYSE®, ecoinvent, WFLDB, etc.). It is not always aligned with the guidelines of the EFP (European Commission, 2016) (e.g. milk/meat allocation).

Certain limitations arise from the methodological choices made in constructing the database. For example, **the use of water for washing fruit and vegetables** has not been taken into account in AGRIBALYSE®.

Other second-order limits are described in this document.

1.3. Scope of the methodological report

AGRIBALYSE® brings together LCIs extracted from various sources. Consequently, the methodological rules specific to LCIs are presented in the various methodological reports available on the AGRIBALYSE® documentation web page or on the AGRIBALYSE® dataverse.

The databases exist in the form of unit processes with ecoinvent datasets in the background. However, some differences between the methodological rules can be identified, particularly in the raw materials production phase:

- The storage of biogenic carbon by crops is taken into account in the production of AGRIBALYSE® raw materials (no effect on impact indicators),
- Fertiliser inputs used in crop rotation are included in AGRIBALYSE®, and
- There may be potential differences in allocation; this is the case, for example, for on-farm milk production where the allocation between milk and meat in AGRIBALYSE® database is different from that of the International Dairy Federation (International Dairy ratioFederation, 2015).

This list is not exhaustive, and the user should refer to the detailed methodology report if necessary.

This report focuses on how the challenge of compiling a vast database on French food consumption was met:

- How the database is structured, and what data has been collected (consumption mix, etc.),
- How foodstuffs have been prioritised (i.e. how accurately basic recipes have been modelled and the choice of proxies, the choice of additional LCIs to be built - see specific reports),
- How LCI datasets were selected and addressed where necessary, and
- How losses have been dealt with throughout the value chain.

When AGRIBALYSE® 3.0 was released, due to the exploratory nature of the work and the lack of existing datasets, the objective was not to provide complete and accurate datasets for each CIQUAL food. The aim was to put in place a robust architecture for a sustainable database on food consumption. Since then, subsequent versions have made it possible to update this data or create new data. However, some limitations remain and are described in this report.

2. General architecture

AGRIBALYSE® 3.2 database contains 2451 finished product datasets. It is built as described in Figure 2. The majority of raw material production processes use AGRIBALYSE® datasets developed in previous versions of the database.

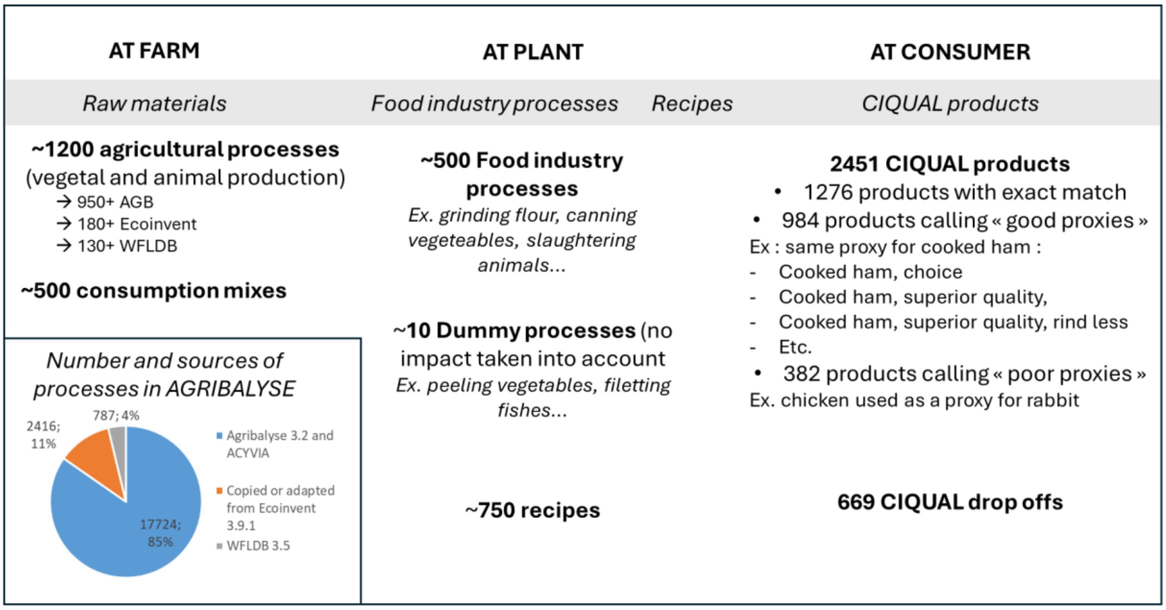


Figure 2 : Overview of the general architecture of AGRIBALYSE® 3.2 database

AGRIBALYSE® 3.2 database contains 2,451 data sets out of the 3,186 items in the CIQUAL 2020 database, i.e. 77% processed.

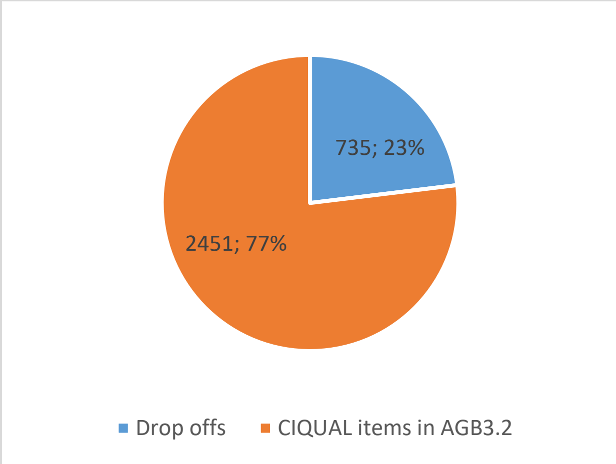


Figure 3 : Coverage of the CIQUAL 2020 database in AGRIBALYSE® 3.2

2.1. System limitations

The current database is an update of the previous database, which contains both inventories relating to French agricultural raw materials and inventories relating to the downstream stages of the food value chain. The datasets are accessible in folders and subfolders organised according to the same CIQUAL nomenclature of groups and subgroups.

CIQUAL food products are ready to eat. They cover all stages from the cradle to the consumer's plate, including :

- Production of raw materials,
- Transport,
- Transformation,
- Packaging,
- Distribution and retailing,
- Consumer preparation and
- End of life and therefore packaging disposal.

2.2. Linking processes

In most cases, AGRIBALYSE® uses and connects existing processes in one of the four databases described in table 2. In the case of duplicate processes in the databases, the order of priority is as indicated in table 2.

For each dataset, metadatas specify the database from which it comes.

Database	Owner	Developers	Reference	Main processes	Background database
Data created for AGRIBALYSE® database since AGRIBALYSE® 3.0	ADEME	GIS REVALIM members or external contributors	See specific reports	All types	ecoinvent 3.9.1
AGRIBALYSE® 1.4 and	ADEME	INRAE and Agroscope and French technical	(P. Koch & Salou, 2020)	Agriculture and fisheries production in FR	ecoinvent 3.9.1

		research institutes			
ACYVIA	ADEME	Quantis Agroscope	(Bayart et al., 2016)	Processing in FR Disaggregated processes (PD) were used.	
Ecoinvent 3.9.1	ecoinvent	ecoinvent	(Moreno Ruiz et al., 2018)	Some agriculture and food processing Background database (energy, transport, materials...)	-
WFLDB 3.5	WFLDB consortium	Quantis Agroscope	(Nemecek et al., 2015)	Some agriculture Mostly processing and preparation at consumer	In the original WFLDB 3.5 : background datasets from ecoinvent 3.5➔ updated to ecoinvent 3.9.1 for AGRIBALYSE® 3.2

Table 2 : List of databases used for each dataset

All databases use ecoinvent 3.9.1 data in the background (cut-off system model).

PLEASE NOTE :
Ecoinvent and WFLDB datasets are copied as unit processes or systems, their value chain is generally NOT specific to France and have been kept "as is". In particular, they do not take into account the consumption mix specific to France or the French electricity mix.
For example: "White sugar, production, consumption mix {FR} U" in AGRIBALYSE® is identified with an Ecoinvent process "Sugar, from sugar beet {GLO}| market for | Cut-off, S - Copied from Ecoinvent U". The sugar beet consumption mix in this Ecoinvent process is 99% "rest of the world" production. The consumption mix has been kept "as is" and the Ecoinvent dataset does not call up the AGRIBALYSE® "sugar beet" production dataset. The energy used to transform sugar beet into sugar is RoW (rest of the world), not specific to France, and has also been kept "as is".

Footnotes in this document will specify where the raw materials in the value chain are not specific to France. Expert users can update the raw materials and electricity mix datasets according to their own case study.

The general construction of AGRIBALYSE® is described in the figure below. All background data sets (transport, packaging, electricity) come from ecoinvent.

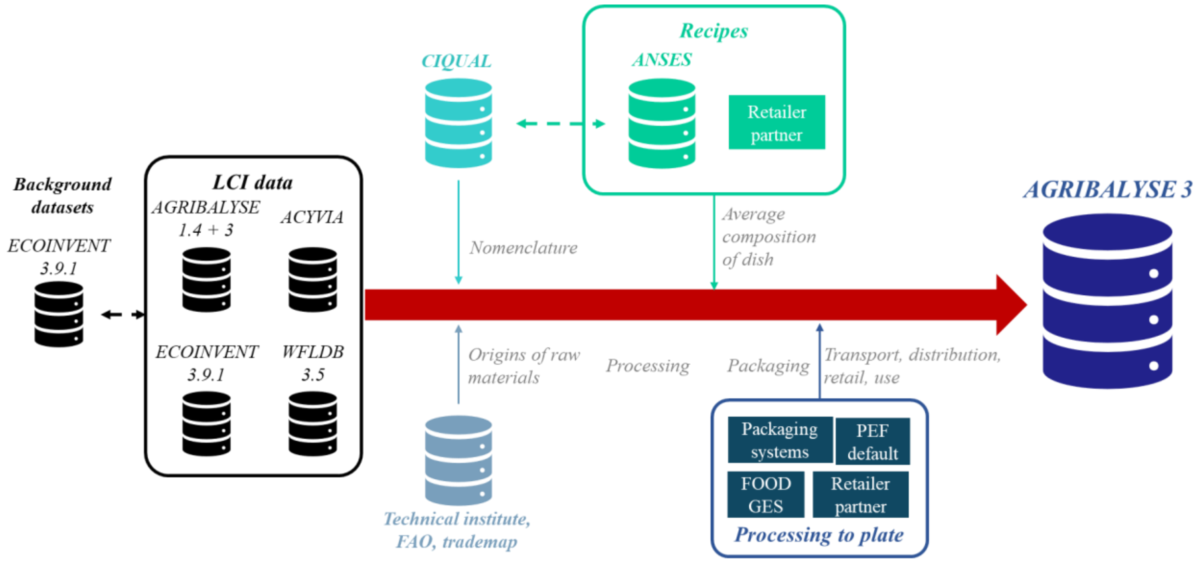


Figure 4 : General principles for building AGRIBALYSE® database

2.3. Characterisation of CIQUAL elements

CIQUAL food products have been classified into 5 categories, described in the table below. These categories have been created to apply systematic rules in the construction of the database, particularly with regard to the life cycle stage (processing or consumption) at which inedible losses and cooking are applied - see section 2.6.

Category Number	Category name	Description	Example (including CIQUAL code)	Accounts for [2]	Comments
1	Raw	Raw materials, fresh	*Apple, raw (13050)*	Raw to Cook ratio Inedible losses Packaging	
2	Raw + use	Raw material, processed at consumer	*Egg, hard-boiled (22010)* *Red beans, cooked*	Possible actions at consumer are: Rehydrating (water cooker) Pan-frying Deep-frying Heating in oven Microwaving Boiling Storing Fridge Storing Freezer No preparation	All plain cooked vegetables, fish, eggs assumed to be cooked at consumer.
3	Processed	Raw material transformed (including dried food, including raw frozen, canned undrained)	*Wheat flour (9410)* *Tomato paste (20068)* *Beef, ground (6259)* *Pork, chop, raw (28100)* *Artichoke base, frozen, raw (20232)* *Peach, canned in light syrup, not drained (13731)*	Inedible losses Losses at transformation except for canned products	
4	Processed + use	Single raw material processed industrially and requiring consumer additional action	*Instant coffee rehydrated (18073)* *Pork chop, grilled (28101)* *Peach, canned in light syrup, drained (13730)*	Possible actions at consumer are: Rehydrating (water cooker) Pan-frying Deep-frying Heating in oven Microwaving Boiling Storing Fridge Storing Freezer No preparation	All plain cooked meat, assumed to be cooked at consumer; rehydrated beverages from a single ingredient

[2] All categories represent transport to the consumer, distribution and retail storage, and losses.

5	Recipes	Mixture of several raw materials and/ or processed raw materials, with potentially some cooking, baking steaming. In some cases, there can be two levels of recipes (e.g. "Pizza dough" and "Pizza")	*Lasagna (25081)* *Pizza dough (pizza base) (23402)* *Pizza (25404)*	All inedible losses and energy intensive operations (cooking, baking, steaming...) assumed to be at processing. Packaging included Might require additional action at consumer (rehydrating, heating, etc . .)	Recipe items are assumed to be prepared at plant and only require minimum preparation at consumer [3] (microwaving, heating, boiling cooling ...)

Table 3 : CIQUAL categories

2.4. Naming conventions and link with CIQUAL

The CIQUAL identifier is mentioned in the final product dataset, at the consumption stage ("at consumer"). For intermediate stages (before consumption), no identification with the CIQUAL database is mentioned. The naming conventions were established in accordance with ecoinvent (Wernet et al., 2016) as used in the software.

CIQUAL items that are a mixture of ingredients from different raw materials are called "recipes" and classified as such.

An example of a cheese pizza (CIQUAL ID 25404) is shown in Figure 5 below.

[3] One exception: cooked pasta. Pasta is itself a recipe, a mixture of several ingredients (wheat flour, eggs, water….). Pasta is supposed to be cooked at home, not in a factory.

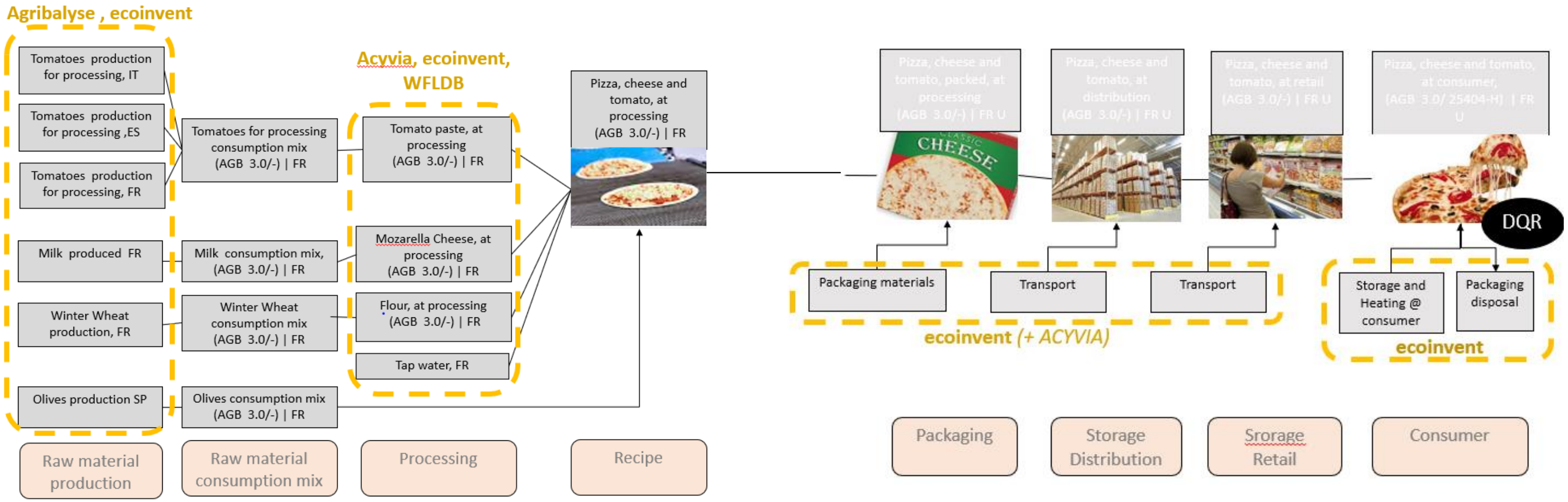


Figure 5 : Example of compiling the unit processes of the life cycle inventory (LCI) to obtain the LCI corresponding to the CIQUAL item "Cheese pizza" - (ID: 25404)

2.5. Cross-functional aspects

2.5.1. Raw/cooked ratio

Weight of certain foods differs depending on whether they are raw or cooked. For example, lentils absorb water and increase in weight when cooked (1 kg raw => 1.5 kg cooked). This variation has been taken into account in AGRIBALYSE® 3 using a raw/cooked ratio (R2C). This ratio was calculated using the water content of similar foods[4] raw and cooked in the CIQUAL database.

Equation 1

$$R2C\ ratio = \frac{Weight\ when\ cooked}{Weight\ when\ raw} = \frac{1 - H20\%_{raw}}{1 - H20\%_{cooked}}$$

With

$H20\%_{cooked}$ Water content: value of the water content of a cooked food product.

$H20\%_{raw}$ value of the water content of a raw food product.

When the water content of cooked and raw foods was available in the CIQUAL database, we used this formula and calculated this ratio. When the water content was not available, we used an average R2C between raw and cooked foods by product category. This average ratio was calculated between foods belonging to the same food group: cereals (rice, wheat, barley, millet), pulses (lentils, beans and peas), fish and shellfish, fruit and vegetables and eggs. The resulting ratio of raw to cooked foods is shown in table 4.

Average raw to cook ratio per food category			
	Average ratio	Standard Deviation	How to
Fruits and vegetables	0,856	0,860	-
Fish and shellfish	0,819	0,341	-
Cereals	2,259	0,186	-
Vegetables	2,330	0,248	-
Eggs	0,974	0,068	-
Red meats	0,792	0,180	Evaluated on minced beef (all fat content), beef, veal, mutton, lamb
Poultry	0,755	0,138	Evaluated on chicken, duck, goose, ostrich, pigeon, rabbit.
Offal	0,730	0,178	Evaluated on kidney and liver from lamb, chicken, turkey, beef and pork

Table 1 : Raw/cooked ratios - vegetable products, fish and eggs (source: CIQUAL database for water content)

Assumptions :

- Seaweed: The ratio between raw and cooked seaweed could not be assessed in the same way because the water content of cooked seaweed is not displayed in the CIQUAL database. We have approximated the R2C for seaweed with the average R2C for vegetables.
- Other foodstuffs not covered by the above food groups (see table 4) are assumed to have an R2C ratio of 1:
  - Dairy products: cheeses, creams, milks (except yoghurts, which are not intended to be cooked)[5]
  - All drinks and products: juices, nectars, spirits, etc.
  - Fats: vegetable oils, animal oils and fats, butter
  - Seeds, nuts

[4] The ratio was calculated for raw and cooked food products included in the CIQUAL database.
5 In the ANSES recipes, no evaporationfactor is available for milk and cream: raw and cooked quantities are the same for milk and cream, which explains the assumption of R2C=1.

- Miscellaneous: herbs, dried fruit and vegetables, flour, salt, spices, sugar, garnishes and condiments (capers, candied fruit, gherkins, etc.).

2.5.2. Non-edible losses

In AGRIBALYSE®, only inedible losses are recorded at the consumption stage. Losses are also accounted for upstream at the distribution and retail stages. However, to comply with CIQUAL limits, **we do not count food waste, i.e. edible food that is wasted in the consumer's household.**

Data on inedible losses are mainly taken from the FoodGES study (Colomb & Martin, 2015) and the LCI Fisheries report (July 2019). Detailed information on inedible losses for fruit, vegetables and eggs is provided in Annex 3. The stage at which inedible losses are accounted for is important as it can in some cases radically alter the mass transferred to downstream phases (in the example of mussels, 75% of the mass (shells) is lost when inedible losses are accounted for). The table below provides information on the treatment and references for inedible losses.

Although edible losses are not accounted for, the structure of the database following the value chain with unit processes allows the user to add a consumer waste stage if they wish.

Type of product	Reference for mass % of inedible losses	Life cycle stage for inedible loss according to food item categories
Vegetables, fruits, nuts	FoodGES and bibliography[6], except pineapple, apricot and cherry[7] for all nuts: based on walnut data (50% edible part)	- At farm for dried products - At consumer for category 1, and 2[8] - At processing plant for category 3, 4 and 5
Eggs	FoodGES Shell represents 10% of the mass	- At consumer for category 1, 2 - At processing plant for category 3, 4 and 5
Chicken (categories 3,4 and 5 only) - Gutting, feathers, beheading - Bones	FoodGES FoodGES	At slaughtering stage for categories 3, 4, 5 - At consumer for category 3, 4, 5 if entire broiler or meat with bone - At processing plant for categories 3,4 and and 5 for meat without bone
Meat other than chicken (categories 3,4 and 5 only) - Live animal to meat/carcass - Deboning for muscle meat + sausages - Deboning for chops or products with bone	- Already accounted for in ACYVIA datasets (beef, pork, chicken) - ACYVIA (ground beef and pork) - FoodGES	- At slaughtering stage - At processing for all categories - At consumer for category 3, 4 - At processing plant for category 5
Fish (categories 3 4 and 5 only) (gutting heading, tailing, peeling, filleting...)	LCI Pêche and expert say[9]. See Annex 5	- at arrival in France (French Harbor or French centre)
Shellfish	Mussels: expert judgment[10]	- At consumer for category 1, 2

[6] https://www.sciencedirect.com/science/article/pii/S0956053X18301946
7 pinapple data comes from: https://www.chefs-resources.com/produce/fruit-yields/
Apricot inedible losses was 50% in FoodGES, updated to 20%, aligned with cherries.
8 For "sweetcorn on the cob", there was no such production dataset. Maize production datasets display grains as output. For the sake of simplification, cob is not accounted for along the value chain, and inedible losses are set to 0%.
9 Thomas Cloâtre (Comité des Pêches) and Vincent Colomb (ADEME) - web meeting April 2019
10 Expert say - Thierry Larnicol - Keraliou - email 5 March 2019 : 25% edible parts for mussels

	Scallops: LCI Pêche Shrimps FAO [11]	- At processing plant for category 3, 4 and 5
Cereals (wheat, oat, spelt, linseed)	loss rate from existing processes (ACYVIA, Ecoinvent, WFLDB)	chaff: at farm bran: at processing (categories 3,4,5)
Vegetables	Accounted for in farm datasets	- at farm
Drained food from canned processed products Vegetables and fruits	61% product, 39% water or syrup	- At consumer
Drained food from canned processed products (fish)	Expert judgment 80% product, 20% water or oil	- At consumer
Drained food from canned processed products	Food GES No loss	

Table 5 : Stage in the life cycle accounting for inedible losses by type of food product and by category as defined in part 2.3 - Corresponding reference.

The ratios for meat are as follows:

- Bone-in meat: 80% for chops, ribs, thighs, necks, wings, poultry; the percentage of bone is supposed to be constant for all bone-in meat from a given animal.
- Boneless meat: 100% for steak, sirloin, tenderloin, fillet, minced meat, rump, breast, belly, shoulder, offal and sausage.

In most cases, the raw/cooked ratio is applied to cooking after the inedible losses have been removed. But in some cases, cooking takes place before the inedible part is removed: for example, when cooking a pork chop. The same R2C value is assumed for the edible and inedible part of the product, which means that the same difference in water content between the raw and cooked product is applied for the edible and inedible part of a product: for example, the inedible part of a cooked pork chop (i.e. the bone) is assumed to have the same raw/cooked ratio as the edible part of the pork chop.

2.5.3. Density use for intermediate calculations

When units between the data sets and the ingredients were different, we used density for conversions.

For liquids, the unit of measurement in the data sets is litres. But the quantity of ingredients in the ANSES recipe is expressed in kilograms. We therefore used density of liquids to convert the kilograms into litres. To do this, we used density values from the FAO (Charrondiere et al., 2012). The table below shows the density assigned to each CIQUAL liquid item.

CIQUAL code	CIQUAL NAME	Bulk density (kg/l)	How (FAO source item)
Dairy products			
19042	Milk, semi-skimmed, pasteurised	1,034	milk, liquid, partially skimmed
19202	Goat milk, whole, raw	1,028[12]	milk, goat, whole
19415	Liquid cream 30% fat, UHT	0,984	Cream, 38% fat
19026 19027	Condensed milk, without sugar, whole Condensed milk, with sugar, whole	1,07	-
Alcohols			
5214	Wine, red	0,998	wine, red

11 http://www.fao.org/3/x5931e/x5931e01.htm#Shrimp%20waste
12 Alexandre Moreno - partners review January 2020

1003	Liqueur	1,016	white, wine, sweet
Juices			
2028	Lemon juice, pure juice	1,060	fruit juice
Oils and fats (datasets in kg)			
16733	Vegetable fat (margarine type), spreadable, 30-40% fat, light, unsalted	0,960	butter, margarine
17130	Rapeseed oil	0,920	oil, other than palm oil (consistent with other oils such as peanut, coconut, corn, olive)
16520	Lard or pork fat	0,919	lard

Table 6 : Densities applied to liquids

2.6.Impact categories covered

We focus on the 'Environmental Footprint 3.1' impact categories as shown in the table below.

Intermediate impact categories are calculated as well as a single score, in accordance with the European Commission (European Commission, 2018).

Impact category	Indicator	Unit	Underlying LCIA method
Climate change	Radiative forcing as Global Warming Potential (GWP100)	kg CO_2 eq	Bern model - Global warming potential (GWP) over a 100-year time horizon based on IPCC 2021 (Forster et al., 2021).
Ozone depletion	Ozone Depletion Potential (ODP)	kg CFC-11eq	EDIP model based on the ODPs of the World Meteorological Organisation (WMO) over an infinite time horizon (WMO 2014 + integrations)
Human toxicity, cancer	Comparative Toxic Unit for humans (CTUh)	CTUh	Based on USEtox2.1 model (Fantke et al. 2017, Rosenbaum et al. 2008), as in Saouter et al. (2018)
Human toxicity, non-cancer	Comparative Toxic Unit for humans (CTUh)	CTUh	Based on USEtox2.1 model (Fantke et al. 2017, Rosenbaum et al. 2008), as in Saouter et al. (2018)
Particulate matter	Human health effects associated with exposure to PM2.5.	Disease incidences	PM model (Fantke et al., 2016 in UNEP 2016)
Ionising radiation, human health	Human exposure efficiency relative tou 235	kBq U^{235}	Human health effect model as developed by Dreicer et al. (1995) and published in Frischknecht et al. (2000).
Photochemical ozone formation, human health	Tropospheric ozone concentration increase	kg NMVOCeq	LOTOS-EUROS model (Van Zelm et al., 2008) as applied in ReCiPe 2008.

Acidification	Accumulated Exceedance (AE)	mol H+eq	Accumulated Exceedance (Seppälä et al. 2006, Posch et al., 2008)
Eutrophication, terrestrial	Accumulated Exceedance (AE)	mol Neq	Accumulated Exceedance (Seppälä et al. 2006, Posch et al., 2008)
Eutrophication, freshwater	Fraction of nutrients reaching freshwater end compartment (P)	kg Peq	EUTREND model (Struijs et al., 2009) as implemented in ReCiPe 2008.
Eutrophication, marine	Fraction of nutrients reaching marine end compartment (N)	kg Neq	EUTREND model (Struijs et al., 2009) as implemented in ReCiPe 2008
Ecotoxicity, freshwater*	Comparative Toxic Unit for ecosystems (CTUe)	CTUe	Based on USEtox2.1 model (Fantke et al. 2017, Rosenbaum et al. 2008), adapted as in Saouter et al. (2018)
Land use	Soil quality index	Dimensionless (pt)	Soil quality index based on LANCA model (De Laurentiis et al. 2019) and on the LANCA CF version 2.5 (Horn and Maier, 2018)
Water use	User deprivation potential (deprivation-weighted water consumption)	m^3 world eq. deprived water	Available WAter REmaining (AWARE) model (Boulay et al., 2018; UNEP 2016)
Resource use, minerals and metals	Abiotic resource depletion (ADP ultimate reserves)	kg Sbeq	van Oers et al, 2002 as in CML 2002 method, v.4.8
Resource use, fossil	Abiotic resource depletion-fossil fuels (ADP-fossil)	MJ	van Oers et al, 2002 as in CML 2002 method, v.4.8

Table 7 : Presentation of impact indicators for the EF 3.1 method

This table presents the midpoint impact categories with their indicator, unit and underlying life cycle impact assessment method for the EF3.1 method.

*: methods updated between version EF3.0 and EF3.1. The adaptation of the other 10 impact categories can be found in Fazio et al. (2018).

AGRIBALYSE® is a LCI database. However, the 16 midpoint LCA indicators and the single score, calculated with EF 3.1, are provided in the results spreadsheets.

3. Description of items in the value chain

Food consumed in France does not necessarily come from raw materials produced in France. And raw materials can be processed before being imported. For example, if we import a ready-to-eat cake containing flour, fat, eggs and sugar, the origin of the raw materials is difficult to trace. Value chains are complex and data gaps are common. Reliable data is currently only available for raw materials.

This is why, in AGRIBALYSE®, we have made the simplifying choice of considering the origin of foodstuffs only at the raw materials stage. For a few raw materials, which represent significant consumption and for which we know there is a significant difference (tomatoes, strawberries, chicken and beef), we have created two different mixes: one "for the process" (i.e. for food industry) and one "for direct consumption".

3.1. Raw materials

3.1.1. Origin

The breakdown of consumption by country of origin was established according to equations 1 and 2, all quantities being expressed in mass (tonnes), and averaged over five years:

Equation 1

$$origin\ ratio_{FR} = \frac{Production_{FR}}{Production_{FR} + \sum_{i=1}^{n} Imports_{from\ Country\ i\ to\ FR}}$$

Equation 2

$$origin\ ratio_{country\ i} = \frac{Imports_{from\ Country\ i\ to\ FR}}{Production_{FR} + \sum_{i=1}^{n} Imports_{from\ Country\ i\ to\ FR}}$$

With

$origin\ ratio_{FR}$: proportion of total French consumption produced in France (%)

$origin\ ratio_{country\ i}$: proportion of total French consumption coming from country i (%)

$Production_{FR}$: total french production in (t)

$Imports_{from\ Country\ i\ to\ FR}$: total imports from country i to France (t)

Exports were not included. In some cases, counting exports would have led to contradictory results where exports were higher than national production, which seemed inconsistent according to the experts (technical institutes). This happens, for example, when a country has a port that is used to import products for transit to other countries in its zone. Furthermore, on the basis of trade statistics, it is impossible to know whether the products exported come from national production or transit of another country's production, and assumptions about distribution can strongly influence the consumption mix. We have therefore excluded exports when determining consumption mixes.

One year's stocks have not been taken into account either. Food products are mainly cereals, oilseeds and protein crops. As we use five-year averages, stocks have no influence, as they are eliminated in most cases from one year to the next.

In addition to the raw materials listed in point 3.1.7, for which the expert knowledge of the technical institutes was mobilised, the countries of origin were determined using data from FAOSTATS (FAO, 2019) with a five-year average of data (2009 to 2013). Trade data were traced back to the second order, eliminating transit countries for raw material trade in most cases. In a few cases, where country-specific data was missing, the composition of world production was used as an approximation with the same five-year average.

3.1.2. 70% threshold for raw material origin breakdown

We first classified the information on the origin of the products, expressed in mass, in descending order. We then sought to have a detailed origin by country for a minimum of 70% of the total. In many cases, we had information on specific countries above the threshold, and where this was the case, it was kept as it was.

Based on this data, we then standardised the origin of the ingredients at 100%.

An example is given for human consumption of soya (animal feed has a different mix) in figure 6 below. National statistics provide information on soya consumed in France in descending order: it comes from France (35%), Brazil (24%), the USA (21%), Canada (7%), and a number of other countries (14%). We have explicit information on 87% of the product's origin, but not on the remaining 13%. These have been 100% standardised.

The cumulative effect of several transit countries is often the cause of errors in identifying the country of origin.

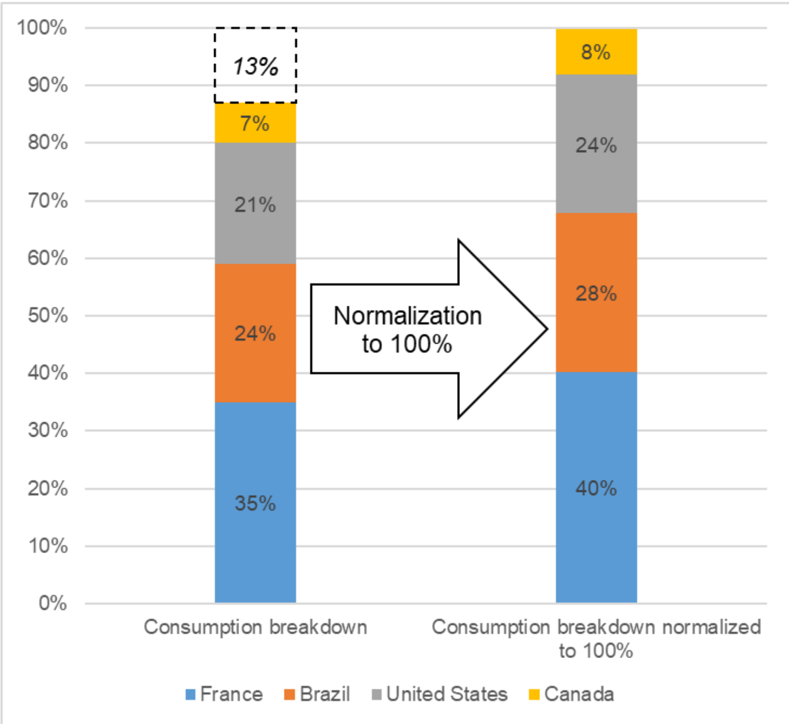


Figure 6 : Distribution of soy consumption, application of the threshold and normalisation to 100%.

3.1.3. Principles for grouping the origins of raw materials and data sets

In practice, four cases are used to combine the origins of raw materials and existing data sets, as shown in Figure 7 below:

Case 1 : the countries of origin are known and the corresponding data sets exist.

Case 2 : the countries of origin are known but the corresponding data sets do not exist for some of countries: approximations have been determined based on other countries with similar practices/climate conditions for raw materials of plant origin.

Case 3 : the country of origin is unknown, but a dataset exists (in most cases, specific to France): this is the case for meat and certain raw materials of plant origin.

Case 4 : unknown country of origin and no existing data set: this occurs for certain raw materials of plant origin.

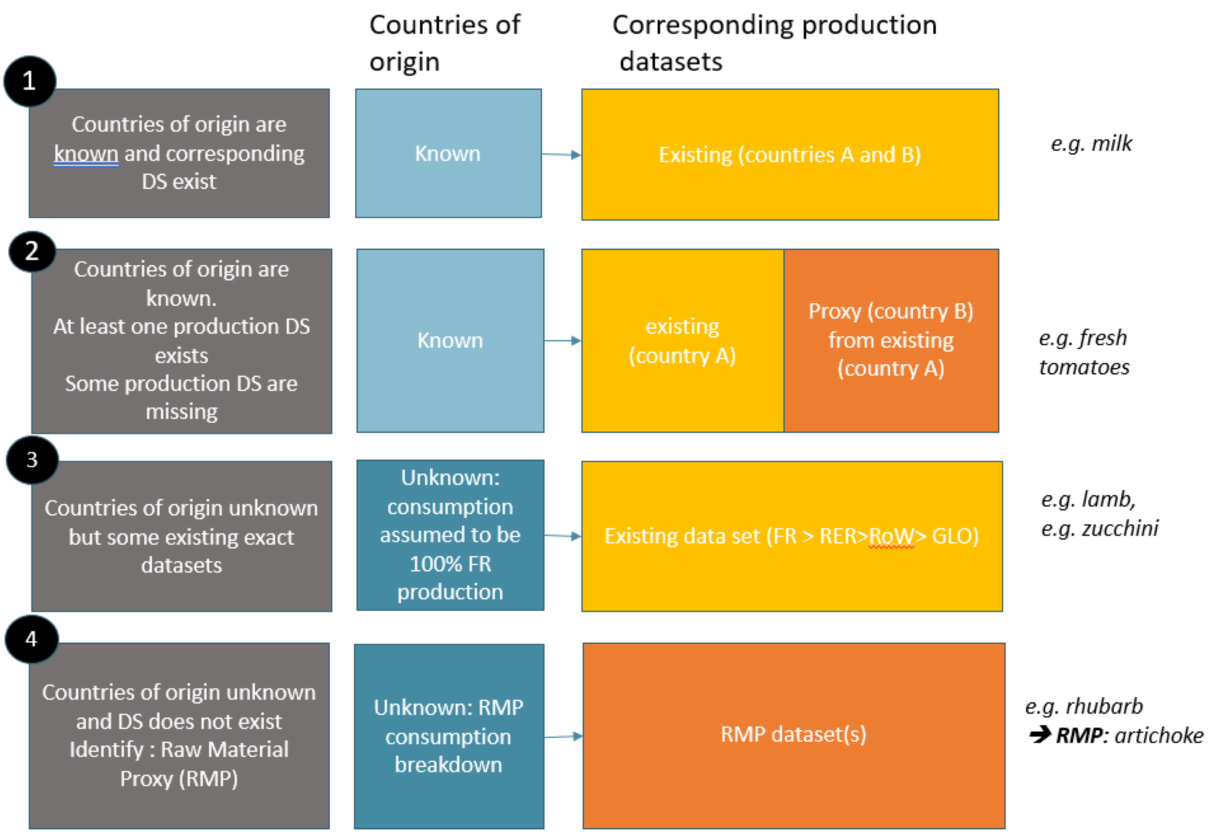


Figure 7 : Description of the four cases to identify the breakdown of raw materials consumption and the corresponding data sets

3.1.4. Vegetal raw materials

An analysis was carried out to check whether data sets existed for each plant raw material in the CIQUAL database.

a) Selection of data sets

161 plant-based raw materials have been identified in the CIQUAL database.

When comparing raw materials with datasets, we noticed that there was a wide range of datasets for a single raw material.

We have followed the rules below to select the most suitable dataset:

- Priority in the choice of database : AGRYBALYSE > Ecoinvent > WFLDB

  The priority applied to the database aims to ensure the best specific and coherent development of the future AGRIBALYSE® database. AGRIBALYSE® data has naturally been used as a priority for French production, while ecoinvent and WFLDB LCIs have been used for imports and to fill data gaps.
  This order of priority has been revised for certain specific products on the basis of recommendations from scientific experts (CIRAD recommendations on LCI to be used for tropical agricultural production).

- Priority in the choice of production method :
  - National average > Conventional > Organic (in AGRIBALYSE®).

As far as production methods are concerned, 'national average' datasets are preferred to 'conventional production' LCIs because they take account of the variability of practices within a country.

- Production" datasets > "Market for" datasets (for ecoinvent datasets),

If an ecoinvent dataset has been selected previously, the "Production" version is preferred. The "Market for" version may include transport from the factory to the consumer, which is not necessary at this stage; transport is dealt with later in the value chain (see section 3.7). In addition, the "Market for" version includes a consumption mix that is already included in the analysis.

Datasets for pear production	Database	Priority
Pear, national average, at farm gate {FR} U	AGRIBALYSE®	1
Pear, conventional, at orchard {FR} U	AGRIBALYSE®	2
Pear {GLO}| market for pear | Cut-off, U	Ecoinvent 3.9.1	4
Pear, at farm {BE} U	WFLDB	5

Table 2 : Prioritisation of databases for dataset selection: example of pear

- Priority in the choice of country of origin :
  - If the exact country of origin is not indicated, a neighbouring country or a country with a similar climate is chosen as a proxy.
  - Otherwise, the "global" (GLO) or "rest of the world" (RoW) origin[13] in ecoinvent is chosen in order of priority: GLO > ROW

NB: most of the proxies were completed using the ecoinvent database.

AGRIBALYSE® datasets most often cover a French origin. France is often used as a geographical proxy for other European countries:

- The French data set "Courges, conventionnelles, moyenne nationale, à la ferme{FR} U" is used as a proxy for Spanish squash.

There are only a few examples of country-specific proxies in AGRIBALYSE® :

- The Brazilian dataset "Mango, conventional, San Francisco Valley, at the {BR} U orchard" is used as a proxy for mangoes from Israel,

See Appendix 1 for the detailed origins of food products and the country proxies used.

b) Proxy for products

For food products without a corresponding LCA dataset, proxies were used according to their nature : the genetic proximity of the foods, and the proximity of the growing methods and environment (same soil, same growing seasons, etc.) (for example, an "orange" proxy for "pomelo"). Certain families (e.g. mushrooms: shiitake, chanterelle, cepe, etc.) have been approached by a single proxy.

This proxy approach is broadly consistent; however, for some groups it has serious limitations. Indeed, yields can be very different (e.g. "orange" as a proxy for "kumquat"). This is taken into account in the DQR. The full list of all proxies is available in Appendix 1.

As the database is regularly improved, new Life Cycle Inventories are added, making it possible to reduce the number of proxies produced. This is done either as part of projects led by the GIS REVALIM (for example, as part of the InCyVie project, life cycle inventories on duck production have been added, so it is no longer a proxy that is used for duck production), or via the contribution of external data.

[13] GLO stands for global and represents activities that are considered to be a valid average for all countries in the world. RoW represents the rest of the world. The RoW is calculated as the difference between the GLO and regional datasets (regional datasets = FR, DE, IN etc. for example).

3.1.5. Animal raw material

MEAT

The following are considered to be of 100% French origin:

- ✓ Pork meat
- ✓ Beef and chicken for direct consumption (excluding transfo)
- ✓ Duck meat
- ✓ Lamb and veal
- ✓ Cow's milk

The proxies used are :

- ✓ Chicken produced in France is a proxy for the following animals: goose, rabbit, turkey (case 4 in figure 7, the proxy being "chicken for direct consumption").
- ✓ Lamb is a proxy for kid.

Nota bene :

- The following animals have been excluded due to their low consumption rate: hare, horse, ostrich, pheasant, pigeon, quail, roe deer and wild boar.
- For beef, pork and chicken, specific research has been carried out into the origin of the products (see section 3.1.3).

FISH AND SEAFOOD

The hypothesis of origin for fish and shellfish (excluding salmon and prawns) is :

- ✓ 40% from France
- ✓ 30% from Europe (RER)
- ✓ 30% from the rest of the world (RoW)

This assumption was based on a report (FranceAgriMer, 2013) combined with expert advice (Comité des Pêches April 2019). The production data comes mainly from AGRIBALYSE® 1.4.

Specific research has been carried out into the origin of salmon and prawns, and the consumption mix is detailed in appendix 1.

The representation of the data was discussed with the relevant technical institute (Comité des Pêches; Thomas Cloâtre), based on the dominant fishing practices.

Apart from scallops, langoustine, prawns and mussels, there was no possible match for shellfish, and the others were excluded.

CIQUAL Food item	Dataset	Created in database version
American or Canadian sea scallops	Great Scallop, BSBrieuc, Dredge, average, at landing/FR U	AGB 1.4
Peru sea scallop	Great Scallop, BSBrieuc, Dredge, average, at landing/FR U	AGB 1.4
scallops	Great Scallop, BSBrieuc, Dredge, average, at landing/FR U	AGB 1.4
Norway lobster	Gadidae, CelticSea, Bottom Trawl, average, at landing/FR U	AGB 1.4
Shrimps	1kg of fresh shrimps, China production (AGRIBALYSE® 3) /EN U	newly created dataset see Annex 18

Mussels	Mussels, with shell, at farm gate (AGRIBALYSE® 3) /EN U	newly created dataset see Annex 18

Table 3 : Table of data sets used for crustaceans and molluscs

Please refer to appendix 4 for the list of proxies and appendix 5 for all the products that have been excluded and therefore not modelled.

Dairy products

According to publications by the Technical Institute (IDELE, 2019), the origin of cow's milk consumed in France is mainly French and an assumption of 100% has been made. The same assumptions were made for goat's and sheep's milk. Mare's milk has not been modelled. ACTALIA provided information on the average transport distance between the farm and the dairy, which was implemented in the average cow's milk consumption mix.

Eggs

Eggs for direct consumption and processing are considered to be 100% French. It has also been used as a proxy for duck, goose and turkey eggs. Quail eggs were excluded.

3.1.6. Focus on specific raw materials

For some of the most important food products consumed in France, we have carried out an in-depth analysis of the origin of the corresponding raw materials. This also provides the LCIs for these "important" products with an improved DQR. The table below shows the list of food products included in this analysis.

Tomatoes	Avocado	Soybean
Strawberry	Palm oil	Wheat
Apple	Cocoa	Potatoes
Kenya French Bean	Coffee	
Banana	Beef	
Pineapple	Pork	
Cashew nuts	Shrimps	
Almonds	Salmon	

Table 4 : Selected "important" products

- A more precise consumption mix

For all the food products in table 10, this analysis was carried out in conjunction with technical institutes in order to deepen our knowledge and verify the data available on the consumption mix.

The consumption mix is based on data from : France Agrimer (France Agrimer, 2019) Trademap (ITC, 2019) and an expert opinion to combine national production data and imports. The breakdowns were established according to preference order detailed in the figure below.

The results for these raw materials are given in Appendix 2.

- Differentiated values for a product category

For tomatoes and strawberries only, we studied certain variations in production and our ability to provide differentiated values. To distinguish between seasonal and out-of-season produce, and the 'destination' of the raw material - whether for direct consumption or for processing. We have therefore created 4 versions for tomatoes and strawberries:

- Fresh tomatoes / fresh strawberries for direct consumption
- Tomatoes / strawberries for processing
- Tomatoes and strawberries in season
- Tomatoes / strawberries out of season

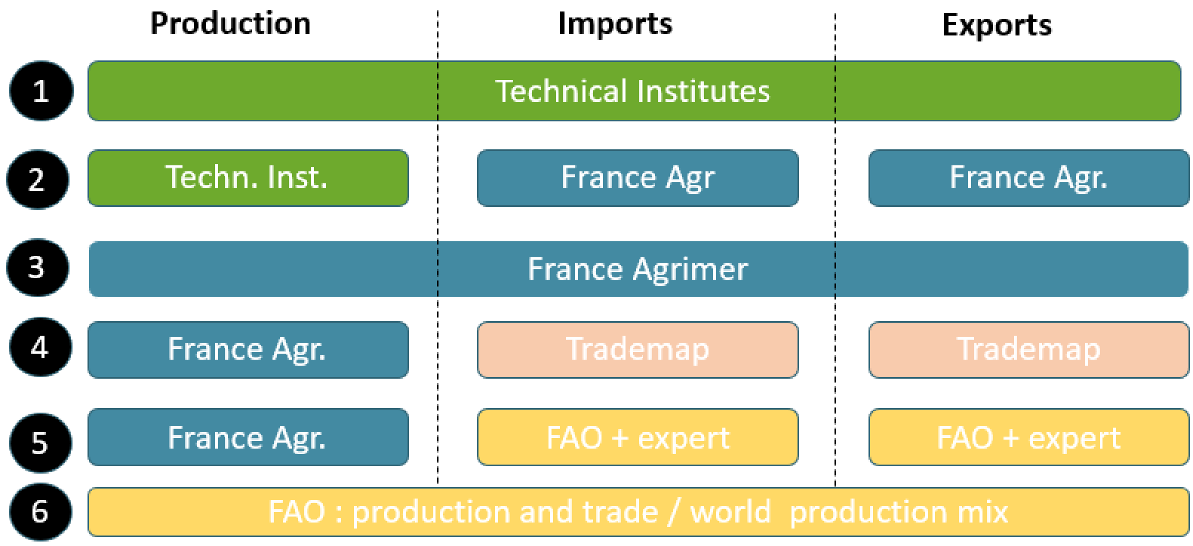


Figure 8 : Preference order for the origin of data in order to create consumption mixes for the specific raw materials processed. FAO is data from FAOSTATS, FranceAgr. means "France Agrimer".

- Distinction between "direct consumption" and "processing".

The environmental impact varies depending on how the food is subsequently used.

The country of origin, harvesting, growing techniques and varieties differ for tomatoes intended for direct consumption or for processing.

This distinction between "direct consumption" and "processing" has been made for 4 products in AGRIBALYSE® :

- Beef,
- Chicken,
- Tomatoes,
- Strawberries.
  We have considered that tomatoes "intended for processing" are produced in unheated greenhouses.

For example,

It is assumed that fresh tomatoes are produced in unheated greenhouses in two different countries (France and Morocco):

- 66% in **unheated greenhouses**, produced in **France**, and
- 34% from an **unheated greenhouse** produced in **Morocco**.

It is assumed that the tomatoes used for processing are produced in unheated greenhouses in three different countries (France, Italy and Spain):

- 18% in **unheated glasshouses**, produced in **France**,
- 46% from unheated **greenhouses** produced in **Italy**, and

- 36% from **unheated greenhouses** produced in **Spain**.

Two different datasets were created, one for 'fresh tomatoes' and one for 'processed tomatoes'.

- Distinction between 'in season' and 'out of season

Depending on the season of consumption, cultural practices and food origins may vary.
This distinction between 'in season' and 'out of season' was made for four products:

- Tomatoes (fresh),
- Strawberries,
- Cucumbers,
- Aubergines.

For example, 'seasonal' tomatoes are considered to be produced entirely in the ground (a strong approximation) and in unheated greenhouses in France.

Out-of-season tomatoes are supposed to be produced in both heated and unheated greenhouses and in two different countries:

- 38% in **heated greenhouses**, produced in **France**, and
- 62% comes from **unheated greenhouses** produced in **Spain**.

Two different data sets were created for 'in-season tomatoes' and 'out-of-season tomatoes'.

The consumption mixes for aubergine and cucumber, constructed for AGRIBALYSE® 3.1, could be distinguished between "in season" and "out of season" by using agricultural production data corresponding to these crops (tomato or courgette proxy under CTIFL recommendations). These distinctions did not, however, give rise to a distinction between CIQUAL products, but it was assumed that in-season products are used for fresh vegetables while out-of-season products are used for vegetables used in industry.

MEAT

The processing datasets come from AGRIBALYSE® 1.4, with the exception of duck, for which the data were created for AGRIBALYSE® 3.2. It should be noted that some datasets are also updated on an ongoing basis, for example the pork processing data were updated for AGRIBALYSE® 3.2 by the IFIP as part of the InCyVie batch 1 project. project (Emonet, et al., 2024).

For beef and chicken, a distinction has been made between meat intended for direct consumption and meat intended for processing and catering.

- For direct consumption, it is assumed that they are 100% sourced in France.
- The breakdown for processing is shown in the table below, based on the references given in Appendix 2.

Type of meat	Purpose	Origin of product for consumption
Beef	For direct consumption	100% France
	For processing and catering	80% France, 20% Netherlands
Chicken	For direct consumption	100% France
	For processing and catering	47% France, 17% Belgium, 17% Netherlands, 9% Germany and 9% Poland

Table 11 : Origin of beef and chicken meat

3.2. Processing (food industry)

- Geographical location

With the exception of drying (see below), we assume that all processing takes place in France, for ingredients, processed products and recipes.

- Order of choice

For the transformation, the descending preference order for the choice of processes among the various databases is as follows:

Acyvia >Ecoinvent 3.9.1> WFLDB 3.5

Acyvia processes used are disaggregated processes (PDi), as they allow the value chain to be broken down.

We are focusing on the operations and parameters that are most important for modelling : drying and cooling operations, processes that have an impact on changes in mass and yield. On the other hand, mechanical operations (slicing, pressing, etc.) have received less attention.

For processed raw materials and recipes, the "inedible portion" ratio is in principle applied at the processing stage. For bone-in meat, the "inedible part" ratio may be applied "at slaughterhouse" or "at consumer", depending on the case. In the case of "Pork, rib, raw", the bones are removed at consumer's step.

For recipes, the raw/cooked ratio applies at this stage of the process. There is, however, one exception to this rule: pasta. Pasta is a recipe in itself, as it contains a mixture of several ingredients. Fresh egg pasta is a mixture of durum wheat semolina, wheat flour, eggs and water.

However, "cooked pasta" in the database (CIQUAL items 9816, 9822, 9871) is considered to be cooked by the consumer.

The use of water for washing fruit and vegetables has not been taken into account, with the exception of new products modelled (or products remodelled) for AGRIBALYSE® 3.1 and later, which may contain this step. This is a limitation of the database.

For some processes, known for their low environmental impact, we have had to use dummies (empty processes), so that the operation is visible even though we are not taking their impact into account. These are mainly operations designed to eliminate the inedible part of the raw materials, such as shelling, peeling, stoning, etc. The full list of empty processes is provided in Appendix 12. As with water consumption, some new products modelled (or remodelled) for AGRIBALYSE® 3.1 may contain this step.

3.2.1. Drying e

The table below describes the processes used for drying.

Raw material	Dataset	Value chain covered	Database
Fish	Ignored Only one CIQUAL item concerned : "cod, salted, dry".14	N/A	
Coffee	Transformation into freeze-dried soluble coffee, green coffee, per kg product (WFLDB)/GLO U	Gate-to-gate process	WFLDB
Tea	Tea, dried {RoW}| tea production, dried | Cut-off, S	Cradle to gate	Ecoinvent

[14] It is treated as "cod, raw", without taking into account the salt and drying.

Eggs (white, yolk, white and yolk)	Water evaporated, Drying process, Vacuum rotary, 1 kg water/FR U	Gate to gate	Newly created dataset see Annex 18 15
Milk (depending on fat content)	Skimmed milk powder, at feed plant /EN S	Gate to gate	AGRIBALYSE®16
Vegetables, fruits and nuts	Water evaporated, Drying process, Vacuum rotary, 1 kg water/FR U	Cradle to gate	Newly created dataset see Annex 18
Apricots, herbs, figs, plums, grapes	[Dummy] Sun drying, at processing/FR U	Cradle to gate	AGRIBALYSE®

Table 5 : List of raw materials dried and drying assumptions

For all fruit and vegetable-based food products, we assume that the drying process takes place on the farm. Cradle to factory gate" processes have been created taking into account the mass balance, including evaporated water. The mass balance for fresh and dried fruit and vegetables has been calculated using the CIQUAL water content for fresh and dried items. Appendix 7 details the calculation.

Example : the water content of a fresh banana is 75.8g/100g and the dry content is 3g/100g.

(100-3)/(100-75,8) = 4,01

So to obtain 1g of dry banana output, you need 4.01g of fresh banana input.

3.2.2. Dairy products

The table below shows the datasets used for each dairy product from cradle to factory gate. The datasets for sheep's and goat's cheese are constructed by adapting the ACYVIA datasets for cow's milk. Milk yields per dairy product are taken into account on the basis of ACTALIA data and recommendations.

See appendix 8 for more information.

Food items	Dataset(s) and proxies	How to	Database
Soft cheese (cow)	cheese production; from raw milk, soft cheese; French production mix, at plant; PDi	Milk yield adapted to each cheese (ACTALIA)	ACYVIA
Hard cheese (cow)	cheese production; from raw milk, hard cheese; French production mix, at plant, PDi	Milk yield adapted to each cheese (ACTALIA)	ACYVIA
Soft cheese (ewe's milk)	Adapted dataset from "cheese production; from raw milk, soft cheese; French production mix, at plant, PDi"	Use of ewe's milk Milk yield adapted to each cheese (ACTALIA)	Adapted from ACYVIA
Hard cheese (ewe's milk)	Adapted dataset from "cheese production; from raw milk, hard cheese; French	Use of ewe's milkMilk yield adapted to each cheese (ACTALIA)	Adapted from ACYVIA

[15] This dataset was originally created for seaweed drying and has been applied to "fruit drying" as a proxy. The drying dataset is based on rotary vacuum dehydration, which is not the most commonly used technology for products other than seaweed. For example, according to (Sanjuán et al., 2014), fruit drying takes place in an oven for a significant period of time (~ a few weeks). Therefore, the use of this seaweed-specific drying is not fully suitable for

[16] Attention data set intended for animal feed.

	production mix, at plant, PDi"		
Soft cheese (goat)	Adapted dataset from "cheese production; from raw milk, soft cheese; French production mix, at plant, PDi"	Use of goat's milkMilk yield adapted to each cheese (ACTALIA)	Adapted from ACYVIA
Hard cheese (goat's cheese)	Adapted dataset from "cheese production; from raw milk, hard cheese; French production mix, at plant, PDi"	Use of goat's milkMilk yield adapted to each cheese (ACTALIA)	Adapted from ACYVIA
Dirty butter / not soft	Butter, unsalted, at dairy (WFLDB)/GLO U Butter, salted, at dairy (WFLDB)/GLO U	Milk yield adapted to each butter, using French milk and French electricity (ACTALIA)	WFLDB[1]
Cream	Cream, from cow milk {RoW}| yogurt production, from cow milk | Cut-off, S	Milk yield adapted to each cream, use of French milk and French electricity, suprpression of ingredients other than milk (ACTALIA)	Ecoinvent 3.5[2]
Whole / semi-skimmed / skimmed milk -	Pasteurisation; from raw milk, at 72¡C for 30 s.; French production mix, at plant; 1 kg of pasteurised milk (PDi) *Proxy: Pasteurisation; from raw milk, at 72¡C for 30 s.; French production mix, at plant; 1 kg of pasteurised milk (PDi)* *Proxy: Pasteurisation; from raw milk, at 72¡C for 30 s.; French production mix, at plant; 1 kg of pasteurised milk (PDi)*	Milk yield adapted to each milk (ACTALIA)	ACYVIA ACYVIA ACYVIA
Liquid infant milk	*Baby milk, ready to feed, recipe, at plant {FR} U*	Recipe created for AGRIBALYSE® 3.2 based on SFAE (syndicat de l'alimentation de l'enfance) recommendations	AGRIBALYSE®
Infant milk powder	*Baby milk, powder, recipe, at plant {FR} U*	Recipe created for AGRIBALYSE® 3.2 based on SFAE (syndicat de l'alimentation de l'enfance) recommendations	AGRIBALYSE®

Concentrated milk	Concentrated milk, 25% dry matter, whole milk, unsweetened, at dairy (WFLDB)/GLO	Adapted milk yield, use of French milk and French electricity, suprpression of ingredients other than milk (ACTALIA)	WFLDB[1]
Yoghurt	Yogurt, from cow milk {RoW}| production | Cut-off	Milk yield adapted to each yoghurt, use of French milk and French electricity, suppression of ingredients other than milk (ACTALIA)	Ecoinvent 3.9.1[2]

[1] WFLDB dataset is cradle to gate; it does not account for specific French raw material nor electricity consumption mixes.
[2] Ecoinvent dataset is cradle to gate; it does not account for specific French raw material nor electricity consumption mixes.

Table 6 : Processed dairy products

3.2.3. Cereals and pulses

Food items	Dataset(s)	Database
Wheat Flour	Global milling process; soft wheat, steel-roller-milled, industrial production; French production mix, at plant; 1 kg bulk flour at the exit gate, PDi	ACYVIA
All other flours (spelt, rice, oat, maize, chickpea, rye, barley, buckwheat, chestnut)	*One dataset created per raw material- Apart from input raw material and output product, inputs/outputs are copied from "wheat flour, at industrial mill (WFLDB)/GLO". NB: grain yield, i.e. mass of grain needed as input per kg flour output has not been modified and kept identical to wheat.*	Adapted from WFLDB
Couscous (durum wheat semolina pre-cooked with steam), raw	Durum wheat, semolina, at plant (WFLDB)/GLO	WFLDB[1]
Potato starch	Potato starch {RoW}| production	Ecoinvent[2]
Maize starch	Maize starch {RoW}| production	Ecoinvent[2]
Tofu	Tofu {RoW}| production	Ecoinvent[2]
Plant-based beverages (soybean, oat, almond, coconut)	*Specific dataset created for each beverage for AGRIBALYSE® 3.1*	AGRIBALYSE®

[1] WFLDB: The data set is a cradle-to-plant gate data set; it does not take into account the mix of raw materials and electricity consumption specific to France.
[2] Ecoinvent: The dataset is a cradle-to-plant gate dataset; it does not take into account the mix of raw materials and electricity consumption specific to France.

Table 7 : Cereals and pulses

3.2.4. Coffee, chocolate, tea and pasta

The table below provides information on the chocolate, coffee, tea and pasta datasets.

Food items	Dataset(s)	Database	Comments

Coffee grinding	Roasting and grinding, green coffee (WFLDB)/GLO U	WFLDB	Process used is a gate-to-gate process. Consumption mix of coffee raw material is accurate
Coffee freeze drying	Transformation into freeze-dried soluble coffee, green coffee, per kg product (WFLDB)/GLO U	WFLDB	
Coffee spray drying	Transformation into spray-dried soluble coffee, green coffee, per kg product (WFLDB)/GLO U	WFLDB	
Coffee, decaffeinated (all)	Same as coffee above, adding "Decaffeination, green coffee, supercritical CO2 process (WFLDB)/GLO U".	WFLDB	
Chicory powder, instant	Proxy " Transformation into spray-dried soluble coffee, green coffee, per kg product (WFLDB)/GLO U"	WFLDB	Processes used are gate-to-gate processes. Consumption mix of chicory raw material is accurate
Cocoa powder	Cocoa powder, at plant (WFLDB)/RER U	WFLDB[1]	
Cocoa butter	Cocoa butter, at plant (WFLDB)/RER U	WFLDB[1]	
Dark chocolate	Dark chocolate 40%, recipe, at plant {FR} U Dark chocolate 70%, recipe, at plant {FR} U	AGRIBALYSE®	Joint work between L'Alliance 7 and its members
Milk chocolate	Milk chocolate, recipe, at plant {FR} U	AGRIBALYSE®	Joint work between L'Alliance 7 and its members
White chocolate	White chocolate, recipe, at plant {FR} U	AGRIBALYSE®	Joint work between L'Alliance 7 and its members
Pasta	Pasta, dried, from durum wheat, at plant (WFLDB)/GLO U	WFLDB[2]	
Tea	already dried at consumption mix		

[1] The "cocoa beans, sun dried, at farm (WFLDB)" dataset has a significant impact on climate change because it takes account of land transformation.

Table 8 : Coffee, chocolate, tea and pasta

3.2.5. Soups (dehydrated)

To model dehydrated soups, stocks and broths, we used the drying process created during the development of the seaweed dataset, as follows:

	Process flow	Amount (kg)
Input	Soup, Asian-style with noodles, prepacked, to be reheated, at plant (AGRIBALYSE® 3) /EN U	1
	Water evaporated, Drying process, Vacuum rotary, 1 kg water AGB(3.0) /EN U	17,09
Output	Soup, Asian-style with noodles, dehydrated, at plant (AGRIBALYSE® 3) /EN U	18,09

Table 9 : Dehydration process applied to the dehydrated soup model

The quantity of incoming fresh soup is calculated on the basis of a manufacturer's dehydrated soup preparation sheet [1]: 11.7 g for 200 ml of water. To obtain 1 kg of reconstituted soup, 55 g of dehydrated soup and 945 ml of water are used. The equivalent quantity of fresh soup used to obtain 1 kg of dehydrated soup is therefore 1/0.055 = 18.09 kg.

- For two soup recipes, the hydrated version was not included in the CIQUAL database. We therefore used a proxy :

Dehydrated soups (hydrated recipe not in CIQUAL)		Proxy	
Name	CIQUAL code	Name	CIQUAL code
Soup, cereals and vegetables, dehydrated and reconstituted, at plant {FR} U	25934	Soup, tomato and vermicelli, dehydrated, at plant {FR} U	25949
Soup, Moroccan, dehydrated and reconstituted, at plant{FR} U	25950	Soup, chorba frik, w meat and frik, at plant {FR} U (+ Dehydrating, processing, at plant "dummy process" {FR} U	25915

Table 10 : Proxies for two dehydrated soups

3.2.6. Cooling and freezing

For products that require it, a freezing process can be used. Downstream processes such as transport and storage (distribution and retailing) also take into account the need for lower temperatures.

3.2.7. Sugars

Food item	Dataset name in AGB	dataset name(s) /proxy(ies) in background database	Background database
Fructose	Fructose, consumption mix {FR} U which calls the GLO	Glucose {GLO}| market for glucose | Cut-off, S - Copied from Ecoinvent U	Ecoinvent[1]
White sugar	White sugar, production, consumption mix {FR} U	Sugar, from sugar beet {GLO}| market for | Cut-off, S - Copied from Ecoinvent U	Ecoinvent[1]
Brown sugar	Brown sugar, production, consumption mix {FR} U	Sugar, from sugarcane {RoW}| sugarcane processing, traditional annexed plant | Cut-off, S - Copied from Ecoinvent U	Ecoinvent[1]
Glucose	Glucose, consumption mix {FR} U which calls the GLO	Glucose {GLO}| market for glucose | Cut-off, S - Copied from Ecoinvent U	Ecoinvent[1]

Table 18 : Other foods

3.2.8. Appertisation (canning)

The following processes are used for canning:

Process	Dataset name(s) /proxy(ies)	Database	How to
Corn canning	Canning corn, industrial, 1kg of canned product/ FR U	AGRIBALYSE®	Dataset created by CTCPA for AGRIBALYSE® 3.1
Ready meals canning	Canning ready meals, industrial, 1kg of canned product/ FR U	AGRIBALYSE®	Dataset created by CTCPA for AGRIBALYSE® 3.1

Root vegetables canning	Canning root vegetables, industrial, 1kg of canned product/ FR U	AGRIBALYSE®	Dataset created by CTCPA for AGRIBALYSE® 3.1
Vegetables canning	Canning vegetables, industrial, 1kg of canned product/ FR U	AGRIBALYSE®	Dataset created by CTCPA for AGRIBALYSE® 3.1
Fruit and vegetable canning	Canning fruits or vegetables, 1kg of canned product/ FR U	AGRIBALYSE®	Newly developed dataset see Annex 18
Tuna canning	Canning Tuna, industrial, 1kg of canned product/ EN U	AGRIBALYSE®	Dataset created by CTCPA for AGRIBALYSE® 3.1
Sardine or mackerel canning	Canning sardine or mackerel, industrial, 1kg of canned product/ FR U	AGRIBALYSE®	Dataset created by CTCPA for AGRIBALYSE® 3.1
Fish canning, in brine	Fish canning, in brine/FR U	AGRIBALYSE®, adapted from ecoinvent gate to gate dataset "Fish canning, small fish {RoW}| fish canning, small fish | Cut-off, U" replacing oil with brine	Used for canned fish in brine Original Ecoinvent dataset serves 1 kg of canned fish but uses a mass of 2kg of raw fish input. In order to respect mass balance, it has 1kg of fish residues as waste.

Table 11 : Data sets for appertisation

Canned pulses are cooked before being canned. In this case, the cooking itself (and the corresponding energy) has not been taken into account in AGRIBALYSE®. However, the raw/cooked ratio has been applied to these pulses, and the canned mass is that which has been cooked.

3.2.9. Recipe preparation

- Pre-treatment of ingredients for recipes

Some of the ingredients used in the recipes are pre-treated before being mixed with the other ingredients in the recipe.

The various pre-treatment processes are detailed in the table below:

Food category	Preprocess 1 (applied to all)	Other possible preprocesses (applied sometimes)
Fruits and vegetables	Peeling	Pitting (apricot, sweet pepper, avocado), Drying
Vegetables	Peeling	Drying (for dried or dehydrated vegetables)
Nuts and seeds	Unshelling	Drying (coconut)
Meats	Slaughtering	Roasting, Smoking
Fishes	Fish filleting	Smoking (salmon)
Eggs	Unshelling	-
Coffee	Grinding	Roasting
Juices	Juicing	Rehydrating (reconstituted juice)

Note: the pre-processes and examples in the last column are not exhaustive.
Note: products added in AGRIBALYSE® updates (e.g. AGRIBALYSE® 3.1) may contain more precise models for these stages.

Table 12 : Several pre-processes defined for the food category

Other pre-processes are not taken into account in the recipe pre-processes but further up the value chain (during production):

- Cutting
- Grinding,
- Drying.

Finally, canning is also included for fish, meat and fruit and vegetables.

3.3.Recipes

In order to implement the recipes as datasets in AGRIBALYSE®, the composition of the recipes must be collected (i.e. the proportion of each ingredient).

We have used different sources for the recipes:

- **Retailer** : recent French industrial recipe, and therefore the most suitable for AGRIBALYSE®,
- **ANSES**: French "home-made" recipe, assumed to be similar to industrial recipes and therefore the second most suitable for AGRIBALYSE®. These recipes have been adapted and simplified from the file Anses_Credoc_Recette_INCA3 for AGRIBALYSE®.
- **Open Food Fact recipe**: recipe observed on products on sale
- Existing **LCA data**: recipes and data not specific to France (Cocoa powder, at the factory (WFLDB)/RER U)

Some recipes had to be approached using proxies:

- Or by a dataset of an existing recipe in another LCA database (aggregated datasets), for example: the CIQUAL item "Dark chocolate with a minimum cocoa content of 40%, for pastry, bar (CIQUAL Code: 31085)" is approximated by the dataset "Dark chocolate, at the factory (WFLDB)/GLO U" from WFLDB.
- Or by approximating a CIQUAL recipe with another CIQUAL recipe (e: "Fish pies"; 8080 with "Tuna pies"; 8082).

Some recipes were excluded because they were consumed only occasionally or because they involved average foods (from the CIQUAL nomenclature) without an exact recipe to match (see 3.3.6).

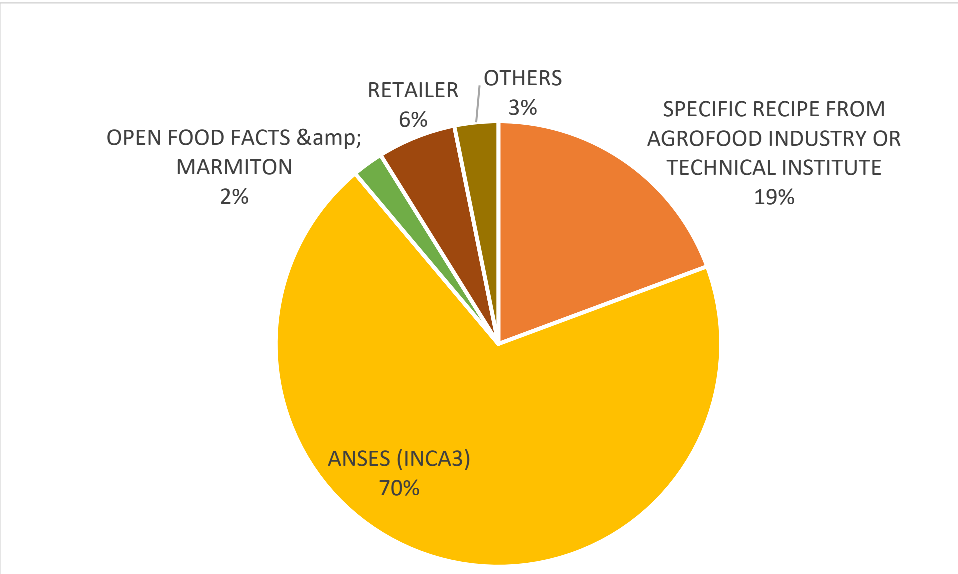


Figure 9 : Origin of recipe for AGRIBALYSE® 3.2

3.3.1. Cut-off threshold of 95% by mass for recipes

A cut-off point of 95% by mass was applied to the recipes. This means that ingredients with a low mass in a recipe have been removed from the modelling (e.g. salt, spices, additives, etc.).

The ingredients remaining after the cut were then standardised to 100%.

Recipe Ingredients	Quantity (%)	CIQUAL Food Item	CIQUAL Code
Rice brown	69,8 %	Rice, brown, raw	9102
Maize	16 %	Corn or maize grain, raw	9200
Buckwheat	7 %	Buckwheat, whole, raw	9380
Millet	7 %	Millet, whole	9330
Salt	0,2 %	Cut-off	Cut-off

Table 13 : Example of "Puff pastry with cereal texture" (7353) - Cut-off rules.

For some products in particular, products representing less than 5% by mass may still have been counted (e.g. chocolate milk: cocoa taken into account).

3.3.2. ANSES recipes

The recipes provided by ANSES have been reworked for AGRIBALYSE® using the "Anses_Credoc_Recette_INCA3" file.

Although these are in fact "homemade" recipes, they are supposed to be similar to industrial recipes. The recipes detail all the ingredients making up a recipe and the proportion of each ingredient.

See the list of Agribalyse recipes based on INCA3 recipes in appendix 9.

If the ingredient is cooked, the actual quantity of the ingredient should be calculated as raw, using the raw/cooked ratio. For most fruit and vegetables included in recipes, inedible losses must be applied upstream, before the recipe stage.

The datasets selected for meat used in a recipe as an ingredient are all "boneless". For chicken and beef, we have used specific datasets "for processing" (see "Specific raw materials"), while for the other meats, we have used datasets "for direct consumption".

3.3.3. Distributor recipes

Industrial recipes have been supplied by a distributor. They are based on their private label. As far as possible, they correspond to the "most common" CIQUAL product on the market. As with the ANSES recipes, these recipes detail the ingredients and their proportions.

See list in appendix 9.

3.3.4. Recipe matching

- ANSES recipes and distributor recipes

ANSES recipes and distributor recipes have been "directly" associated with CIQUAL products.

CIQUAL Recipe Name	CIQUAL Code	Matched ANSES or Retailer Recipe
Doughnut filled with jam	23881	Doughnut with raspberry jam filling

See list in appendix 9.

- **Recipe remaining after matching with ANSES recipe and distributor recipe**

For other CIQUAL products, approximations have been made to bring CIQUAL products into line with other similar products that could represent them.

See list in appendix 10.

3.3.5. Creation of new recipe data sets

Because of its frequency of consumption and its use in other recipes, we decided to create a new LCI for beer: "regular" beer (4-5° alcohol) (CIQUAL Code: 5001), which serves as a proxy for the other six beers. The methodology is described in a specific report (Rapport spécifique sur la création d'inventaires pour la publication d'Agribalyse 3.0, Asselin-Balençon et al. 2020).

3.3.6. Recipe/CIQUAL excluded

A number of CIQUAL products have been excluded because they are consumed only occasionally or because they concern average foods in the CIQUAL nomenclature without a suitable recipe. For example, "average pâté" is excluded but specific pâtés are included in the database (Paté de porc etc.). See list in appendix 11.

3.3.7. Recipe production process

Energy is consumed in the factory to transform the ingredients into the recipe.

The list of manufacturing processes used is described in the table below. We have often used proxies for these processes due to the lack of data sets in the databases (see table below):

Process at factory	Dataset used
Cooking	Cooking (AGRIBALYSE®)
Boiling	Cooking (AGRIBALYSE®)
Roasting	Proxy cooking (AGRIBALYSE®)
Braising	Proxy cooking (AGRIBALYSE®)
Frying (incl. deep frying)	Proxy cooking (AGRIBALYSE®)
Grilling	Proxy cooking (AGRIBALYSE®)
Pre-cooking	Proxy cooking (AGRIBALYSE®)
Steaming	Proxy boiling
Drying	Proxy : Drying created for Algae (see Annex 18)
Grinding	Proxy: "milling for grains" (ACYVIA) and "grinding and forming of frozen beef" (ACYVIA)
Juicing	Juicing, at processing (AGRIBALYSE® 3) dummy /EN U
Salting fish	Salting meat" proxy (ACYVIA)
Canning	Canning, fruits and vegetables (AGRIBALYSE®) Fish canning

Table 14 : Data sets used for recipe processes

All data sets are defined for 1 kg of recipe.

N.B:

- The canned products are LCIs created specifically for AGRIBALYSE® (see the specific CTCPA report for AGRIBALYSE® 3.1[17] for more details on these datasets).
- Cooking is also taken into account (in addition to the energy consumption included in the "cooking" dataset) by applying the raw/cooked ratio (mass balance with evaporated water).
- The mixing process for pasta, biscuits, etc. ("Mixing") has been taken into account, but is a "dummy".

3.4. Packaging

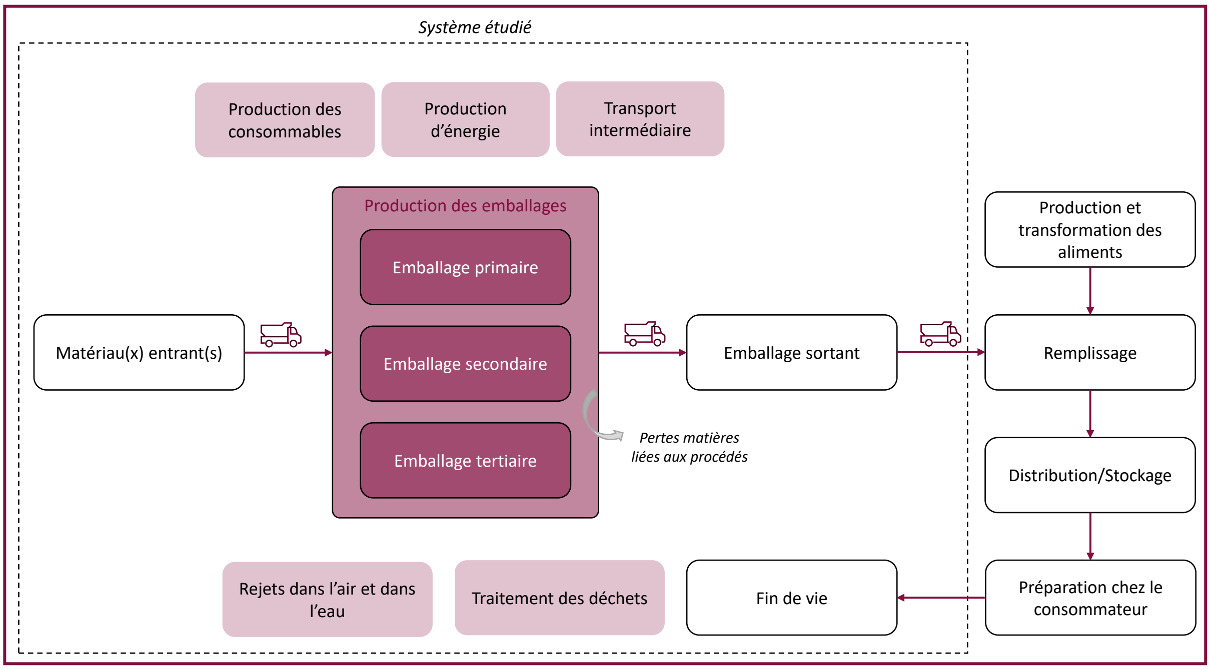
As improving the modelling of packaging in the AGRIBALYSE® database has been identified as a priority in the roadmap of the GIS REVALIM (Scientific Interest Group on the environmental assessment of food products), the Agro-Industrial Technical Institutes, partners in the GIS, with the CTCPA in the lead (and the support of the Centre technique des Plastiques et des Composites and a consultancy specialising in packaging LCA) have proposed a new methodological framework (established as part of the PACK-AGB project) to model packaging for all the products covered by the AGRIBALYSE® database in a uniform and consistent manner. As part of the PACK-AGB project, new life-cycle inventories of sales packaging have been produced using this methodology: these new inventories constitute a catalogue of packaging solutions containing 486 packaging solutions covering around 1,130 food products in the database. This means that for each product covered, several packaging solutions are available in the "expert" version of the Agribalyse database (version available in LCA software). The main packaging for each product has been identified in order to model each CIQUAL product. These new packaging inventories cover almost 50% of the product references in the database, and have been delivered to ADEME for integration into version 3.2 of AGRIBALYSE®.

Please refer to all the deliverables produced as part of this project :[18]

- Methodology report : AGRIBALYSE® 3.2 packaging section: Report drawn up to make it easier to understand and use the data from the Pack-AGRIBALYSE® project in LCA software, so that it can be used as a reference for taking into account the packaging of products not covered by this project.
- Packaging modelling tutorial in AGRIBALYSE® 3.2: The aim of this tutorial is to enable an LCA specialist to implement a new packaging solution by reproducing the same methodology as that developed in the PACK AGB project (2024).
- Methodological note : packaging not covered by the scope of the PACK_AGB project

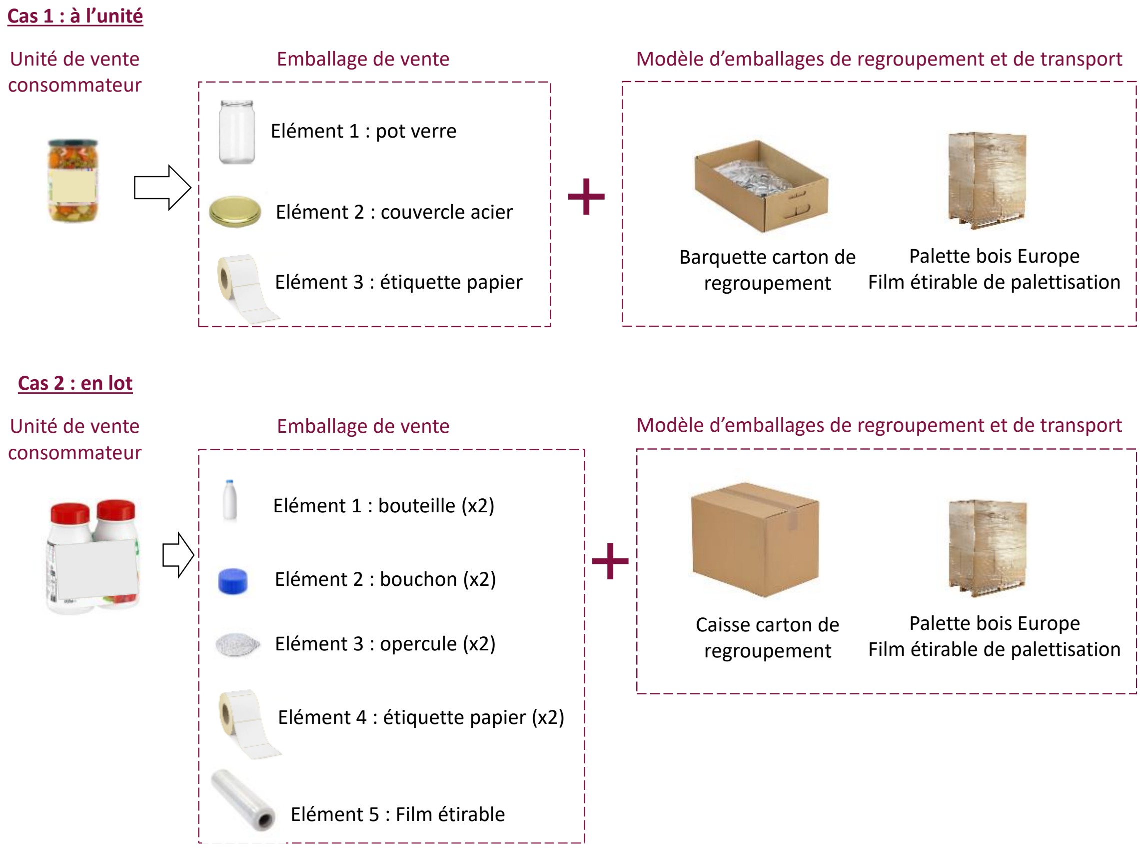
In this new packaging modelling methodology, the boundaries of each "packaging solution" are described in the diagram below:

[17] Colombin, Margaux; Audoye, Pauline; Farrant, Laura; Labau, Marie-Pierre, 2024, "Rapport méthodologique pour les produits élaborés CTCPA AGRIBALYSE v3.1 : inventaires produits, procédés et données sur les pertes et le stockage", https://doi.org/10.57745/ZRJUYN, Recherche Data Gouv,
[18] *Colombin et al. 2024, "Pack-AGRIBALYSE Project", https://doi.org/10.57745/ZTZUQR, Recherche Data Gouv*



Each packaging solution represents a "typical" or "standard" configuration of a packaging unit solution as sold to a consumer, to which is allocated a share of the impacts associated with grouping packaging and transport.

Each solution can be made up of one or more elements, and each element can be made up of one or more materials. This packaging solution can be considered individually or in batches. Both grouping packaging ("secondary packaging") and transport packaging ("tertiary packaging") are considered.



The following stages were included in the scope of the study for all elements of the packaging solution :

- The extraction and production of the raw materials for each of the elements
- Primary, secondary and tertiary packaging shaping and finishing processes
- Transport upstream of the use phase: supply of raw materials for packaging for products sold on the French market and delivery of packaging to the filling plant in France.
- The end-of-life stages for packaging: collection and sorting, transport for collection and to the sorting centre, end-of-life treatment (recycling, energy recovery and landfill).

The end-of-life of packaging is modelled using the Circular Footprint Formula (CFP) methodology.

The following stages and flows were excluded from the scope of the study:

- The packaging use phase: filling, storage, distribution, refrigeration/heating;
- The stages in the life cycle of packaged food.

The other food products, not covered by the PACK_AGB project, have been the subject of a simplified improvement for version 3.2. AGRIBALYSE®, based in part on the library of LCIs proposed in the PACK-AGB project and on data from the Plein Pot sur les Emballages project (collaboration between OpenFoodFacts and ADEME, 2023), which involved collecting a range of information on the packaging of the products most widely consumed in France from businesses and citizens in order to generate a database of the format, composition and weight of food packaging. Further work could be envisaged to harmonise the inclusion of packaging for these products. A specific methodological note has been written on these products not covered by the PACK-AGB project project (Audoye, Brambati, & Colombin, 2024)..

3.5.Distribution and supermarket sales

The distribution and supermarket sales phases are modelled primarily using the default EFP data, taken from the EFP guidance document guidance document (European Commission, 2016). Default data are therefore defined for cooling, freezing, lighting and heating during these phases. These parameters depend on the defined storage time as well as the density of the products, i.e. the volume that the product occupies per kg of product (Charrondiere et al., 2012). The use of storage time and density as parameters for estimating energy consumption is detailed in the box below.

Product density

<u>How product lifespan and density are linked to energy consumption in distribution:</u>

The energy requirements of products at distribution level are determined in units of energy per m^3 , in the PEF guidance document. Each product must therefore be allocated a space and an occupancy time. An average distribution centre can store 60,000 m^3 of products. The storage period on an annual basis is 52 weeks, or 31,200 m^3 -weeks/year. The total capacity is then allocated with the following storage volumes and times:

1. For ambient products: 4 times the volume of product * stored 0/1/4 weeks for short/medium/long ambient
2. For chilled products: 3 times the volume of the product * stored for 1 week
3. For frozen products: 2 times the volume of the product * stored for 4 weeks

The densities used are shown in the table below. For fruit and vegetables, the FAO Density database Version 2.0 of the FAO INFOODS database database (Charrondiere, U. R., Haytowit, D., & Stadlmayr, 2012) was used. was used. Broad categories of fruits and vegetables are formed to assign a density to all fruits and vegetables. The other densities (for liquids) are presented in table 6 (see section 2.6.3 Density for liquids).

Category	Name	Density (kg/l)	Also proxy for
Raw products (categories 1 and 2)	Potato	0,6375	Proxy for all tubers, roots, french fries
	Onion	0,6195	Proxy for leek, shallot and kholrabi
	Eggplant	0,398	Proxy for zucchini
	Cabbage	0,362	Proxy for asparagus, artichoke squash, brussels sprout, pumpkin
	Lemon	0,575	Proxy for all citrus fruits
	French bean	0,271	Proxy for all long beans (french bean, butter bean, flat bean, haricot bean, soy bean)
	Cauliflower	0,2355	Proxy for broccoli and romanesco cauliflower
	Cow pea	0,24	Proxy for all small beans (flagolet, mung bean, etc.), peas and legumes, lentils...
	Spinach	0,118	Proxy for lettuce, endives, cress, sorrel, mushrooms (very light food)
	Chile	0,295	Proxy for all sweet peppers
	Pointed gourd	0,447	Proxy for cucumber, melon, watermelon, all fruits and berries, coconut, celery stalk, rhubarb (water rich fruits and vegetables)
	Dried apple	0,24	Proxy for other dried fruits and vegetables : apricot, dates, fig, banana, peach, tomato
	Nuts	0.7	
	Corn	0.8	
	Egg	0.6	
	Others	1	eggs, algae, shellfish
	All	1	Dairy, meat, flours, fish
Processed products (categories 3 and 4)	All	1	Dairy, cheese, meat, flour, fish, tomato sauce ...
Recipes (category 5)	All	1	

Table 28 : Assumptions for product density by category and type of food product

Certain densities have been evaluated by the Centre Technique Agroalimentaire (CTCPA) and are available in the methodological report for processed products (Colombin et al. 2022) .[19]

[19] COLOMBIN Margaux, AUDOYE Pauline, FARRANT Laura, LABAU Marie-Pierre, CTCPA, July 2022. Methodological report for CTCPA AGRIBALYSE® V3.1 processed products: INVENTORIES OF PRODUCTS, PROCESSES AND DATA ON LOSSES AND STORAGE. 79 pages.

- Losses

Losses during distribution and sale in supermarkets are accounted for at the "at retail" supermarket sales stage, in line with the data in Annex 3 of the OEFSR (Quantis et al., 2015)which are shown in the table below.

Product Group (PEF/OEF)	Loss rate at retail
Fruits and vegetables	10%
Meat and meat alternatives	4%
Dairy products	0.5%
Grain products	2%
Oils and fats	1%
Prepared/processed meals (ambiant)	10%
Prepared/processed meals (chilled)	5%
Prepared/processed meals (frozen)	0.6%
Confectionery	5%
Other foods	1%
Coffee and tea	1%
Alcoholic beverages	1%
Other beverages	1%

Table 15 : Retail losses

For losses, each recipe category (category 5) is allocated a PEF category, as detailed in the table below.

Type of food	Sub type	Assigned to PEF category for losses	Corresponding loss at retail (PEF)
Pastries	At bakery or with cream (puffed pastries)	Prepared/processed meals (ambient)	10% (ambient) 5% (chilled) 0.6% (frozen)
	Others (prepacked or not)	Other foods	1%
All soups and broths	Other foods	Other foods	1%
Baby food	Dishes	Prepared/processed meals (ambient)	10% (ambient) 5% (chilled) 0.6% (frozen)
	Milk and dairy products	Dairy products	0.5%
	Others	Other foods	1%

Table 16 : Retail losses - allocation of food recipe

The losses associated with certain products have been adapted in accordance with the recommendations of the CTCPA: for more information, please refer to the associated methodological report .[20]

3.5.1. Distribution

An average distribution centre can store 60,000 m³ of products. The storage period on an annual basis is 52 weeks, or 3,120,000 m³ - weeks/year. The energy requirements per m³ of cooling and freezing by default of the PEF are used to calculate the values used presented in table 31 below. The distribution distance of 450 km is taken from the report ADEME & AFNOR, 2012. The distribution parameters have been adapted for certain products added as the database is updated.

Parameter	Type product	Amount	Unit
Distance to distribution	All products	450	km
Cooling at distribution	Chilled	2,31	kWh/m3
Freezing at distribution	Frozen	6,15	kWh/m3
Energy distribution	Ambient (short)	1,15	kWh/m3
Energy distribution	Ambient (average)	4,62	kWh/m3
Energy distribution	Ambient (long)	8,08	kWh/m3
Energy distribution	Chilled	0,87	kWh/m3
Energy distribution	Frozen	2,31	kWh/m3
Heat distribution	Ambient (short)	13,85	MJ/m3
Heat distribution	Ambient (average)	55,39	MJ/m3
Heat distribution	Ambient (long)	96,92	MJ/m3
Heat distribution	Chilled	10,39	MJ/m3
Heat distribution	Frozen	27,69	MJ/m3
Water use distribution	Ambient (short)	0,47	L/m3
Water use distribution	Ambient (average)	1,87	L/m3
Water use distribution	Ambient (long)	3,28	L/m3
Water use distribution	Chilled	0,35	L/m3
Water use distribution	Frozen	0,94	L/m3
R404 emissions	Chilled	0,000837	kg/m3
R404 emissions	Frozen	0,002231	kg/m3

Table 17 : Overview of default values used for the distribution phase

It was necessary to estimate the density of each CIQUAL element in order to use the PEF default values.

Type of delivery	Storage volume (volume/ product)	Storage time (weeks)	Storage demand (m³ - week)	Lighting (kWh/m3)	Heating (MJ/m3)	Cooling (kWh/m3)	R404a (kg/m3)	Water use (L/m3)
Ambient (average)	4	4	16	4.61	55.38	NA	NA	1.872

[20] COLOMBIN Margaux, AUDOYE Pauline, FARRANT Laura, LABAU Marie-Pierre, CTCPA, July 2022. Methodological report for CTCPA AGRIBALYSE® V3.1 processed products: INVENTORIES OF PRODUCTS, PROCESSES AND DATA ON LOSSES AND STORAGE. 79 pages.

Chilled	3	1	3	0.87	10.38	2.31	0.000837	0.351
Frozen	2	4	8	2.31	27.69	6.15	0.002231	0.936

Table 18 Calculation of energy demand, water consumption and R404a emissions per cubic metre of product for the distribution phase

- Storage at ambient temperature: the duration of storage at ambient temperature may differ depending on the food category. The ambient storage time (short, medium or long) has been defined as follows:

CIQUAL sub-groups	Ambient long (4 weeks at retail and 4 weeks at distribution centre (DC))	Ambient average (1 week at retail and 1 week at DC)	Ambient short (0 week at DC and 3 days at retail)
0101. mixed salads	N/A (=no ambient storage for this group)		
0102. soup	x		
0103. dishes	x		
0104. pizzas, crepes and pies	N/A (=no ambient storage for this group)		
0105. sandwiches	N/A (=no ambient storage for this group)		
0106. savoury pastries and other starters	N/A (=no ambient storage for this group)		
0201. vegetables		x	
0202. potatoes and other tubers		x	
0203. vegetables	x		
0204. fruit		x	
0205. nuts and seeds	x		
0301. pasta, rice and grains	x		
0302. breads and pastries			x
0303. biscuits and breakfast cereals	x		
0304. cakes	x		
0305. flours and pie crusts	x		
0401. cooked meat	N/A (=no ambient storage for this group)		
0402. raw meat	N/A (=no ambient storage for this group)		
0403. delicatessen meat	N/A (=no ambient storage for this group)		
0404. other meat products	N/A (=no ambient storage for this group)		
0405. fish, cooked	N/A (=no ambient storage for this group)		
0406. fish, raw	N/A (=no ambient storage for this group)		
0407. seafood, cooked	N/A (=no ambient storage for this group)		
0408. seafood, raw	N/A (=no ambient storage for this group)		
0409. fish products	x		
041002. eggs raw		x	
041001. eggs cooked and 041003. omelettes	N/A (=no ambient storage for this group)		
0501. milk	x		
0502. dairy products and deserts	N/A (=no ambient storage for this group)		

0503. cheese	N/A (=no ambient storage for this group)		
0504. creams	N/A (=no ambient storage for this group)		
0600. beverages	x		
0601. water	x		
0602. non-alcoholic beverages	x		
0603. alcoholic beverages	x		
0701. sugars and honey	x		
0702. chocolate and chocolate products	x		
0703. non-chocolate confectionery	x		
0704. jams	x		
0801. ice cream	N/A (=no ambient storage for this group)		
0802. sorbet	N/A (=no ambient storage for this group)		
0803. frozen desserts	N/A (=no ambient storage for this group)		
0901. butters	N/A (=no ambient storage for this group)		
0902. vegetable oils	x		
0903. margarines	N/A (=no ambient storage for this group)		
0904. fish oils	x		
0905. other fats	N/A (=no ambient storage for this group)		
1001. sauces	x		
1002. condiments	x		
1003. cooking aids	x		
1004. salts	x		
1005. spices	x		
1006. herbs	x		
1007. seaweed	x		
1008. foods for particular nutritional uses	N/A (=no ambient storage for this group)		
1009. miscellaneous ingredients	x		
1101. baby milk and beverages	x		
1102. baby dishes	x		
1103. baby deserts	x		
1104. baby biscuits and cereals	x		

The losses associated with certain products have been adapted in accordance with the recommendations of the CTCPA: for more information, please refer to the associated methodological report (Colombin et al. 2022) .[21]

Table 19 : Shelf life at ambient temperature by food group

- Food waste at the end of life

[21] COLOMBIN Margaux, AUDOYE Pauline, FARRANT Laura, LABAU Marie-Pierre, CTCPA, July 2022. Methodological report for CTCPA AGRIBALYSE® V3.1 processed products: INVENTORIES OF PRODUCTS, PROCESSES AND DATA ON LOSSES AND STORAGE. 79 pages.

In France, the Garot law (2015) prevents distributors from throwing away food that is no longer fit to be sold but can still be consumed. We assume that this accounts for a significant proportion of food waste during distribution.

We have therefore decided to model end-of-life food losses as follows:

- 50%[22] no impact (food given, no impact)
- 30% incinerated[23] : Biowaste {GLO}| treatment of biowaste, municipal incineration | Cut-off, S - Copied from Ecoinvent U16,6% méthanisation[23] Treatment of biowaste, anaerobic digestion, allocation cut-off on process {RER} U
- 3.4% industrial composting[23] Treatment of biowaste, co-composting biowaste-greenwaste 90-10, allocation cut-off on process {RER} U

For beverages, the product will be disposed of via waste water:

- 100% wastewater : Wastewater, average {FR}| treatment of wastewater, average, wastewater treatment | Cut-off, U - Adapted from Ecoinvent U

3.5.2. Retail (supermarket)

The default energy requirements for cooling and freezing per m3 (according to PEF) are shown in Table 34 and used to calculate the values shown in Table 21 below.

Parameter	Type product	Amount PEF	Unit
Distance to supermarket	All products	50	km
Product losses	All products	See "PEF losses	%
Cooling at supermarket	Chilled	219,23	kWh/m3
Freezing at supermarket	Frozen	415,38	kWh/m3
Energy supermarket	Ambient (short)	30,77	kWh/m3
Energy supermarket	Ambient (average)	123,08	kWh/m3
Energy supermarket	Ambient (long)	269,23	kWh/m3
Energy supermarket	Chilled	46,15	kWh/m3
Energy supermarket	Frozen	61,54	kWh/m3
Water use supermarket	Ambient (short)	140,4	L/m3
Water use supermarket	Ambient (average)	561,5	L/m3
Water use supermarket	Ambient (long)	1228,4	L/m3
Water use supermarket	Chilled	210,6	L/m3
Water use supermarket	Frozen	280,8	L/m3
R404 emissions	Chilled	0,001673	kg/m3
R404 emissions	Frozen	0,002231	kg/m3

Table 20 : Overview of data used for the retail phase

Type of delivery	Storage volume	Storage time (weeks)	Storage demand	Energy (kWh/m3)	Cooling (kWh/m3)	R404a (kg/m3)	Water use (L/m3)

[22] ADEME Video, Fabien Thiébaut, director of supermarket " Intermarché Pleurtuit ", 2019: https://www.youtube.com/watch?v=4_7ssCloDrA&feature=youtu.be&t=49

23 Objectif Zéro Déchet, 2019, https://comerso.fr/wp-content/uploads/2019/02/2019-Etude_Comerso_Ipsos_RetailDistribution_ObjectifZeroDechet.pdf, pp 37 (59% incineration and for the remaining biowaste 63% digesting and 13% composting = when scaling up to 100% 17,1% composting and 82,9% digesting = at the end 30% incineration , 16,6% digesting and 3,4% composting

	(volume/ product)		(m3-week)				
Ambient (average)	4	4	16	123.08	NA	NA	561.5
Chilled	3	2	6	46.15	219.23	0.001673	210.6
Frozen	2	4	8	61.54	415.38	0.002231	280.8

Table 21 : Energy demand and R404a emissions calculated per tonne of product for the retail phase

3.6. Transport along value chain

This table summarises the paragraphs in this chapter; please refer to the corresponding paragraph for further details.

Item transported	Transport stage	Values	Comments
Agricultural raw materials	Field→ Place of manufacture / processing (France)	Calculated using the spreadsheet tool distances_calculations and calculator	Does not apply to fish, dry F&V or MP transported by air.
Fish (French origin)	Port/ Processing plant {FR}→ distribution centre	Transport recorded from port to factory or from port to place of distribution.	
Fish (European origin)	Port/ Processing plant {Europe}→ distribution centre	Distance of 1000 km by refrigerated lorry.	
Fish (from outside Europe)	Port/ Processing plant {Rest of the world}→ distribution centre	Distance of 10,000 km by refrigerated ship.	
Pre-treated ingredients	where the ingredients are pre-treated→ where the recipe is produced	Zero distance	Hypothesis
Ingredient	ingredient processing→ recipe	Zero distance	Hypothesis
All products	Place of manufacture / processing (France)→ distribution centre	450 km	PEF and OEFSR guidelines (Quantis et al., 2015).
All products	Distribution centre→ supermarket	150 km	PEF and OEFSR guidelines (Quantis et al., 2015).
All products	Supermarket→ consumer	Not taken into account	Out of scope

- Transport of raw materials to processing plant / distribution centre (except fish and dried fruit)

➢ Logistics, from agricultural production to processing, are determined according to the country mix. The "DISTAPRO Tool for creating consumption mixes in AGRIBALYSE®[24] " calculates the distances and modes of transport used to create the complete consumption mix for an ingredient.

For some country-crop combinations, more specific transport scenarios are defined, for example for soya from Brazil. We have used data from different sources (depending on the country) to estimate distances and transport modalities for country-crop combinations, according to (Wageningen University, 2013).

The transport model consists of two parts. Firstly, the distance within the country of origin (where the crop/livestock is grown/raised) (1). From there, the crops are then transported to the country where processing takes place (2).

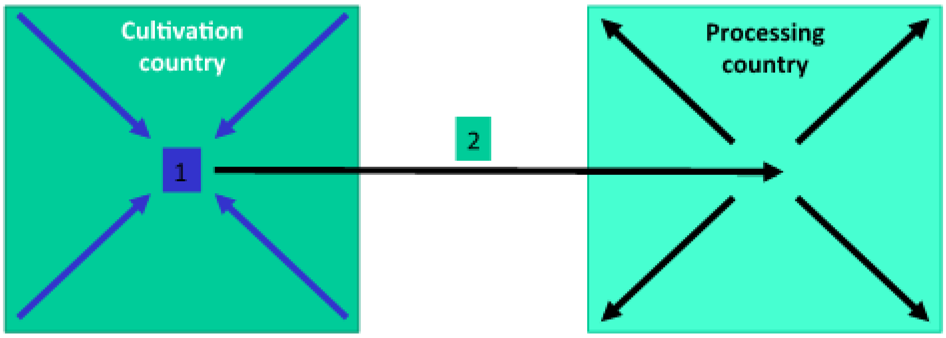


Figure 10 : Generic transport model from a central hub in the country of cultivation to the country where processing takes place.

The data sets for refrigerated vehicles were used according to the type of food product (see table below).

Type of food product	Transportation phase #1: from cultivation areas to central collection hubs	Transportation phase #2: from central collection hubs to processing country (France)	Transportation phase #3: from processing place to retailer
Meat and milk	Refrigerated vehicles	Refrigerated vehicles	Refrigerated vehicles
Fruits, vegetables and cereals	Non-refrigerated vehicles	Refrigerated vehicles	Refrigerated vehicles
Eggs	Non-refrigerated vehicles	Non-refrigerated vehicles	Non-refrigerated vehicles

[24] GIS REVALIM, 2024, "DISTAPRO Tool for creating consumption mixes in AGRIBALYSE®", https://doi.org/10.57745/NLXPDB , Recherche Data Gouv

Table 22 : Data sets for refrigerated vehicles

(1) Transport in the country of origin from the growing area to the collection centre

For national and EU transport, EuroStat (European Commission, 2014) provides detailed statistics on average modes of transport and distances for goods within a country. This data was used as a proxy for the average distance and mode of transport for crops. For the United States, the average distance and type of transport mode are based on the GREET model (Elgowainy et al., 2014).. For non-EU countries, the distances are based on the literature where available or on expert opinion (these distances have often been taken from the Feedprint method) (Vellinga, T.V., Blonk, H., Marinussen, M., van Zeist, W.J., de Boer, 2012).

Cultivation country	Datasets (transport and distance)
From European Union	Eurostat (European Commission, 2014)
From USA	GREET model (Elgowainy et al., 2013)
Others	Literature, expert judgment based on past experience

Table 23: Transport modelling references

(2) Import into France (transport from the country of cultivation to the country of processing)

For simplicity, we assume that the country of transformation is always France. EuroStat transport mix data (European Commission, 2014) is used (modal split). Transport distance is estimated using google maps (the distance between geometric centres).

Specific cases: for green beans from Kenya and mangoes, the mode of transport is by air. We duplicated the bean and mango datasets in AGRIBALYSE®, kept the same CIQUAL code and changed the name:

- *Mango, pulp, raw (Brazil by plane) - CIQUAL Code: 13025)*
- *French bean, raw (Kenya by plane) - CIQUAL Code: 20061)*

- Transport of raw materials : fish

The transport of fish from France is counted from the port to the factory or from the port to the place of distribution. For fish from Europe, a distance of 1,000 km by refrigerated lorry is assumed, and a distance of 10,000 km by refrigerated ship for fish from the rest of the world (RoW).

- Transporting pre-treated ingredients

We have assumed that the distance between the place where the ingredients are pre-treated and the place where the recipe is manufactured is 0 km.

- Transport - from process to acceptance

For food products that are recipes (category 5) using ingredients that are raw materials (category 1) and/or processed raw materials (category 3), we assume that there is no transport between the processing of the ingredients and the recipes.

- Downstream transport - distribution and retailing

Downstream transport includes transport from the place of manufacture to the distribution centres and then from the distribution centres to the supermarkets (see figure below). It does not take into account transport from the supermarket to the consumer (the limit of our study).

All transport distances are aligned with PEF and OEFSR guidelines guidelines (Quantis et al., 2015).. The post-processing stages are located in France. As Ecoinvent datasets are not specific to France, European and Swiss datasets are selected.

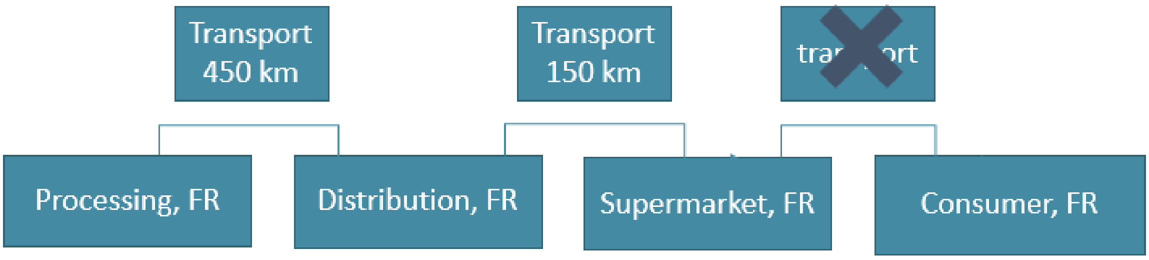


Figure 11 : Downstream transport

- Background LCA data

All modes of transport are integrated into the database using country codes to give a precise distance at each stage.

For air, rail and sea transport, the Ecoinvent database provides global data sets (GLOs). Each is available in a reference version (cooling and freezing), which includes a refrigeration process.

We consider two types of vessel: barges and ocean-going vessels. The barge is specific to transport from Europe to France, while the ocean-going vessel is used for products imported from all over the world.

There are several versions of road transport, depending on the characteristics described in the table below.

Characteristics	Range - options	Value selected	How to
European emission standard	EURO1 to EURO6	EURO5	Norm established in 2009 (715/2007/EC)
Payload	3.5-7.5 tons to >32 tons	Ambient: 16-32 tones Refrigerated: 7.5-16 tons	Average payload applicable to raw material and bulk delivery
Dataset origin	RER or RoW	RER: within Europe RoW: outside of Europe	Applied distance and dataset origin based on the country code of the raw material to be transported
Refrigerant	R-134 or liquid CO_2	R-134 (cooling and freezing)	Commonly used in automotive refrigeration[25]

Table 38 : Choice of characteristics for road transport (Ecoinvent)

The choice of the European emission standard leads to uncertainties for transport abroad. The EURO5 standard has been specific to Europe for some years now. The application of this standard at global level

[25] https://www.agasaustralia.com/media/2526/a-gas_r134a.pdf

is inaccurate, as the evolution of the fleet in no way guarantees the improvements due to this standard. However, road transport from farm to factory or from farm to sea port/airport in a foreign country is no more important than transport distances within Europe.

The origin of the data set concerns only truck transport. Transport by barge and rail only takes place in Europe. The other modes of transport are only available in the GLO version (see table below).

Mode	Storage	Dataset name
Transport (tkm) - truck	Non refrigerated	Transport, freight, lorry 16-32 metric ton, EURO6 {RER}| market for| Cut-off, U
		Transport, freight, lorry 16-32 metric ton, EURO6 {RoW}| market for| Cut-off, U
	Refrigerated (cooling)	Transport, freight, lorry with refrigeration machine, 7.5-16 ton, EURO5, R134a refrigerant, cooling {GLO}| market for| Cut-off, U
	Refrigerated (freezing)	Transport, freight, lorry with refrigeration machine, 7.5-16 ton, EURO5, R134a refrigerant, cooling {GLO}| market for| Cut-off, U
Transport (tkm) - barge	Non refrigerated	Transport, freight, inland waterways, barge {RER}| market for transport, freight, inland waterways, barge | Cut-off, U
	Refrigerated (cooling)	Transport, freight, inland waterways, barge with reefer, cooling {GLO}| market for | Cut-off, U
	Refrigerated (freezing)	Transport, freight, inland waterways, barge with reefer, freezing {GLO}| market for | Cut-off, U
Transport (tkm) - aircraft	Non refrigerated	Transport, freight, aircraft {GLO}| market for | Cut-off, U
	Refrigerated (cooling)	Transport, freight, aircraft with reefer, cooling {GLO}| market for | Cut-off, U
	Refrigerated (freezng)	Transport, freight, aircraft with reefer, freezing {GLO}| market for | Cut-off, U
Transport (tkm) - train	Non refrigerated	Transport, freight train {RER}| market group for transport, freight train | Cut-off, U
	Refrigerated (cooling)	Transport, freight, train with reefer, cooling {GLO}| market for | Cut-off, U
	Refrigerated (freezing)	Transport, freight, train with reefer, freezing {GLO}| market for | Cut-off, U
Transport (tkm) - ocean ship	Non refrigerated	Transport, freight, sea, transoceanic ship {GLO}| market for | Cut-off, U
	Refrigerated (cooling)	Transport, freight, sea, transoceanic ship with reefer, cooling {GLO}| market for | Cut-off, U
	Refrigerated (freezing)	Transport, freight, sea, transoceanic ship with reefer, cooling {GLO}| market for | Cut-off, U

Table 24 : Transport data sets for distribution and retail sales

3.7.Use phase

Avoidable food losses at the consumer level (at home) **are not taken into account.**

All items refrigerated or frozen during transport are considered to be stored in the consumer's refrigerator or freezer respectively.

Food preparation methods and product characteristics (inedible parts and raw/cooked ratios) are applied at the consumption stage. It is also at this stage that the end-of-life of packaging takes place. The disposal scenario depends on the type of packaging. Food preparation at the consumer level is modelled according to default data modelled by Blonk Consultants for preparation/cooking scenarios defined by product. The type of preparation is based on the most common practices for each type of food.

- Definition of preparation scenarios by product:

For the recipe, we have chosen minimal preparation (only reheating) during the use phase, as the recipes are already cooked at the factory.

Food Category	Precision in the CIQUAL name	Preparation at consumer

RAW FOOD ITEMS (e.g: apple, raw)	"raw, dried	No Preparation
BEVERAGES		Chilled at consumer (even if not chilled during transport and storage at retail and supermarket)
MEAT	"cooked" or "grilled	Pan-frying
	"boiled	Boiling
	braised	Oven
VEGETABLES AND LEGUMES	"baked, roasted	Oven
	Boiled	Boiling
	"cooked", "steamed	Pressure cooker (approached by water cooker)
	"deep-fried	Deep-frying
	"pan-frying	Pan-frying
	"canned	Microwave
	"puree	Microwave
COFFEE AND TEA		Water cooker
CEREAL AND GRAIN PRODUCTS	"precooked	Pressure cooker (approached by water cooker)
	"cooked"	Boiling
EGG	"cooked"	Pan-frying
OIL AND FATS		No preparation
RECIPES	Dehydrated products (e.g: dehydrated soup, baby milk powder, cocoa)	Water cooker
	Cooked vegetables and purees (e.g: carrot, cooked)	Microwave
	Prepared cooked meals (e.g: cheese tart),	Oven
	Cooked meat, fish, egg (e.g: sausage, cooked)	Oven
	Sauces	Microwave

	Cooked pasta	Microwave

Table 25 : Overview of product preparation scenarios at the consumer stage

Inedible losses at the end of consumer life are modelled as follows :[26]

- 73.6% incinerated : Biowaste {GLO}| treatment of biowaste, municipal incineration | Cut-off, S
- 26.4% landfill: Municipal solid waste {GLO}| treatment of municipal solid waste, unsanitary landfill, wet infiltration class (500mm) | Cut-off, U

For sterilised products, water is eliminated via waste water:

- 100% wastewater : Wastewater, average {FR}| treatment of wastewater, average, wastewater treatment | Cut-off, U - Adapted from Ecoinvent U

- Energy for cooking

The energy required for cooking is determined by several factors, such as :

- The type of preparation, nine preparation techniques are taken into account (table 40),
- The mass of food (and water) used in the preparation,
- The proportion of electricity and natural gas used for energy consumption.

For certain types of food preparation, such as frying or microwaving, we have assumed the use of 100% electricity. For other types of preparation, we have used a ratio of 40% and 60% for electricity and natural gas respectively. (ADEME & AFNOR, 2012).

Technical preparation	Electricity (kWh/kg)	Natural gas (MJ/kg)	Oil	Water
Deep frying	0.667 *(default value)*	n/a	Yes 0,005kg sunflower oil	-
Pan frying	(40%) *Refer to Table 41 for cooking times*	(60%)	Yes 0,005kg sunflower oil	-
Boiling	(40%) *Refer to Table 42 for cooking times*	(60%)	-	Yes
Water cooker	0.127 *(default value)*	n/a	-	Yes
Oven	3000 W * time (default = 20 mn)	n/a		
Microwave	1100 W * time (default = 7 mn)[27]	n/a	-	-

[26] ADEME 2019, Résultats de la Campagne nationale de caractérisation des déchets ménagers et assimilés de 2017 (Results of the 2017 national campaign to characterise household and similar waste)

[27] This amount seems high with regard to what one usually heats in microwave but makes sense for 1kg of food.

Chilled at consumer	0.0777 0.0111 *(for bottled water)* 0 *(for tap water)*	n/a	-	-
Freezing at consumer	0.294	n/a	-	-
No preparation	-	-	-	-

N.B.: pressure cooking is similar to water cooking.

Table 26 : Overview of preparation techniques and quantity of inputs per kg of inputs

Product category	Baking time low heat (600 W)	Baking time high heat (3500 W)
Meat and fish	4 min	7 min
Fruits and vegetables	3 min	7 min
Grain products	8 min	0 min
Other foods	8 min	0 min

(e.g. meat cooked for 4 minutes over a low heat, 600W, and for 7 minutes over a high heat, 3500W).

Table 27 : Low and high heat cooking times for "pan-fried" preparations

Product category	Boiling time	Added water (L/kg)
Meat and fish	120 min	0.2
Fruits and vegetables	11 min	0.7
Grain products	15 min	1.5
Other foods	5 min	5

Table 28 : Boiling times and water added per kg of product for "boiling" preparations

Beverage	Input (kg/kg)	Water added	How to
Coffee, coffee drink, café americano, instant coffee, liquid	0.05833	1.10	Based on PEF data (7g/120 ml)
Tea, black tea, fruit tea, infusion	0.01	1	
Soup	0,05527	0,945	Based on a recipe description
Dehydrated potato flakes	0.14	0.57 water + 0.29 milk Gold 0.83 milk + 0.03 butter	Depending on the CIQUAL product, only milk or milk and butter are added

Table 29 : Inputs and water added for prepared drinks by consumers

Two data sets are used to model the energy required to prepare food for the consumer:

- Electricity: Electricity, low voltage {FR}| market for | Cut-off, U ;
- Thermal energy : Heat, central or small-scale, natural gas {Europe without Switzerland}| market for heat, central or small-scale, natural gas | Cut-off, U .

4. Data quality rating (DQR)

AGRIBALYSE® is a complex database, covering a wide range of food products and using different databases. In addition, proxies and dummies are used. As a result, the Data Quality Rating (DQR) system plays a crucial role. A bespoke system has been developed to apply the DQR consistently across the database. The DQR is in line with the PEF approach, while being adapted to our field of application.

On the one hand, the DQR system developed attempts to take account of this complexity and heterogeneity. On the other hand, it has technical limitations and limitations due to possible subjective interpretation when scoring. These limitations will be clearly explained in this chapter and in the following sub-chapters.

Taking into account the DQR is crucial to the correct use of the data. DQRs >3 should be treated with great caution as they do not allow for accurate comparison. They should only be used as 'background systems', or adjusted to better suit the user's situation.

This Data Quality Rating (DQR) in AGB 3.1 is inspired by the PEFCR guidelines ((European Commission, 2016) ch.7.19). Four data quality indicators (DQIs) are considered for measuring the DQR:

- Precision (P)
- Temporal representativeness (TiR)
- Geographical representation (GR)
- Technological representativeness (TeR)

The 4 IQDs are assessed for the most important stages in the life cycle (from cradle to grave). In general, 7 main stages in the life cycle are identified (Figure 12) :

1. Production of raw materials from cradle to market mix
2. Transformation of raw materials
3. Mixture of processed ingredients (recipe production)
4. Packaging
5. Distribution
6. Supermarket sales
7. Preparation and consumption.

These 4 IQDs are assigned to each stage of the life cycle and take account of specific characteristics (table 44).

Some specific inputs (e.g. transport) and parameters (allocation factors and mass change ratios such as raw/cooked) are considered separately (see Figure 12), and the 4 IQRs are evaluated specifically for these inputs. In addition, the use of proxies implies penalties on the IQDs. In total, 18 different criteria (life cycle stages, parameters and additional inputs) are evaluated (Figure 12).

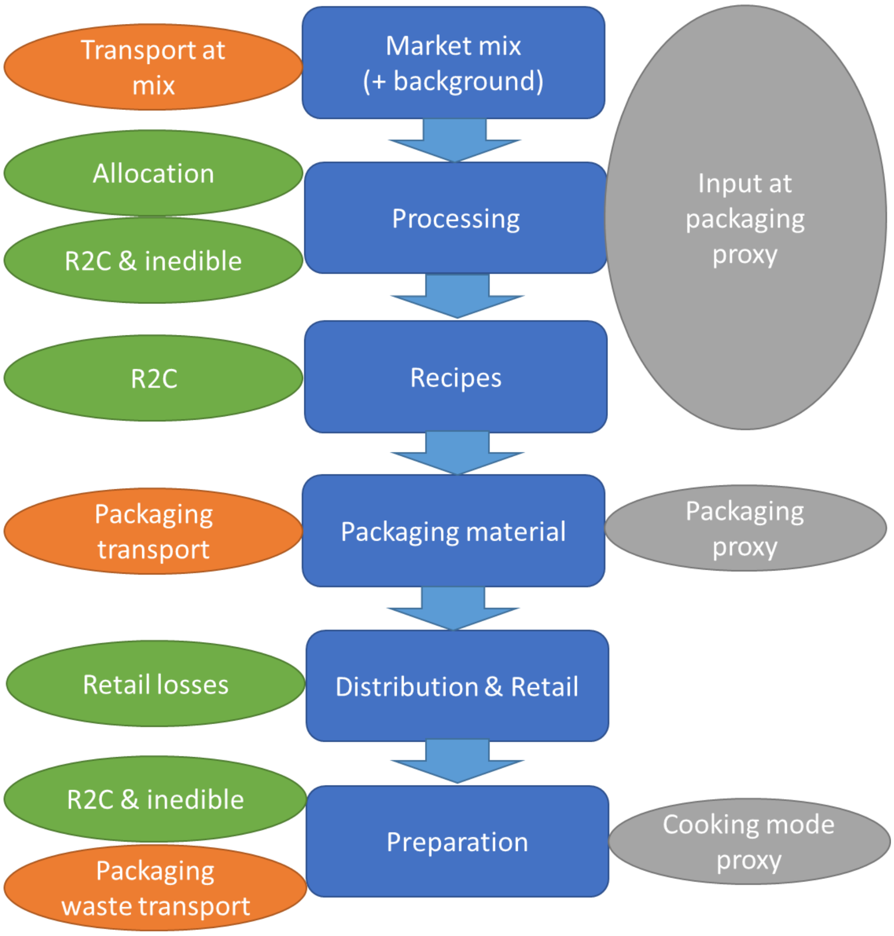


Figure 12 : View of the 18 criteria used to calculate the DQR : main stages in the life cycle (blue boxes), additional parameters (green boxes), transport (orange boxes) and penalty criteria (grey boxes).

These 18 assessments are merged into a final DQR score using a weighted average. The weighting factors (or Weighting Factor WF) are estimated on the basis of an analysis of the contribution[28] of the impact of each of the 15 stages on the overall impact. The process for calculating the final product DQR is summarised in the figure below:

[28] For timing reasons, the contribution analysis is based on the "ILCD 2011 Midpoint+ (adjusted for biogenic CO2)" indicators, then converted into a single score according to the PEFCR guidelines guidelines (European Commission, 2016). In the future, contribution analysis will have to be carried out directly on the basis of PEF indicators instead of ILCD.

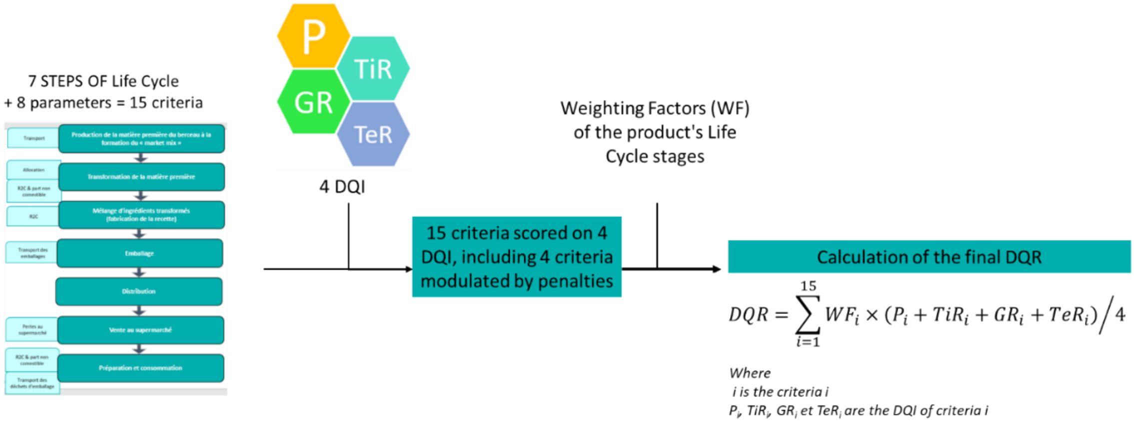


Figure 13 : Process for calculating the final product DQR

In previous versions of AGRIBALYSE® (3.0, 3.1 and 3.1.1), WFs were defined at product group level rather than product level. The 2517 food products in AGRIBALYSE® 31 were divided into 21 food category groups. For each group, a representative product was selected and a contribution analysis carried out. The calculated WFs were then used for all the products in the same group. The representative product was selected on the basis of the completeness of its data sets (for example, a product that does not use a proxy or dummy). Using WFs for grouped categories instead of product-specific WFs led to a degree of uncertainty in the DQR system.

Starting with AGRIBALYSE® 3.2, the WFs specific to each product are calculated in order to have a more accurate weighting of the IQDs within the product life cycle.

The Table 30 shows an example where the final RDI is calculated from the WFs and IQDs of each of the 15 stages. The example is based on the product "Chicken burger, fast foods restaurant (H)". The WFs shown in the first row are based on the "sandwiches" category group (cf. Table 31 calculation of the WF for the representative product: "Baguette sandwich, chicken, raw vegetables (lettuce and tomato) and mayonnaise (H)"). The IQDs indicated on lines 2 to 5 are evaluated for each of the 14 stages, on the basis of the "WF". **Erreur ! Source du renvoi introuvable.**. For each DQI, a weighted average (based on the W F) is calculated in lines 6 to 9. The results of the weighted average are shown in the last column (lines 6 to 9). The average of the four overall DQIs gives the final overall DQR (line 10).

N°	Sandwiches category group	Mix	Transport mix	Process	Process alloc.	R2C & inedible process	Recipe	Recipe R2C	Packaging material	Packaging transport (PEF)	Distribution (PEF)	Retail (PEF)	Retail losses	Preparation transport (PEF)	Preparation cooking mode	Preparat R2C allocatio
1	WF	19%	0.2%	0%	1%	72%	1%	3%	1%	0.2%	0,5%	0%	1%	0%	1%	0%
2	P	1	3	3	0	3	2	3	1	2	2	2	2	2	3	3
3	TiR	5	3	3	0	3	1	3	5	2	2	2	2	2	3	3
4	GR	2	3	3	0	1	1	1	3	2	2	2	2	2	3	1
5	TeR	1	3	4	0	5	4	5	3	2	2	2	2	2	3	5
6	WF*P	0.22	0.01	0.192	0	0.63	0.36	0.21	0.04	0.00	0.08	0.19	0.09	0.00	0.09	0.00
7	WF*TiR	1.11	0.01	0.192	0	0.63	0.18	0.21	0.18	0.00	0.08	0.19	0.09	0.00	0.09	0.00
8	WF*GR	0.44	0.01	0.192	0	0.21	0.18	0.07	0.11	0.00	0.08	0.19	0.09	0.00	0.09	0.00
9	WF*TeR	0.22	0.01	0.256	0	1.06	0.73	0.34	0.11	0.00	0.08	0.19	0.09	0.00	0.09	0.00
10	Average Final DQR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 30 : Example of an RQD calculation for the product "Chicken burger , fast foods restaurant (H)" (CIQUAL : 25502).

Life cycle internship	Precision (P)		Time representativeness (TiR)		Technological representativeness (TeR)		Geographical representativeness (GR)	
Market mix	Coverage % of the market mix is >85% & origin is industry data	1	Data no older than 3 years	1	Production datasets corresponding to exact product and practices to those included in the scope of the dataset	1	Data are based on FR trade statistics, no proxies are used	1
	Coverage % of the market mix is >85% & origin is statistics or Coverage % of the market mix is >70% & origin is industry data	2	Data between 3 and 5 years old	2	Production datasets corresponding to similar product and practices to those included in the scope of the dataset, with small change in yield	2	Data are partially based on FR trade statistics, proxies used are from the same region (EU)	2
	Coverage % of the market mix is >70% & origin is statistics or Coverage % of the market mix	3	Data between 5 and 7 years old	3	Production datasets corresponding to similar product to that included in	3	Data are partially based on FR trade statistics, proxies used	3

	is between 50% and 70% & origin is industry data				the scope of the dataset, different practices but small change in yield		are not from the same region (non-EU)	
	Coverage % of the market mix is between 50% and 70% & origin is statistics	4	Data between 7 and 10 years old	4	Production datasets are proxies - change in yield max 30%	4	Data are not based on FR trade statistics, proxies used are from the same region (EU)	4
	Coverage % of the market mix <50% or use of market mix of proxy product	5	Data older than 10 years	5	Production dataset are proxies - change in yield >30% or unknown	5	Data are not based on FR trade statistics, , proxies used are not from the same region (non-EU)	5
Transportation at mix	Data on transportation are measured/ calculated/literature and externally verified	1	Data no older than 3 years	1	Transport modalities, emission level, distance and cooling are based on exactly the same technologies	1	Data are based on FR production, no proxies are used	1
	Data on transportation are measured/ calculated/literature and internally verified	2	Data between 3 and 5 years old	2	Transport modalities, emission level, distance and cooling are based on a mix of technologies represented in the scope of the dataset	2	Data are based on EU production	2
	Data on transportation are measured/ calculated/ literature and not verified	3	Data between 5 and 7 years old	3	Transport modalities, emission level, distance and cooling are similar to the scope of the dataset, with proxies involved	3	Data are based on EU country production	3
	Data on transportation are estimated and not verified	4	Data between 7 and 10 years old	4	Transport modalities, emission level, distance and cooling are different to the scope of the dataset	4	Data are based on non-EU country production , but there are sufficient similarities based on expert judgement	4
	Data on transportation are neglected (dummy)	5	Data older than 10 years	5	Transport modalities, emission level, distance and cooling are based on unknown technologies	5	Data are based on non-EU country production	5
Processing	Data on mass balance, energy and water inputs are measured/	1	Data no older than 3 years	1	Process is exactly the same as the process in scope & the input product is the one	1	Data are based on FR production, no proxies are used	1

	calculated/literature and externally verified				required for the output in scope for the dataset			
	Data on mass balance, energy and water inputs are measured/calculated/literature and internally verified	2	Data between 3 and 5 years old	2	The technology used is included in the mix of technologies in scope of the dataset & the input product is the one required for the output in scope for the dataset OR Process is exactly the same as the process in scope & the input product is a proxy	2	Data are based on EU production	2
	Data on mass balance, energy and water inputs are measured/ calculated/ literature and not verified	3	Data between 5 and 7 years old	3	The technology used is included in the mix of technologies in scope of the dataset & the input product is a proxy	3	Data are based on EU country production	3
	Data on mass balance, energy and water inputs are estimated and not verified	4	Data between 7 and 10 years old	4	Process is a proxy with similar technology to those included in the scope of the dataset (expert judgement)	4	Data are based on non-EU country production , but there are sufficient similarities based on expert judgement	4
	Data on mass balance, energy and water inputs are neglected (dummy)	5	Data older than 10 years	5	Process is a proxy with different technology to those included in the scope of the dataset (expert judgement)	5	Data are based on non-EU country production	5
Allocation factor	Data on prices are based on exact product in scope for the dataset	1	Data no older than 3 years	1	Data on prices are based on exact technology in scope for the dataset	1	Allocation is based on FR prices, no proxies are used	1
	Data on prices are based on similar product in scope for the dataset (same crop group)	2	Data between 3 and 5 years old	2	Data on prices are based on similar technology in scope for the dataset (e.g. grinding proxy for milling	2	Allocation is based on EU prices averages	2

	Data on prices are based on different product in scope for the dataset, but there are sufficient similarities based on expert judgement	3	Data between 5 and 7 years old	3	Data on prices are based on different technology in scope for the dataset, but there are sufficient similarities based on expert judgement	3	Allocation is based on EU country prices	3
	Data on prices are based on different product in scope for the dataset	4	Data between 7 and 10 years old	4	Data on prices are based on different technology in scope for the dataset	4	Allocation is based on non-EU country production , but there are sufficient similarities based on expert judgement	4
	One of the co-products is treated with a cut-off approach (no allocation due to lack of data)	5	Data older than 10 years	5	One of the co-products is treated with a cut-off approach (no allocation due to lack of data)	5	Allocation is based on non-EU country prices	5
Assembling ingredients recipes	Coverage % of the recipe mix is >=95%.	1	Data no older than 3 years	1	An industrial recipe & exact ingredients are used	1	Recipe is based on FR market, no proxies are used	1
	Coverage % of the recipe mix is >80%.	2	Data between 3 and 5 years old	2	A home-made recipe & exact ingredients are used	2	Recipe is based on EU market	2
	Coverage % of the recipe mix is between 70% and 80%.	3	Data between 5 and 7 years old	3	An industrial recipe & proxy ingredients are used leading to realistic results according to expert judgement	3	Recipe is based on an EU country market	3
	Coverage % of the recipe mix is between 70% and 80%.	4	Data between 7 and 10 years old	4	A home-made recipe & proxy ingredients are used leading to realistic results according to expert judgement	4	Recipe is based on a non-EU country , but there are sufficient similarities based on expert judgement	4
	Coverage % of the recipe mix <50	5	Data older than 10 years	5	Proxy ingredients are used leading to unrealistic results according to expert judgement	5	Recipe is based on a non-EU country	5
Packaging								

	For the packaging stage, please refer to the table below specific to this stage							
Distribution and retail, transport at packaging and losses at retail (PEF	Data are measured and externally verified, and data are based on exact product	1	Data no older than 3 years	1	The technology concerning the distribution, retail or transport is exactly the same as the one in scope of the dataset	1	Data are based on FR market, no proxies are used	1
	Data are measured and externally verified, and data are not based on exact product but on product categories	2	Data between 3 and 5 years old	2	The technology concerning the distribution, retail or transport is included in the mix of technologies in scope of the dataset	2	Data are based on EU	2
	Data are measured or ext verified, and data are based on exact product	3	Data between 5 and 7 years old	3	The technology concerning the distribution, retail or transport are only partly included in or are similar to the scope of the dataset	3	Data are based on EU country market	3
	Data are measured or ext verified, and data are based on product categories	4	Data between 7 and 10 years old	4	The technology concerning the distribution, retail or transport are different from those included in the scope of the dataset, good proxy according to expert judgement	4	Data are based on a non-EU country, but there are sufficient similarities based on expert judgement	4

	Data are estimated and not verified externally and based on exact product or category product	5	Data older than 10 years	5	The technology concerning the distribution, retail or transport are different from those included in the scope of the dataset, bad proxy according to expert judgement / double counting of packaging	5	Data are based on a non-EU country	5
Preparation	data on storage and preparation are measured/ calculated/literature and externally verified	1	Data no older than 3 years	1	Data on storage and preparation are exactly the same as those in scope & the products are exactly those required for the dataset	1	The process modelled takes place in FR, no proxies are used	1
	data on storage and preparation are measured/calculated/literature and internally verified	2	D.V. Data between 3 and 5 years old	2	Data on storage and preparation are based on similar technology as those in scope & products are exactly those required for the dataset OR Data on storage and preparation are exactly the same as those in scope & the products are proxies	2	The process modelled takes place in EU	2
	Data on storage and preparation are measured/ calculated/ literature and not verified	3	Data between 5 and 7 years old	3	Data on storage and preparation are based on similar technology and products to those in scope for the dataset and involve the use of proxy	3	The process modelled takes place in an EU country	3
	data on storage and preparation are estimated and not verified	4	Data between 7 and 10 years old	4	Data on storage and preparation are based on similar technology to those included in the scope of the dataset (expert judgement)	4	The process modelled takes place in a non-EU country, but there are sufficient similarities based on expert judgement	4
	data on storage and preparation are neglected (dummy)	5	Data older than 10 years	5	Data on storage and preparation are based on are proxies with different technology to those included	5	The process modelled takes place in a non-EU country	5

					in the scope of the dataset (expert judgement)			
Raw to cooked ratio and inedible losses	Data are based on exact product in scope for the dataset And measured/ calculated/literature and externally verified	1	Data no older than 3 years	1	Data on R2C and inedible losses are based on exactly the same technologies	1	Data are based on FR	1
	Data are based on exact product in scope for the dataset And measured/ calculated/literature and internally verified	2	Data between 3 and 5 years old	2	Data on R2C and inedible losses are based on a mix of technologies represented in the scope of the dataset	2	Data are based on EU	2
	Data are based on similar product in scope for the dataset	3	Data between 5 and 7 years old	3	Data on R2C and inedible losses are based on similar technologies	3	Data are based on EU country market	3
	Data are based on different product in scope for the dataset, but there are sufficient similarities based on expert judgement	4	Data between 7 and 10 years old	4	Data on R2C and inedible losses are based on different technologies	4	Data are based on a non-EU country, but there are sufficient similarities based on expert judgement	4
	Data are based on different product in scope for the dataset , bad proxy	5	Data older than 10 years	5	Data on R2C and inedible losses are based on unknown technologies	5	Data are based on a non-EU country	5

Life cycle stage	Precision (P)				Time representativeness (TiR)		Technological representativeness (TeR)		Geographical representativeness (GR)	
	Choix P - matériaux = 50% note précision	0	Choix P - procédés = 50% note précision		Choix TiR	0	Choix Processing/TeR	0	Choix Packaging /GR	0
	Data are represented by correct inventories	1	Le périmètre couvre les procédés de finition et transformation	1	Data no older than 3 years	1	Process is exactly the same as the process in scope (process + mix géo) *Procédés crées par IPC + mix adaptés FR/RER*	1	Material dataset is based on FR data, no proxies are used	1
			Le périmètre couvre tous les procédés de transformation et une partie des procédés de finition	2	Data between 3 and 5 years old	2	The technology used is included in the mix of technologies in scope of the dataset *Ecoinvent ou eco-emballages clé en main mais qui correspondent aux procédés à représenter*	2	Material dataset is based on EU data (RER)	2
Packaging	Data is represented by a good proxy	3	Le périmètre couvre tous les procédés de transformation et aucun procédé de finition **ou** une partie des procédés de transformation et une partie des procédés de finition	3	Data between 5 and 7 years old	3	Process is a proxy with similar technology to those included in the scope of the dataset (expert judgement) *Proxy : pas exactement le bon procédé mais dans la même famille*	3	Material dataset is based on EU country market data	3
					Data between 7 and 10 years old	4	Process is a proxy with different technology to those included in the scope of the dataset (expert judgement) *Proxy procédé famille différente*	4	Material dataset is based on non-EU country data, but there are sufficient similarities based on expert judgement	4
	Data is represented by a bad proxy	5	Le périmètre couvre une partie des procédés de transformation et aucun procédé de finition	5	Data older than 10 years	5	Process is a dummy dataset	5	Material dataset is based on non-EU country data	5

4

Lifecycle stages and additional parameters

In this section, we analyse the life cycle chain step by step, from cradle to consumer. The life cycle stages, additional parameters and penalties applied are explained. We also describe how to allocate IQDs to these 15 stages.

The first life cycle covers the formation of the market mix and the production of raw materials. For example, in the apple production chain, the first stage of the life cycle includes not only the mix of apples from various regions of the world, but also the crops and all the inputs linked to these systems. This is why rating this stage of the life cycle is particularly important and open to subjective interpretation. Such simplification was necessary because of the different databases involved in AGRIBALYSE®. The particular structure of these databases makes it impossible to identify generic life cycle stages for the DQR system. The indicators of precision (P) and geographical representativeness (GR) refer to the coverage of the market mix and the origin of the commercial data. The temporal representativeness (TiR) and technological representativeness (TeR) indicators refer to the production of raw materials from background databases.

Where the market mix is not explicitly indicated, but a raw material is used directly in processes or recipes, the manufacturing process of the raw material is noted to give a quality index of both the production of the raw material and the representativeness of the consumption mix. For example, many beef products make direct use of a set of background data from the ACYVIA database, without the intermediate formation of a consumer mix. This process is based on French production systems, but in reality, beef from other countries is also consumed in France (around 25% according to statistics). Consequently, the precision (P) takes this aspect into account, even if a market mix is not explicitly modelled (P=3, the % coverage of the consumption mix is >70% & the origin of the data is statistical, see table 46).

In the database, transport requirements at market mix level are generated from the same source and with the same background processes. As a result, transport quality at market mix level is assessed separately, and the same IQRs are given.

The transformation phase is assessed on the basis of the data used for energy consumption, the use of auxiliary materials and the use of proxies. The use of dummies at this stage is penalised (+1 in P and TeR).

During processing, mass change factors such as inedible losses or raw/cooked ratios (R2C) are considered separately and the 4 IQRs are indicated. For example, drying an apple divides the mass by 8.4. This is a significant change, which has a major influence on the final impact. The 4 IQRs are attributed to this raw/cooked factor on the basis of the **Erreur ! Source du renvoi introuvable.**. As all R2Cs and inedible l osses are based on the same source, the same IQRs are always allocated.

The quality of the allocation factor at the processing stage is also taken into account separately. For example, prices are used in flour processing to estimate the value of the two co-products: flour and bran. These prices are evaluated for the four IQDs on the basis of Table 46. In this example, given that the same allocation factors (based on wheat) are used for all types of flour, the precision (P) and technological representativeness (TeR) indicators for wheat will be lower (higher quality) than those for other cereals.

The recipe life cycle stage focuses mainly on data relating to recipe preparation and energy use (Table 46). The quality of mass change factors (raw/cooked ratio) is also considered separately at the recipe stage, in the same way as for the processing stage (above).

The IQRs at packaging level are assigned according to the characteristics of the packaging material. Transport of packaging material, again based on the same source (European Commission, 2016) and considered separately, is still scored with the same IQRs (Table 46).

In some cases, the same recipe or transformation process is used for different packaged food products. This involves the use of proxies. To take account of this, foods "at the packaging stage" which are then used as inputs in recipes as proxies are identified. A penalty is given to the IQDs (+1 in P and TeR in the case of a good proxy) which is similar to that of the real dataset in terms of scope, +2 in P and TeR in the case of a poor proxy. For example, "Apple compote, at plant (AGRIBALYSE® 3) /FR U", a processed product, is used in various packaged products. When it is used by "Apple compote", no penalty is applied. When it is used as an input for the product "Petit pot fruit sans banane pour bébé", the food is considered to be a proxy similar to the product in question. When used as an input for the product "Baby food jar with banana", the maximum penalty is applied. The use of approximations at this stage is a significant element in the modelling, so this penalty is crucial.

The choice of packaging type also involves the use of proxies. This results in a penalty for the DQI of the packaging (+0.5 in P and TeR in the case of an approximation similar to a real dataset). For example, the use of a PET bottle for tonic drinks can be considered a good approximation for this dataset, since most tonic drinks in France are sold in plastic bottles (and only a minority in cans). For energy drinks, the situation is different: as the vast majority of energy drinks are in cans, the use of PET bottles is a poor proxy. Only products whose packaging stage has a WF greater than 12.5% are taken into account for this final analysis and packaging penalty. This threshold has been defined in order to select an appropriate number of products for detailed analysis.

The distribution stage, the retail stage and the transport of consumer-generated waste are based on data from the same source (European Commission, 2016), which is why the same IQD is assigned to all products (Table 46).

The quality of mass change factors at retail (mass losses) and at consumption (R2C and inedible factors) is considered separately, in the same way as the processing and recipe stages.

The type of preparation at the consumer's home is often a proxy, which is why a penalty system is provided (+0.5 in P and TeR in the case of a proxy whose scope is similar to that of the actual dataset, +1 in P and TeR in the case of a proxy whose scope is not similar to that of the dataset). Only the group of categories in which the preparation step has a weighting factor greater than 12.5% is taken into account for the preparation penalty.

Calculation of weighting factors (WF).

As explained above, for each stage of the life cycle and each additional parameter (e.g. allocation and R2C), a weighting factor is given in order to calculate the RDI of the final product. The weighting factors are based on an analysis of contributions.

The Table 31 shows how the WFs are calculated for a product (here "French bread sandwich, chicken, raw vegetables (lettuce and tomato) and mayonnaise" CIQUAL: 25476). These WFs will be applied to all products, with a recalculation on the basis of 100 when stages are missing from the life cycle of the product in question.

Life stages processes as exported from the database	Single score (mPt/kg)	Life stages + additional parameters	Additional parameter (OUT/IN)	Formula	Single score Contribution	WF
		Total		64.55+0.86	65.41	100%
Sandwich made with French bread, chicken, raw vegetables.../at preparation	64.55	Preparation		64.55-63.93-0-0	0.62	0.9%
		R2C/inedible at preparation	1	63.93*(1-1)/1	0	0%
		Transportation at preparation		-	0.00	0.0%
Sandwich made with French bread, chicken, raw vegetables.../at retail	63.93	Retail		63.93-58.56-3.08	2.29	3.5%
		Losses at retail	ParameterLosses=0.95	58.56*(1-ParameterLosses)/ ParameterLosses	3.08	4.7%
Sandwich made with French bread, chicken, raw vegetables.../at distribution	58.56	Distribution		58.56-55.85	2.71	4.1%
Sandwich made with French bread, chicken, raw vegetables.../at packaging	55.85	Packaging		55.85-54.24-0.05	1.56	2.4%
		Transportation at packaging		-	0.05	0.1%
Sandwich made with French bread, chicken, raw vegetables.../at recipe	54.24	Recipe		54.24-33.12-4.82	16.30	24.9%

		R2C/inedible at recipe	R2C=0.91	48.64b*(1-R2C)/R2C	4.82	7.4%
Meat without bone, chicken/at processing	33.12 a	Process		33.12-15.07-13.86	4.19	6.4%
		R2C/inedible at processing	Inedible= 0.5	15.07*(Alloc-Inedible)/Inedible	13.86	21.2%
		Allocation at processing	Alloc = 0.96 Massoutput = 0.62 is the mass output ratio of the allocated product (0.62 kg meat/kg of broiler).	33.12*Massoutput*(1-Alloc)/Alloc	0.86	1.3%
Broiler, live, for processing/at mix	15.07 a	Mix		15.07-0.31	14.76	22.6%
		Transport at mix		-	0.31	0.5%

Table 31 : Example of calculation of weighting factors (WF) for a group of sandwich categories, based on the representative product "French bread sandwich, chicken, raw vegetables (lettuce and tomato) and mayonnaise" (CIQUAL: 25476).

[a]Impact of meat and broiler (mPt/kg) is multiplied by 0.36, the amount (kg) of meat actually entering the recipe.
[b] 48.64 mPt is the sum of single score impact the various ingredients entering the recipe.

For each stage in the life cycle, calculating its contribution is straightforward. For example, during distribution, the contribution to the impact is due to the various energy inputs (light and heating), transport and water use. As explained above, in some cases, transport is considered separately. Consequently, the contribution of transport to the final impact is extrapolated and a separate WF is assigned.

An important choice is made at the recipe stage. A single main ingredient is selected to identify the upstream stages of the life cycle. This means that the previous life cycle of other ingredients (for example, the salt used in sausages) is not taken into account. Instead, the impact of these ingredients is attributed to the recipe stage when calculating the WF. This simplification was necessary because of the complexity of the recipe formulation (up to 10 different ingredients). The identification of the most significant contribution is based on a contribution analysis using the ILCD single score method, corrected for negative emissions due to carbon absorption, as explained above. For example, in the case of "Asian soup, with pasta, dehydrated reconstituted", six different ingredients are mixed and cooked. The main ingredient contributing to the recipe is shrimp fillet (67% of the recipe's impact), which is why the previous stages of its life cycle are considered representative for this recipe. For the future, it should be considered a priority to upgrade the DQR system to include the life cycle stages of all ingredients used in the recipe.

The contribution of the mass change and allocation parameter is more complicated to calculate. This is because the analysis of contributions carried out in SimaPro makes it possible to extend the impact of mass change to earlier stages in the life cycle. A specific equation has been developed to calculate these contributions. The impact of raw/cooked ratios and inedible losses (always expressed as OUTPUT/INPUT ratios) is calculated as follows:

$$I_{parameter} = I_{input} * (1 - parameter)/parameter$$

Where:

- $I_{parameter}$ is the impact (single ILCD score) due to the mass change parameter ;
- I_{input} is the impact (single ILCD score) of the main material input, the one affected by the change in mass;
- $parameter$ is the parameter that changes en masse. It is always expressed as a ratio between inputs and outputs. It may be mass losses (e.g. during retailing and distribution), the raw/cooked ratio (e.g. during preparation at the consumer's premises) or inedible losses (e.g. in an industrial peeling plant).

In the case of benefits :

$$I_{allocation} = I_{output} * Mass * (1 - allocation)/allocation$$

Where:

- $I_{allocation}$ is the impact (single ILCD score) due to the allocation;
- I_{output} is the impact (single ILCD score) of the output;
- $Mass$ is the mass (kg) of the output
- $allocation$ is the allocation factor linked to the output analysed.

As the allocation represents an avoided impact attributed to a co-product (essentially a negative impact), it must be related to the final impact when analysing the contribution. The same applies to positive R2C ratios (water absorption of pasta or dilution of instant coffee). In addition, to avoid over-allocation to additional parameters, a maximum acceptable value has been set at 50%. This applies in particular to beverages that are highly diluted at the consumer level.

When a specific product does not go through one of the stages (e.g. processed product not mixed in a recipe, fish fillet, etc.) or has no additional parameter (e.g. from raw to cooked during preparation, raw apple). In this case, the WF is set at 0%, and all the other WFs are standardised (recalculated to total 100%).

The two figures below illustrate the distribution of DQR scores for the AGRIBALYSE® 3.2 database.

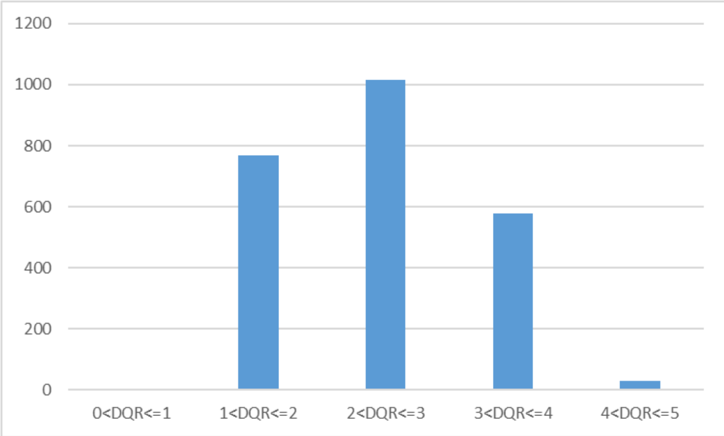


Figure 14 : Distribution of datasets by DQR

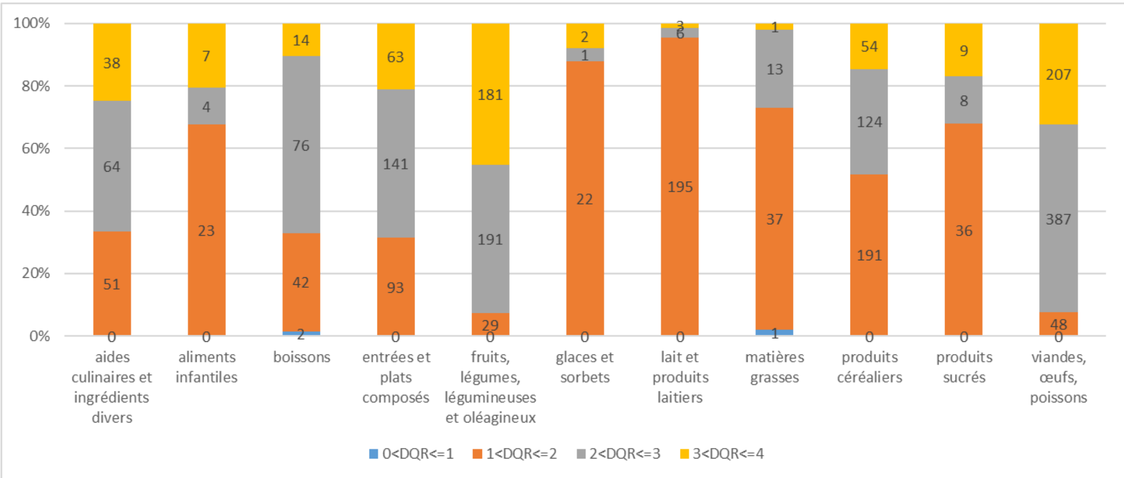


Figure 15 : Breakdown of quality scores (DQR) by product category

5. Outlook

Four years after the publication of AGRIBALYSE® 3.0, we can say that a reference database has been built and is now widely used, which testifies to its usefulness and relevance. However, limitations have been identified, and we recognise the importance of addressing these issues. Thanks to the work carried out by the GIS REVALIM, we are currently in a phase of continuous improvement, both in terms of data and the integration of the latest research on methodological research fronts. This proactive approach allows us to strengthen the quality and effectiveness of the database with each update, while guaranteeing even more reliable data in the future. GIS REVALIM relies not only on the expertise of its members, but also on feedback and contributions from users to bring this tool to life.

Further information: www.AGRIBALYSE®.fr

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ABBREVIATIONS AND ACRONYMS

ACTA	Association de Coordination Technique Agricole (French Technical Coordination Association for Agriculture)
ACTALIA	Association de Coordination Technique Agricole pour l'Industrie Laitière (French Technical Coordination Association for Dairy Industry)
ACTIA	Association de Coordination Technique pour l'Industrie Agroalimentaire (French Technical Coordination Association for Food Industry)
LCA	Life cycle analysis
ACYVIA	French Food cradle to processing gate LCI database
ADEME	Agence de l'Environnement et de la Maîtrise de l'Énergie (French Environmental Protection Agency)
AGB 1.3	AGRIBALYSE® 1.3
AGB 1.4	AGRIBALYSE® 1.4
ANSES	Agence Nationale de la sécurité sanitaire de l'alimentation, de l'environnement et du travail (French National Health and Nutrition Agency)
CF	Characterization factor
CIQUAL	Public French food nutritional composition table developed and maintained by ANSES
DQI	Data Quality Indicators
DQR	Data Quality Ratio
LCI	Life cycle inventories
IDELE	Institut de l'Elevage (French Technical Institute for Livestock)
ITERG	Institut des corps gras et produits apparentés (French technical institute for fatty substances and related products)
LCIA	Life Cycle Impact Assessment
R2C	Raw to cook ratio
RoW	Rest of World
WF	Weighting factor
WFLDB	World Food LCA Database

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EXPERTISES

AGRIBALYSE 3 - Methodological report 3.2

AGRIBALYSE 3 is a French database of life cycle inventories (LCIs) for agricultural products and food consumption. It is produced as part of the AGRIBALYSE programme, run since 2009 by ADEME and INRAE, with the support of numerous organisations and experts. Since 2021, AGRIBALYSE has been updated with the support and expertise of the members of the REVALIM Scientific Interest Group (ADEME, INRAE, ACTA, ACTIA).

AGRIBALYSE provides LCIs for 2,500 food products recorded in CIQUAL, the national nutritional database (ANSES, 2017). Each food has a similar identification number and limits, enabling consistent links to be made between nutritional and environmental properties.

In September 2024, AGRIBALYSE 3.2 was published as the successor to AGRIBALYSE 3.1.1. This report describes the methodology used for the food products in the database.