EXPERTISES

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AGRIBALYSE 3.1

THE FRENCH AGRICULTURAL AND FOOD LCI DATABASE

Methodology for food products

REPORT

In partnership with :

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En partenariat avec :

Abstract

Agribalyse 3.1, 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 organizations and experts.

AGRIBALYSE 3 provides a large number of LCIs of French agricultural products, described in another report (P. Koch & Salou, 2022). 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 (PEF, Ecoinvent). Priority has been given to transparency over accuracy, with the mindset of an evolving and improving database in time. 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.
- **For non-experts:** Life Cycle Impact Assessment indicators for 2500 food products: aggregated indicators at the product level, available freely on the program webpage (www.agribalyse.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 communication tools are available: User Guidance (ref), video clip etc.

The calculation of version 3.0 was performed by Gingko 21, Sayari and Blonk consultants, mandated by ADEME. The external review was performed by RIVM, GreenDelta and P.Koch consulting.
The update to 3.1 was performed by EVEA S.A.S Coopérative, mandated by ADEME too, and in relation wis GIS REVALIM.

Résumé

AGRIBALYSE 3, est une base de données française d'inventaires de cycle de vie (ICV) de produits agricoles et de consommation alimentaire. Elle est produite dans le cadre du programme Agribalyse, mené depuis 2009 par l'ADEME et l'INRAE, avec le soutien de nombreux organismes et experts.
AGRIBALYSE 3 fournit un grand nombre d'ICVs de produits agricoles français, décrits dans un autre document (P. Koch & Salou, 2022). Ce rapport présente la méthodologie utilisée pour élaborer les ICVs des produits alimentaires AGRIBALYSE 3.
AGRIBALYSE fournit les ICVs de plus de 2500 produits alimentaires enregistrés dans CIQUAL, base de données nutritionnelle nationale (ANSES, 2020). Chaque aliment possède un numéro d'identification et des limites similaires, permettant de réaliser des liens cohérents entre les propriétés nutritionnelles et environnementales.
Cette base de données est, par son ampleur et son ambition, un projet innovant et stimulant. La priorité a été d'établir une infrastructure solide de la base de données et de se concentrer sur les points sensibles afin de pouvoir atteindre un niveau de qualité approprié à la publication. Le travail s'est principalement appuyé sur des ICVs existants : AGRIBALYSE 3 combine des ICVs agricoles (Agribalyse v1.4, Ecoinvent, WFLDB,), les ICVs relatifs aux processus alimentaires (ACYVIA, WFLDB), des ICVs concernant la logistique (PEF, Ecoinvent). La priorité a été donnée à la transparence plutôt qu'à la précision, dans l'optique d'une base de données évoluant et s'améliorant au fil du temps. La transparence de ce projet s'appuie sur une documentation complète, l'utilisation de "processus unitaires" et le ratio de qualité des données (DQR). La méthodologie est conforme aux principales directives internationales en matière d'ACV : ISO 14040 ; LEAP et PEF.

La base de données est disponible sous deux formats :

- **Le format expert** : Il s'agit d'une base de données d'inventaires du cycle de vie composée de processus modulaires et unitaires du « berceau à l'assiette ». Elle comprend une grande variété de produits agricoles français (bio, culture sans labour, etc.) ainsi que des produits importés, des données de transformation et de logistiques qui une fois combinés forment 2500 produits-alimentaires moyens. Ce format permet des adaptations (changements pour utiliser un produit biologique par exemple), il est ainsi particulièrement adapté aux travaux d'éco-conception. Il nécessite toutefois des utilisateurs experts. Cette base de données est disponible dans les différents logiciels ACV.
- **Le format tout public :** Il comprend les indicateurs d'évaluation du cycle de vie de 2500 produits alimentaires. Ces indicateurs sont agrégés pour chaque produit. Ils sont disponibles gratuitement sur la page web du programme Agribalyse (https://agribalyse.ademe.fr/). Les impacts sont également fournis par étapes du cycle de vie et par ingrédients. Il est ainsi particulièrement adapté à l'analyse des points chauds de la chaîne de valeur. Il peut par exemple contribuer aux informations environnementales et aux éco-scores. Il est destiné à un public non-expert.

Une documentation supplémentaire et des outils de communication sont disponibles : Guide utilisateur, clip vidéo, etc.

La réalisation de la version 3.0 a été menée à bien par les bureaux d'études Gingko21, Sayari et Blonk Consultants, mandates par l'ADEME. La revue critique quant à elle a été réalisée par RIVM, GreenDelta et P.Koch consulting.

La mise à jour vers la version 3.1 a été réalisée par EVEA S.A.S Coopérative, mandaté par l'ADEME également et en lien avec le GIS REVALIM.

1 Context and Goal

1.1 Description of AGRIBALYSE 3

AGRIBALYSE is a Life Cycle Inventory (LCI) database describing French agriculture and food sector. The database has been developed by a partnership evolving since 2009, led by ADEME, INRAE and the French technical institutes mainly.

AGRIBALYSE 3 provides a large number of LCIs of French agricultural products, developed by INRAE based on an update of previous Agribalyse dabatase v1.3. The methodology for those agricultural LCIs is described in another report(P. Koch & Salou, 2020).

The current report only describes the methodology used to develop AGRIBALYSE 3 food LCIs.

The calculation of version 3.0 was performed by Gingko 21, Sayari and Blonk consultants, mandated by ADEME for the food part. The update to 3.1 was done performed by EVEA S.A.S Coopérative, in relation with the GIS REVALIM.

Before version 3.0 (published in 2020), AGRIBALYSE program used to focus on French agricultural production (Peter Koch & Salou, 2016). In addition to the database developments, AGRIBALYSE also includes methodological projects (OLCA Pest, AGRIBALYSE Water etc.). From this version 3.0, its scope is expanded to French food consumption. It aims at providing LCIs for all the food items registered in CIQUAL, the national nutritional database (ANSES, 2017), with similar ID number and boundaries.
The 3.1 version allowed to continue this work with significant improvements in the quality of some data thanks to the work of AGRIBALYSE partners, the addition of new data, and methodological improvement or fixes. All of the changes are documented in a specific report (in French).

AGRIBALYSE 3 relies on previous and updated AGRIBALYSE version for French agricultural and food products, and is completed with additional data related to food processing, Acyvia (Bayart et al., 2016), data for logistic, packaging etc. from different data sources.

AGRIBALYSE database is built with unit processes, corresponding to a LCI disaggregated and aggregated database.

The database is available in two formats:

- A Life Cycle Inventory Database: 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. Using this format, the data can be adjusted (ex: switch to organic product) ; this format is especially suitable for eco-design work, but requires expert users. This database is available in SIMAPRO and OpenLCA.

- Life Cycle Impact Assessment indicators for 2500 food products: aggregated indicators at the product level, available freely on the program webpage (https://agribalyse.ademe.fr). The data are provided for average conventional products only. Detail by production stages (agriculture, process, transport, packaging etc.) and by ingredients is also available. This format does not provide the detail for emissions sources and data cannot be adjusted. However, it does not require specific LCA software and it is more accessible for non LCA experts. It is especially suitable for hot-spots analysis and can contribute to the calculation of "eco-scores".

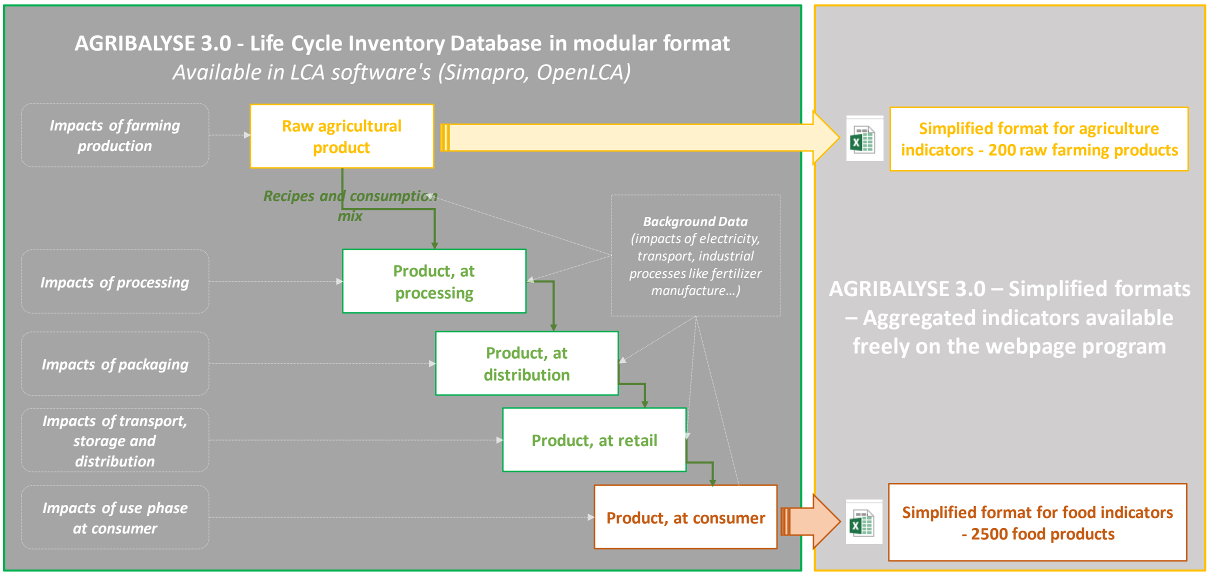

Figure 1: Presentation of AGRIBALYSE 3.0 access options

<u>ZOOM: CIQUAL Database</u>

CIQUAL provides nutritional composition of food consumed in France, pre-packaged (industrial source) or not (ex: « apple, pulp and peel, raw », « water, municipal »). In its 2020 version, CIQUAL contains 3186 food items and provides, for each one, their content in 61 nutritional components per 100 g edible portion. Food items are classified by groups, subgroups and sub-subgroups. It is run and maintained by ANSES (French agency for food, environmental and occupational health safety). It is freely downloadable from the <u>CIQUAL website</u>, both in French and English. It is used by the French Agency for food, especially for risk assessment in nutrition. Other users include administration, researchers, nutritionists, food companies and consumers.

1.2 Goal and scope of AGRIBALYSE 3 database

1.2.1 General

AGRIBALYSE 3 is a farm-to-fork LCI-database for France. AGRIBALYSE 3 links food products in the French CIQUAL nutrition database to environmental impacts using the same boundaries and the same identifiers. This will enable coupling between environmental and nutritional information for food items consumed in France. The coupling of CIQUAL and AGRIBALYSE is seen as a foundation to studies and tools for decision making regarding food transition in France. The data are not intended to be used for comparative assertions between products with unequal functions and varying nutritional properties.

Users of AGRIBALYSE 3 datasets are diverse. LCA experts will be able to use the value chains as described in AGRIBALYSE 3 and update them according to their own specificities. Food professional (managers, product developers, R&D teams) and civil society (NGOs, consumers) are also a target audience for the use of environmental impacts. It is recommended to read the "User Guide (only 15 pages)" which contains the key information in an accessible way for all users.

1.2.2 Goal

AGRIBALYSE 3 aims to be the 'mirror' environmental database to the CIQUAL database, that describes nutritional properties of more than 3000 food items consumed in France. Therefore, the goal of AGRIBALYSE 3 is to be the French LCI-database for the same 2800 food items, enabling to describe the corresponding environmental properties.

1.2.3 Functional unit, system boundaries and allocation

Food products have been modelled per 1 kilogram of prepared product, but individual processes of the value chain can be modelled for other functional units. AGRIBALYSE 3 database is provided in the form of unit processes, following the value chain of food items from raw material production, to processing, assembly, distribution, retail and storage and preparation at consumer. Transport between each stage of the value chain is included, except for transport between retail and the consumer home. Waste and food losses are accounted for at various stages of the life cycle, except at consumer home.

Allocation used throughout the database is mostly economic allocation, in line with existing processes used (ACYVIA, Ecoinvent etc.). Known exceptions are the modelling for dairy husbandry though uses biophysical allocation and cheese production uses mass allocation; or processing aiming at obtaining the edible part of the product (such as peeling, pitting, unshelling, fish filleting); for those, a simplified assumption was made to allocate 100% of the inventory to the edible part.
In case of doubt, user should refer to allocation procedures as described in each of the database corresponding documentation.

1.2.4 LCIA method and impacts

The impact assessment method targeted is Environmental Footprint (EF) midpoints and EF single score (European Commission, 2018)). AGRIBALYSE 3 enables to compute impact assessments of the CIQUAL food items and display them together with the quality of the assessment. These are accessible on the ADEME website.

1.2.5 Type of data, sources and nomenclature

AGRIBALYSE 3 aims at putting together different unit process databases that have been developed in parallel with similar methodological rules:

- previous versions of Agribalyse wich has been updated (v1.3 - v.1.4/unpublished and v3.0) (French agricultural raw material production and food products),
- ACYVIA (French food industry processes),
- ecoinvent 3.88 (imports of raw materials and food processes)
- World Food LCA database v3.5 (food processes) – background copies of ecoinvent were updated to ecoinvent 3.8 instead of 3.5.

Ten additional "strategic" datasets have been developed in the context of AGRIBALYSE 3.0, and an additional 50 products were added for AGRIBALYSE 3.1 (see specific reports). Furthermore, AGRIBALYSE 3 is largely inspired by PEF rules, which is mainly reflected in the modelling of the life cycle stages from distribution to fork.

As AGRIBALYSE 3 is largely built upon existing unit process databases, the nomenclature will follow the original nomenclature as adapted in LCA software. From processing to fork the nomenclature follows mainly consistent rules developed in this context as adapted in LCA software. The consumer stage dataset includes the corresponding CIQUAL ID.

1.2.6 DQR and review

At consumer stage, Agribalyse includes a Data Quality Ratio (DQR) indicator, based on time representativeness, precision, geographic and technological specificity of the whole value chain; in line with PEF methodology (European Commission, 2020).
DQR assessment of each of the food items has to be aligned with the "goal and scope" of the database.
A food item aligned with the goal and scope of the data base has the following characteristics:

- It is representative of the French food consumption.
- It describes consumption mixes for "raw" agricultural products with at least 70% coverage
- Data are no older than 3 years from French trade statistics.
- Processing is using representative technology with verified data for mass balances, energy consumption and water consumption wherever possible.
- Recipes for assembled food products cover at least 95% of the mass in terms of ingredients.
- Representative primary packaging is used for the food item.

AGRIBALYSE 3.0 has been reviewed by RIVM and GreenDelta. RIVM reviewed the data used, modelling and impact assessment, while GreenDelta reviewed the DQR methodology and DQR rating. See Annex 20 for review specifications and reports.
It has also been commented by French technical institutes (ACTA and ACTIA leading – see annex 21). "Peter Koch Consulting" made a final pre-publication review, bringing additional improvements and corrections (Annex 22).
AGRIBALYSE 3.0 was updated in October 2022 to AGRIBALYSE 3.1, with significant improvements in the quality of some data thanks to the work of AGRIBALYSE partners, the addition of new data, and methodological improvement or fixes. All of the changes are documented in a specific report (in French). This update was done by EVEA S.A.S. Coopérative, in relation with AGRIBALYSE partners (GIS REVALIM, ADEME, ITERG, CIRAD, ACTALIA, ANMF and with the consulting company GINGKO21. This version was reviewed by GIS REVALIM.

1.2.7 Limitations of the database

It has to be noted that this database presents several limitations. First, it has been assembled from several existing databases, that are similar in terms of dataset boundaries, data collection and methods, but not always 100% consistent. The original dataset is mentioned in the AGRIBALYSE 3 metadata and documentation, and user should refer to it in case of questions. For example, depending on the datasets, and regardless of their original database, capital goods are not necessarily covered. Some inventory items related to "still open" methodological questions have not been consistently implemented across the databases. It is especially the case in agricultural inventories for carbon uptake,land use change data and crop protection.

Allocation rule (economic, bio-physic etc.) is define in each original dataset (Agribalyse 1.3, ecoinvent, WFLDB), it is not always aligned with PEF guidance (European Commission, 2018) (ex : milk/meat allocation).

Some limitations stem from methodological choices made in the construction of the database. Primary packaging is covered, but not secondary and tertiary packaging; water use for fruits and vegetables washing has not been accounted for in this version of Agribalyse.
Other limitations are described along the document.

1.3 Scope of this methodological report

AGRIBALYSE 3 gathers LCI datasets extracted from diverse sources. As a consequence, specific LCI methodological rules framing the elaboration of the datasets is displayed in the corresponding methological reports mentioned in Table 1. The documentation is available on the program webpage.

Table 1. Documentation for AGRIBALYSE 3

General Methodology AGRIBALYSE 3	This report
Main agriculture methodology (AGB v1.4)	(P. Koch & Salou, 2022)
Specific report, fruits and vegetables	(Grasselly et al., 2017)
Specific report, banana	(Deloitte Développement Durable, 2018)
Specific report, pineapple	(Biard et al., 2020)
Specific report, organic agriculture	(Nitschelm et al., 2020)
Specific report, Ecoalim : feed	(Wilfart et al., 2017)
Specific report, sea products	Cloâtre 2019
Specific report, Bleu Blanc Cœur products (chicken, egg, pig)	(Bleu Blanc Cœur, 2019)
Processing operations ACYVIA	(Bayart et al., 2016)
World Food LCA Database Methodology (imported agricultural products and food processing)	(Bengoa et al., 2015) (Nemecek et al., 2015)
Ecoinvent Methodology (imported agricultural products and non food process (background).	(Nemecek & Schnetzer, 2012) (Nemecek & Kagi, 2007)
Topic Focus : Water Footprint	(Martin & et al., 2019)
Topic Focus : Biogenic Carbon	(Tailleur et al., 2018)
Topic Focus : Organic fertilization	(Avadí, 2020; Avadí et al., 2019)
Topic Focus : Pesticides	(P. Koch & Salou, 2022)
Agribalyse 3.1 : New and updated data by GINGKO21	(Gastaldi, 2022)
Agribalyse 3.1 : New and updated data by CTCPA	(COLOMBIN Margaux, AUDOYE Pauline, FARRANT Laura, LABAU Marie-Pierre, CTCPA, juillet 2022)

This report does not aim at repeating these methodological rules.

All databases belong to the same family of databases developed as unit processes with ecoinvent datasets in the background. Some of the differences between the methodological rules can however be identified, especially on the raw material production phase:

- Biogenic carbon uptake in crops accounted for in Agribalyse raw material production (no effect on impact indicators)
- Inputs of fertilizers distributed over the crop rotation for Agribalyse
- Potential differences in allocation; this is the case e.g. for the production of milk at farm where the allocation between milk and meat is different from International Dairy Federation (International Dairy Federation, 2015) in Agribalyse.

This list is not exhaustive, and user should refer to detailed methodological report if need be.

Indeed, this report deals with how the challenge of building a large food consumption database was handled:

- How the database is structured, and which data were collected (consumption mix etc.)
- How food items were prioritized (i.e. Core recipes precisely modeled and choice of proxies, choice of additional LCIs to be built – see Annex 18),
- How LCI datasets were selected and approached when necessary, and
- How losses were dealt with along the value chain.

Due to the exploratory nature of the work, and the lack of existing datasets, the objective of AGRIBALYSE 3 is not to provide complete and precise LCI datasets for each and every CIQUAL food item. The goal is to set up a robust architecture as a basis for a long-lasting food consumption database that will be improved in the coming years. In its 3.0 version, it is populated with the best existing datasets available. However, many limitations remain and are described in this report (Section 4).

2 General architecture

AGRIBALYSE 3 database contains 2517 datasets constructed as described in Figure 2. A majority of the raw material production processes use priorily developed AGRIBALYSE datasets.

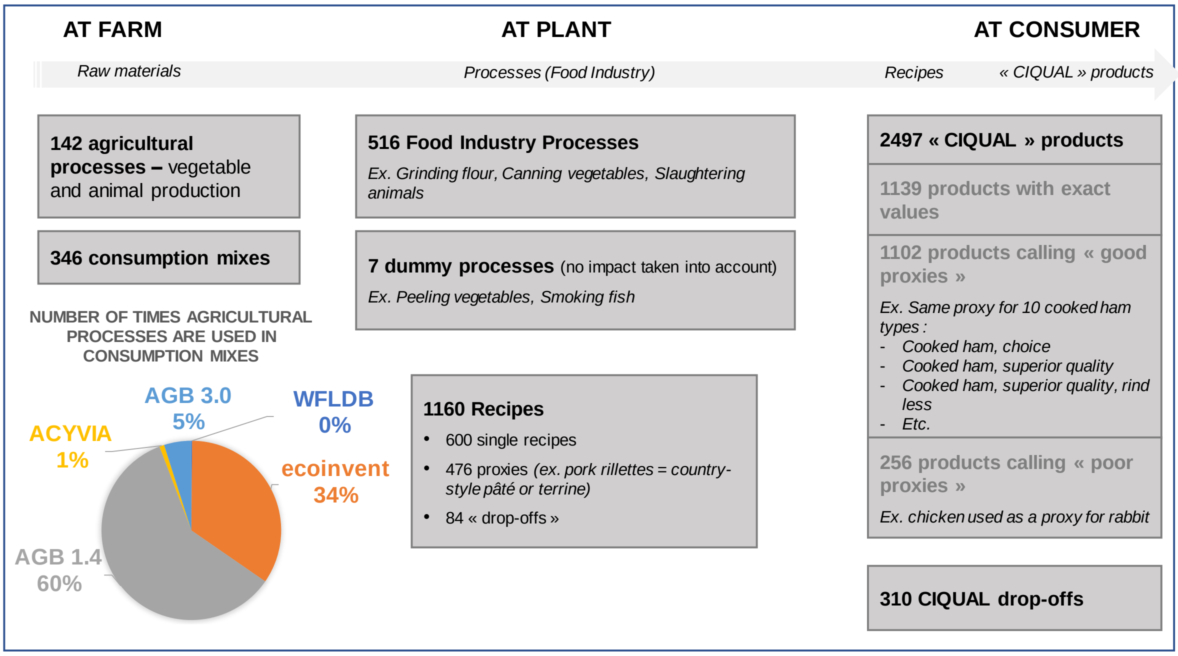

Figure 2 : Overview of the general architecture of the AGRIBAYSE 3.0 database.

AGRIBALYSE 3 database contains 2517 datasets out of 3186 items in the whole database CIQUAL. i.e. 79% treated.

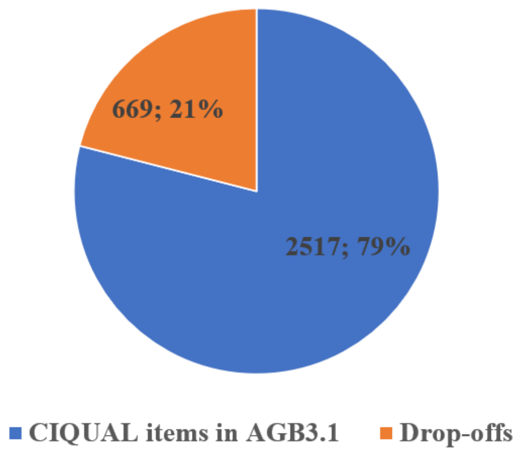

Figure 3: Overall coverage of CIQUAL database in AGRIBALYSE 3

2.1 Boundaries

The database 3.0 is a major update of AGRIBALYSE 1.4 (unpublished). On top of what the database 1.4 includes, it contains the life cycle inventory datasets for most of the more than 3000 CIQUAL food items. It also contains the related unit processes along their value chain. Datasets are accessible in folders and subfolders organized with the same group and subgroup nomenclature as CIQUAL.

CIQUAL food items are ready for consumption. They cover cradle to consumer plate including:

- Production of raw materials,
- Transport,

- Processing,
- Packaging,
- Distribution and retail,
- Preparation at consumer and
- Disposal of packaging.

2.2 Linking processes

In most cases, AGB 3.0 is using and connecting existing processes from 4 databases that are described in Table 2. If there are duplicate processes across databases, the order of prioritization is the one indicated in Table 2[1].
Metadata of the dataset mentions from which database the dataset was extracted.

Table 2 : List of databases used for datasets

Database	Owner	Developers	Reference	Main processes	Background database
AGRIBALYSE 1.4 and ACYVIA	ADEME ADEME	INRAE and Agroscope and French technical research institutes Quantis Agroscope	(P. Koch & Salou, 2020) (Bayart et al., 2016)	Agriculture and fisheries production in FR Processing in FR Disaggregated processes (PD) were used.	ecoinvent 3.8
ecoinvent 3.8	ecoinvent	ecoinvent	(Moreno Ruiz et al., 2018)	Some agriculture and food processing Background database (energy, transports…)	-
WFLDB 3.5	WFLDB consortium	Quantis Agroscope	(Nemecek et al., 2015)	Some agriculture Mostly processing and preparation at consumer	ecoinvent 3.8 datasets (updated to Ecoinvent 3.8 for AGRIBALYSE 3)

All databases have copies of ecoinvent 3.8 'cut-off' system model datasets as the background.

CAUTION:
Ecoinvent and WFLDB datasets are copied as unit processes. However, their value chain is in general NOT specific to France and were kept 'as is'. Especially, they do not account from specific French consumption mixes nor for the French electricity mix.
For example: "sugar from sugar beet" in Agribalyse is approached by an ecoinvent process "Sugar, from sugar beet {RoW}| beet sugar production | Cut-off". The sugar beet consumption mix in this ecoinvent process is 14% from France, 14% from Russia, 11% from the US and 11%from Germany, and the rest (50%) from the "Rest of the World". The consumption mix was kept 'as is and the ecoinvent dataset is not calling Agribalyse sugar beet dataset for agricultural input.' [2] *. The energy used for processing sugar beet into sugar is a RoW, not specific to France, and was also kept 'as it'.*

[1] A few exceptions to this rule have been applied when Agribalyse1.4 existing datasets were developed only for animal feed (see section 3.2). In this case, the order of priority was kept but skipping directly to ecoinvent.
[2] *The mix in Ecoinvent is however different from the mix production for sugar from sugar beet in France, for which we know that most of the sugar comes from France* See https://www.franceagrimer.fr/Eclairer/Etudes-et-Analyses/Etudes-et-

Table footnotes along this document will specify when the raw materials within the value chain are not specific to France. Expert LCA users have the possibility to update the raw material datasets and electricity mixes to their own case study.

The general construction scheme for AGRIBALYSE 3 is described in **Erreur ! Source du renvoi introuvable.**. All background datasets (transport, packaging, electricity) are from ecoinvent 3.8.

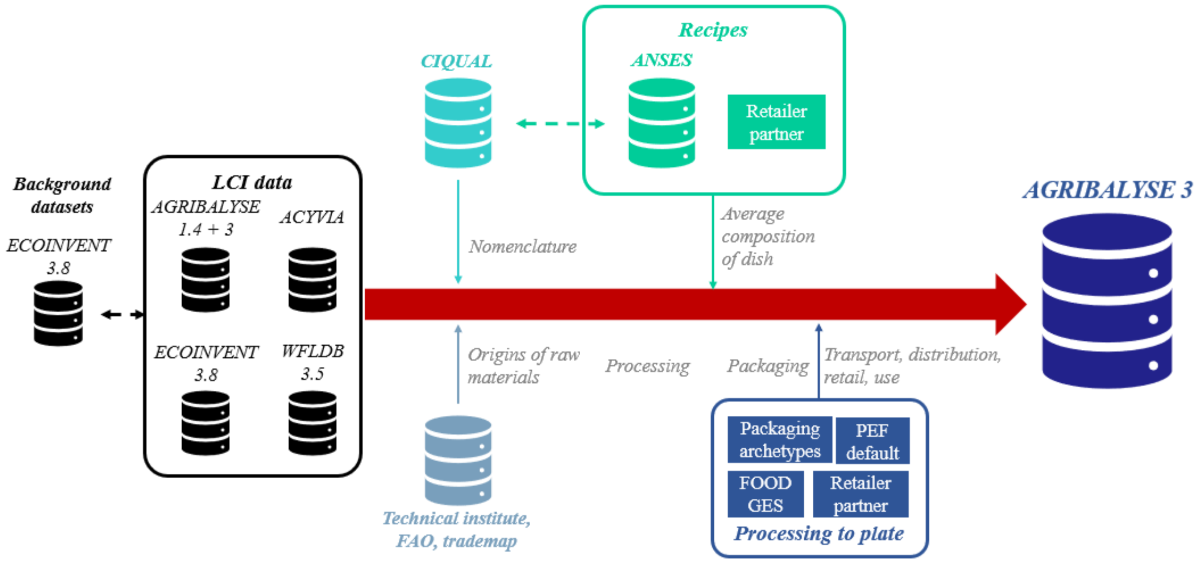

Figure 4: General principles for construction of the AGRIBALYSE 3 database

2.3 Characterization of CIQUAL elements

CIQUAL food items have been categorised in 5 categories, described in the table below. Such categories were set up to apply systematic rules in the building of the database, especially regarding the life cycle stage (processing or consumer) at which both inedible losses and cooking are applied – see section **Erreur ! Source du renvoi introuvable.**.

syntheses?SearchText=&activeFacets%5Bclass%3AType+de+contenu%5D=Autre+ressource+documentaire&filter%5B0%5D=contentclass_id%3A%2284%22&page=1&moteur%5BfiltreTypeContenu%5D=actualite&moteur%5BfiltreFiliere%5D=1495&moteur%5BfiltreDate%5D=-1 - “le Marché du sucre n° 36 – Septembre 2017 pages 11 to 13

Table 3: Categorization of CIQUAL food items

Category Number	Category name	Description	Example (including CIQUAL code)	Accounts for [3]	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
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 [4](microwaving, heating, boiling cooling …)

[3] All categories account for transport up to consumer, distribution and retail storage and losses.

[4] One exception is Pasta, cooked. Pasta in itself is a recipe, as a mixture of several ingredients (wheat flour, eggs, water….). Pasta is supposed to be cooked at home and not at plant.

2.4 Naming conventions and link with CIQUAL

CIQUAL ID is mentioned in the final product at consumer stage. For intermediary stages prior to consumer, no ID is mentioned. Naming conventions have been set up in line with naming conventions for ecoinvent (Wernet et al., 2016) as used in software tools.
CIQUAL items that are a mixture of ingredients from various raw materials are called “recipes” and categorized as such (see section 0).

Example for Cheese Pizza (CIQUAL ID 25404) is provided in Figure 5 below.

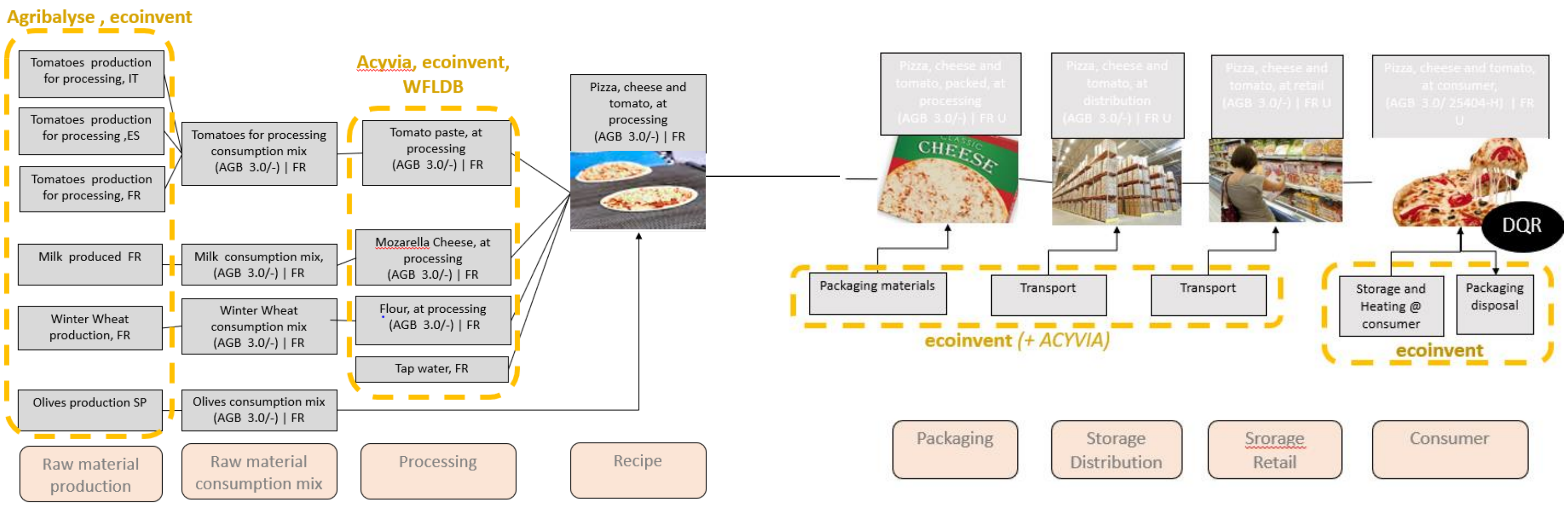

Figure 5 : Example of the compilation of Life Cycle Inventory (LCI) unit processes to obtain the LCI corresponding to the CIQUAL Item "Cheese Pizza" – (ID : 25404)

2.5 Cross cutting aspects

2.5.1 Raw to cook ratio

The weight of some food items differs when raw or cooked. For example, lentils gain water and weight when cooked (1kg=> 1,5kg). This was accounted for in AGRIBALYSE 3 using a raw to cook ratio (R2C ratio). The ratio was calculated using water content of food items[5] of similar raw and cooked food items from CIQUAL.

Equation 1

$$\text{Ratio R2C} = \frac{\textbf{Weight when cooked}}{\textbf{Weight when raw}} = \frac{1-H2O\%_{raw}}{1-H2O\%_{cooked}}$$

With
$H2O\%_{cooked}$ value for water content of cooked food item.
$H2O\%_{raw}$ value for water content of raw food item.

When water content for cooked and raw food item were available, we used the calculated ratio. When water content was not available in CIQUAL, we used an average raw to cook ratio. The average ratio was calculated among food items belonging to the same food group: cereals (rice, wheat, barley, millet), legumes (lentils, beans and peas), fish and shellfish, fruits and vegetables, eggs. The resulting raw-to-cook ratio are displayed in the table 4.

Table 4: Raw to cook ratios – vegetal, fish and eggs products (source: CIQUAL database for water content)

Average raw to cook ratio per food category			
	Average ratio	**Standard Deviation**	**Comment**
Fruits and vegetables	0,856	0,860	-
Fish and shellfish	0,819	0,341	-
Cereals	2,259	0,186	-
Legumes	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

Assumptions:

- Algae: Raw to cook ratio for algae could not be evaluated the same way since the water content of cooked algae is not displayed in the CIQUAL database. We approached the R2C for algae by the average R2C for vegetables.

- Other food items not covered by the food groups above (see Table 4 and **Erreur ! Source du renvoi introuvable.**) are assumed to have a R2C ratio of 1:

[5] The ratio was calculated for food items included in CIQUAL database in raw and cooked versions.

- Dairy: cheeses, creams, milks (except yogurt which are not meant to be cooked)[6]
- All beverages and drinks: juices, nectars, alcohols
- Fats: vegetable oils, animal oils and fat, butter
- Seeds, nuts
- Miscellaneous: herbs, dried fruits and vegetables, flours, salt, spices, sugar, toppings and condiments (capers, candied fruits, pickles etc.).

2.5.2 Inedible losses

In AGB 3.0, only inedible losses are accounted for at consumption phase. Losses are also accounted for upstream at distribution and retail phases. But we do not account for food waste, i.e. food that is wasted in the consumer's household, in order to stick with CIQUAL boundaries. Inedible losses are mostly coming from FoodGES study (Colomb & Martin, 2015) and ICV Pêche report (July, 2019). Detailed information on inedible losses for fruits, vegetables and eggs are provided in Annex 2. The stage at which inedible losses is accounted for is important as it can in some cases drastically change mass transferred to downstream phases (in the example of mussels, 75% of mass (shelves) is lost when accounting for inedible losses). Table below presents information on the treatment and reference of inedible losses.
Despite of not accounting for edible losses, the structure of the database following the value chain with unit processes enables the user to add a stage of consumer waste if need be.

Table 5 : Life cycle stage accounting for inedible losses per type of food item and category as defined in section 2.3 – Corresponding reference.

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[7], except pineapple, apricot and cherry [8] for all nuts: based on walnut data (50% edible part)	- At farm for dried products - At consumer for category 1, and 2[9] - 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	- Already accounted for in ACYVIA datasets (beef, pork, chicken)	- At slaughtering stage

[6] In ANSES recipes, no evaporation factor were available for milk and cream : raw and cooked quantities are the same for milk and cream, explaining the hypothesis of R2C=1.
[7] https://www.sciencedirect.com/science/article/pii/S0956053X18301946
[8] 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.
[9] 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%.

- Deboning for muscle meat + sausages - Deboning for chops or products with bone	- Acyvia (ground beef and pork) - FoodGES	- 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…)	ICV Pêche and expert say[10]. See Annex 5	- at arrival in France (French Harbor or French center)
Shellfish	Mussels : expert judgment [11] Scallops : ICV Pêche Shrimps FAO [12]	- At consumer for category 1, 2 - 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)
Legumes	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	

The edible part ratio of meat is:

- Meat with bone: 80 % for chop, rib, leg, neck, wing, poultry; the percentage of bone is supposed to be constant for all bony meat of a given animal.
- Meat without bone: 100 % for steak, loin, sirloin, tenderloin, fillet, minced meat, rump, topside, breast, shoulder, offal, sausage.

In most cases, application of the raw to cook happens downstream from removal of inedible losses. But in some cases, the cooking occurs prior to the removal of the inedible part: for example, when cooking a pork chop. The same R2C value is assumed for the edible and inedible part of the product, meaning that the same water content difference between raw and cooked is applied for the edible and inedible part of a product: e.g. inedible part of a cooked pork chop (i.e. the bone) is assumed to present the same raw to cook ratio as the edible part of the pork chop.

2.5.3 Use of density for intermediary computation

When units between datasets and recipes were different, we used density for conversions.
Indeed, for liquids, the dataset unit is in L. But the ingredient quantity in ANSES recipe is expressed in kg. We thus used liquid density to convert kg in L.
We used FAO Bulk density values from (Charrondiere et al., 2012).

[10] Thomas Cloâtre (comité des Pêches) and Vincent Colomb (ADEME) – web meeting April 2019
[11] Expert say – Thierry Larnicol – Keraliou – email 5 March 2019 : 25% edible parts for mussels
[12] http://www.fao.org/3/x5931e/x5931e01.htm#Shrimp%20waste

Table below presents density assigned to each CIQUAL liquid item.

Table 6: densities used for liquids

CIQUAL code	CIQUAL NAME	Bulk density (kg/l)	Comment (FAO source item)
Dairy products			
19042	Milk, semi-skimmed, pasteurised	1,034	milk, liquid, partially skimmed
19202	Goat milk, whole, raw	1,028[13]	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			
5204	Wine, red, 11°	0,998	wine, red
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

2.6 Impact categories covered

We focus on EF 2.0 impact categories as listed in the table below.
Impact midpoint categories are computed as well as a single score, according to (European Commission, 2018)

[13] Alexandre Moreno – partners review January 2020

Table 7: Presentation of impact assessment indicators for PEF method

Impact category	Indicator	Unit	Recommended default LCIA method
Climate change - Climate change - biogenic - Climate change - land use and land transformation	Radiative forcing as Global Warming Potential (GWP100)	kg $CO_{2\ eq}$	Baseline model of 100 years of the IPCC (based on IPCC 2013)
Ozone depletion	Ozone Depletion Potential (ODP)	kg CFC-11_{eq}	Steady-state ODPs 1999 as in WMO assessment
Human toxicity, cancer	Comparative Toxic Unit for humans (CTUh)	CTUh	USEtox model 2.1 (Fankte et al, 2017)
Human toxicity, Non-cancer	Comparative Toxic Unit for humans (CTUh)	CTUh	USEtox model 2.1 (Fankte et al, 2017)
Particulate matter	Impact on human health	disease incidence	UNEP recommended model (Fantke et al, 2016)
Ionising radiation, human health	Human exposure efficiency relative to U^{235}	kBq U^{235} $_{eq}$	Human health effect model as developed by Dreicer et al. 1995 (Frischknecht et al, 2000)
Photochemical ozone formation, human health	Tropospheric ozone concentration increase	kg NMVOC $_{eq}$	OTOS-EUROS model (Van Zelm et al, 2008) as implemented in ReCiPe
Acidification	Accumulated Exceedance (AE)	mol H+ $_{eq}$	Accumulated Exceedance (Seppälä et al. 2006, Posch et al, 2008)
Eutrophication, terrestrial	Accumulated Exceedance (AE)	mol N $_{eq}$	Accumulated Exceedance (Seppälä et al. 2006, Posch et al, 2008)
Eutrophication, freshwater*	Fraction of nutrients reaching freshwater end compartment (P)	kg P $_{eq}$	EUTREND model (Struijs et al, 2009b) as implemented in ReCiPe
Eutrophication, marine	Fraction of nutrients reaching marine end compartment (N)	kg N $_{eq}$	EUTREND model (Struijs et al, 2009b) as implemented in ReCiPe
Land use	- Soil quality index - Biotic production - Erosion resistance - Mechanical filtration - Groundwater replenishment	-Dimensionless (pt) - kg abiotic production - kg soil - m^3 water - m^3 groundwater	- Soil quality index based on LANCA (EC-JRC) - LANCA (Beck et al. 2010) - LANCA (Beck et al. 2010) - LANCA (Beck et al. 2010) - LANCA (Beck et al. 2010)
Ecotoxicity, freshwater	Comparative Toxic Unit for ecosystems (CTUe)	CTUe	USEtox model 2.1 (Fankte et al, 2017)

Impact category	Indicator	Unit	Recommended default LCIA method
Water use	User deprivation potential (deprivation-weighted water consumption)	m^3 world $_{eq}$	Available Water Remaining (AWARE) Boulay et al. 2016
Resource use, minerals and metals	Abiotic resource depletion (ADP ultimate reserves)	kg Sb $_{eq}$	CML 2002(Guinée et al. 2002) and Van Oers et al. 2002
Resource use, fossils	Abiotic resource depletion - fossil fuels (ADP- fossil)	MJ	CML 2002(Guinée et al. 2002) and Van Oers et al. 2002

For raw material production datasets, Agribalyse data is not complete regarding inventory of particulate matters and water use. Hence the results on impact categories on "resource depletion, water" and "particulate matter/respiratory inorganics" should be taken with caution. AGRIBALYSE is a LCI database. However, we provide LCA indicators in the excel "simplified" version of the database. We provide 16 midpoint indicators calculated using EF3 method and the EF3 single score indicator (European Commission, 2018, European Commission 2021).

3 Description of value chain elements

Food consumed in France does not necessarily come from raw materials produced in France. And the raw materials can be processed prior to being imported. For example, if we import a ready-to-eat cake containing flour, fat, eggs, and sugar, origin of raw materials is hardly traceable. Value chains are complex and data gaps are frequent. For now, reliable data is available only at raw material level.
Therefore, in AGRIBALYSE 3, we have made the simplifying choice of looking into origin of food only at the raw material stage. For a few raw materials, which represent significant consumption and for which we know there is a notable difference (tomatoes, strawberries, chicken and beef), we made two different market mixes: one "for processing" (i.e for food industry) and one "for direct consumption".

3.1 Raw materials

3.1.1 Origins

Consumption breakdown per country of origin have been established according to the following Equation 2 and Equation 3, all quantities being expressed in mass (tons), and averaged over five years :

Equation 2

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

Equation 3

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

With

$origin\ ratio_{FR}$: ratio of French consumption total over French production (%)

$origin\ ratio_{country\ i}$: ratio of French consumption total originated 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 accounted for. Accounting for exports led in some cases to odd results where exports were higher than domestic production, which, based on expert judgement (technical institutes) was not accurate. This occurs for instance when a country has a harbor which is used to import products for throughput to countries in its region. Also, based on trade statistics it is impossible to know whether the exported products are from domestic production, or from import (from a specific country). Any assumption made on this issue can highly influence the mix used for the origin of products. The assumption is that excluding exports leads to the most accurate estimation of the mix of origins.

Stocks from one year were not accounted for either. For raw materials, they mostly are for cereal, oil and protein commodities. Indeed, as we average five years, stocks do not have influence, as they are dealt with in most cases from one year to the next.

Apart from the raw materials listed in section **Erreur ! Source du renvoi introuvable.**, for which expert knowledge from technical institutes was mobilised, countries of origin were determined using data from FAOSTATS (FAO, 2019) with an average of five years data (2009 to 2013). Trade data was traced back to the second order, allowing to eliminate countries of transit for raw material trading. In a few cases, when specific country data was missing world production mix was used as a proxy with the same 5 years averaging.

3.1.2 70 % cut-off threshold for consumption origin breakdown

We first classified the information of origin of products, expressed in mass, in a decreasing order. We then targeted 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 when it was the case, it was kept as such.
Based on those data, we then normalized the origin of ingredients to 100%.

An example is given for soybean human consumption (animal feed has a different mix) in Figure 6 below, National statistic provided information on soybean consumed in France in decreasing order: is coming from France (27%), Brazil (23%), USA (18%), Canada (10%), Paraguay (9%) and a number of others countries (14%). As we had explicit information on 86% of the origin of the product, but not on the 14% remaining which was then normalized to 100%. This approach remained to be improved as some data obviously suffer from bias (e.g.

production of soy is extremely low in France). The effect of cumulating several intermediaries is probably the origin ill-identification of the country of origin.

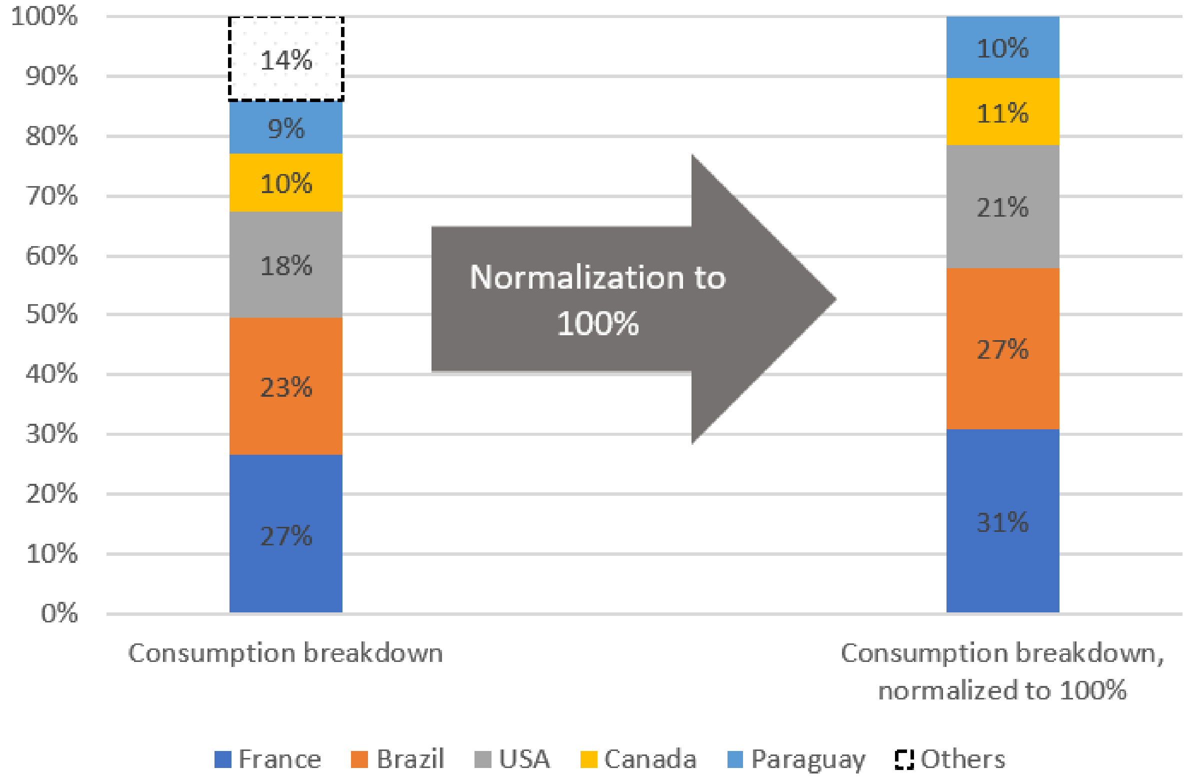

Figure 6: Consumption breakdown for soybean, cut-off application and normalization to 100%

3.1.3 Principles for combining raw material origins and datasets

In practice, four cases are dealt with to combine raw material origins and existing datasets, as described in the figure 7 below:

Case 1: countries of origin are known and corresponding datasets exist.

Case 2: proxies have been determined according to other countries with similar practices /climatic conditions for vegetal based raw materials.

Case 3: country of origin unknown but some existing datasets (in most cases those are specific to France): happens for meat and some plant-based raw materials.

Case 4 country of origin unknown and no existing datasets: this happens for fish and some plant-based raw materials.

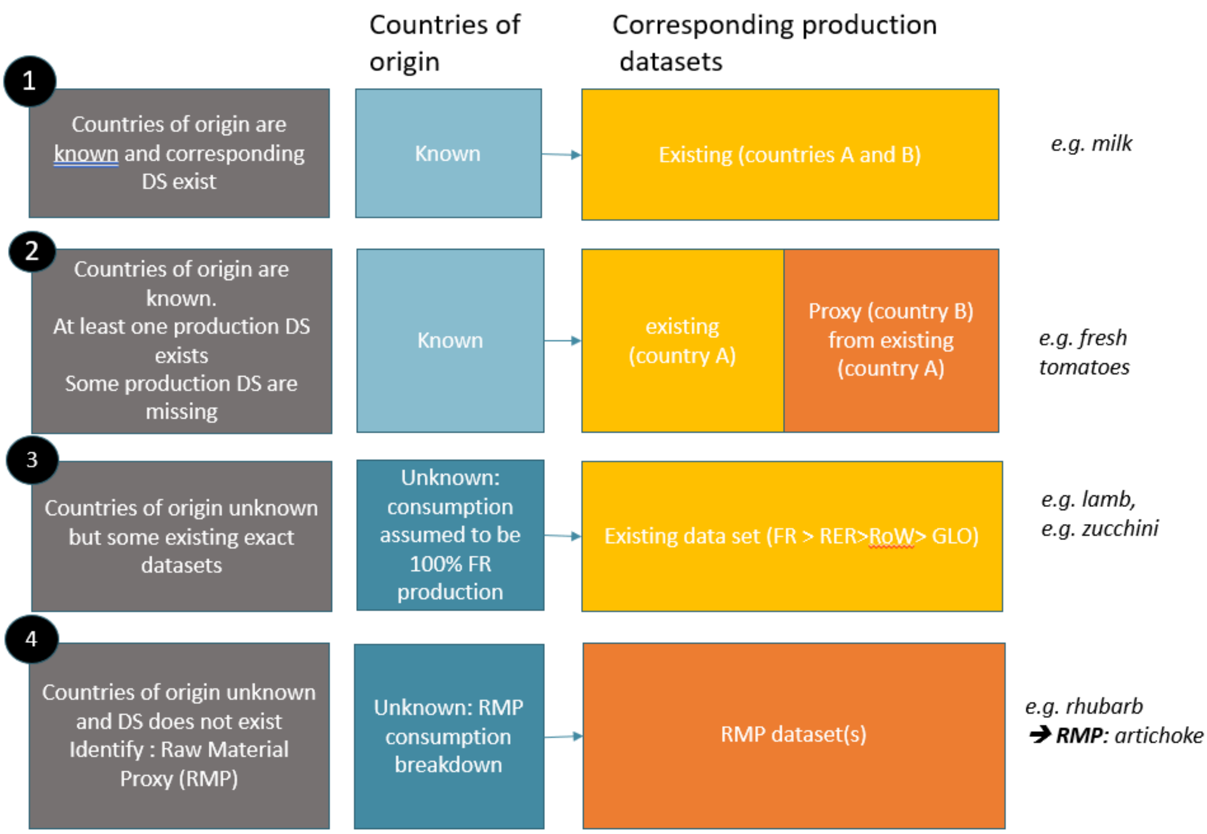

Figure 7 : Four cases are dealt with to identify raw material consumption breakdown and corresponding datasets

3.1.4 Plant-based raw material

An analysis was conducted to check if LCA datasets for the CIQUAL vegetal raw ingredients were existing.

(a) Dataset selection

161 vegetal raw ingredients were identified in CIQUAL database.
When mapping raw materials with datasets, it appears that a wide range of LCA datasets exists for one single raw material.
We followed the rules below to select the most adapted dataset:

- **Priority for database choice: Agribalyse v1.4 > Ecoinvent 3.8 > WFLDB**
  The priority applied on database is meant to ensure the best agricultural specific and consistent development of the future Agribalyse database. Agribalyse was naturally used for French productions in priority, whereas Ecoinvent and WFLDB were used for imports and completing data gaps. This order has been changed for some datasets of tropical products, based on recommandations by experts (CIRAD).

- **Priority for production mode choice:**
  - National average > Conventional > Organic (in Agribalyse),

Regarding the production mode, datasets with "national average" are preferred to "conventional production" as they account for the variability of practices within a country.

- "Production" dataset > "Market for" dataset (for Ecoinvent datasets),

If an Ecoinvent dataset was previously selected, "Production" version is preferred. The "market for" version may include transportation from gate to consumer that is not needed at this stage; Transportation is dealt with later along the value chain (see section 3.7). Also, "market for" includes a consumption mix which is already included in the analysis.

Table 1 : Database priority order for dataset selection: example of pear

• Datasets for pear production	Database	Priority
Pear, national average, at farm gate/FR U	Agribalyse 1.4	1
Pear, conventional, at orchard/FR U		2
Pear {GLO}| market for | Cut-off, U	Ecoinvent 3.8	4
Pear, at farm (WFLDB 3.5)/BE U	WFLDB 3.5	5

- **Priority for country origin choice:**
  - If the exact location is missing, neighboring country or country with similar climate is chosen as a proxy.
  - Otherwise "Global" (GLO) or "Rest of the World" (RoW)[14] origin in Ecoinvent is chosen with a priority order: GLO > RoW

Note that most proxies were completed via the Ecoinvent database.
The datasets from Agribalyse 1.4 covers most of the time a French origin. France is often used as a geographical proxy for other European countries:

- The dataset from France "Squash, conventional, national average, at farm gate/FR U" is used as proxy for Squash **from Spain**.

There are only a few examples of specific country proxies in Agribalyse:

- The dataset from Brazil "Mango, conventional, Val de San Francisco, at orchard/BR U" is used as proxy for mangoes from **Israel**,

See Annex 16 for the detailed origins of food items and the country proxies used.

(b) Product proxy

For food items without corresponding LCA datasets, proxies were used depending on:
the biologic proximity of the food items, and the proximity of the cultural methods and cultivation environment (same soil, seasons of cultivation etc.) (e.g.: an "orange" proxy for "pumelo"). Some families (ex: mushrooms : shiitake, chanterelle, cep etc) have been approached by ony one proxy.

[14] GLO means global and represents activities which are considered to be an average valid for all countries in the world. RoW represents the Rest-of-the-World. The RoW is calculated as a difference between GLO and regional datasets (regional datasets = FR, DE, IN etc. for example).

This proxy approach is coherent overall; however for some given group it shows strong limitation. Indeed yields can be quite different (ex : “orange” as a proxy for “kumquat”). This is accounted for in DQR. The full list of all proxies is available in Annex 16.

- **Gaps and drop offs**

Not all vegetal raw ingredients could be mapped to a dataset or approached by a proxy. Remaining food items are the listed below, with chosen treatment:

  - Dataset specifically generated during the project (see Annex 18)
    - French beans
    - Cherry

    According to their importance in the French diet, it was decided to generate LCA datasets for those two raw materials.

  - Drop-offs (see list in Annex 19)

All mushrooms[15].

3.1.5 Algae

Based on their nutritional interest, specificity and potential role in sustainable diets, it was decided to a generate LCI dataset for this raw material. The raw material produced is ‘Algae (Laminaria), fresh, at farm (AGB 3.0) /FR U’. This algae then go through a drying process on farm site, resulting in a second cradle-to-farm-gate dataset, named ‘Algae (Laminaria), dried, consumption mix (AGB 3.0) /FR U’. This dataset is used in the consumption mix ‘Tangle (Laminaria digitata), dried or dehydrated, consumption mix/FR U’, which is used in all (dried) algae consumption mixes for France. However, a large part of the algae consumed in France is imported from Asia, so a second mix was created to represent Asian-inspired algae with the data ‘Tangle (Laminaria digitata), dried or dehydrated, consumption mix/AS U’. As the modelling was based on a unique dataset for the raw material, only the transport was modified. The origins for the algae is based on bibliography[16].

The Asian-inspired algae are the following:

- Seaweed, agar, raw
- Sea lettuce (Enteromorpha sp.), dried or dehydrated
- Gracilaria seaweeds (Gracilaria verrucosa), dried or dehydrated
- Kombu or Japanese kelp (Laminaria japonica), dried or dehydrated
- Sea belt (Saccharina latissima), dried or dehydrated
- Laver (Porphyra sp.), dried or dehydrated
- Spirulina, (spirulina sp.), dried
- Wakame (Undaria pinnatifida), dried or dehydrated

The French-inspired algae are the following:

- North Atlantic rockweed (Ascophyllum nodosum), dried or dehydrated
- Dulse (Palmaria palmata), dried or dehydrated
- Toothed wrack or bladder wrack (Fucus serratus et vesiculosus), dried or dehydrated
- Sea thong (Himanthalia elongata), dried or dehydrated

[15] When mushrooms are used in recipes, a proxy « onion » has been chosen.

[16] Le Bras et al. 2015 https://hal.archives-ouvertes.fr/hal-01344025/document

- Tangle (Laminaria digitata), dried or dehydrated
- Sea lettuce (ulva sp.), dried or dehydrated)
- Carragheen mosses (Chondrus crispus), dried or dehydrated
- Atlantic wakame (Alaria esculenta), dried or dehydrated

See Annex 18 for more details.

3.1.6 Animal-based raw material

Meat

For beef, pork and chicken specific research has been done on origin of products (see section **Erreur ! Source du renvoi introuvable.**).

Lamb and veal are assumed to come 100% from France, and production dataset at farm gate come from AGB 1.4. Those first assumptions would deserve to be specified.

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

Lamb is a proxy for "young goat".

The following animals have been dropped off due to low consumption rate: hare, horse, ostrich, pheasant, pigeon, quail, venison, wild boar.

Fish and shellfish

Specific research has been done for origin of salmon and shrimp, and consumption mix is detailed in Annex 5. For other fish and shellfish, based on report (FranceAgriMer, 2013) combined with expert judgement (Comité des Pêches Avril 2019)[17] origin is assumed to be 40% from France, 30% from Europe and 30% from the rest of the world (RoW). Production datasets are mostly from Agribalyse 1.4.

Dataset mapping has been discussed with the relevant technical institute (Comité des Pêches; Thomas Cloâtre), based on dominant fishing practice.

Apart from scallops, Norway lobster, shrimps, and mussels, there were no possible matches for shellfish, and the other ones were dropped off.

Table 2 : table of datasets for shellfish

CIQUAL Food item	Dataset	database
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	AGBL 1.4
Shrimps	1kg of fresh shrimps, China production (AGB 3.0) /FR U	newly created dataset see Annex 18
Mussels	Mussels, with shell, at farm gate (AGB 3.0) /FR U	newly created dataset see Annex 18

[17] Information provided by Vincent Colomb (Ademe) and Thomas Cloâtre (Technical institute, Comité des Pêches), April 2019

See Annex 5 for list of proxies and Annex 19 for list of drop-offs.

Dairy

Based on publications from the Technical Institute (IDELE, 2019), origin of cow milk consumed in France is mostly France and an assumption of 100% was made. The dataset from Agribalyse 1.4 was chosen. The same was assumed for goat and ewe's milk. Mare's milk was dropped off. The French technical institute ACTALIA has provided informations on the yield to be used for each cheese, and on the mean distance between farms and cheese plant, which was implemented in the consumption mix of milk.

Eggs

Eggs for both direct consumption and processing are assumed to come 100% from France. Chicken egg dataset from Agribalyse was chosen. It was also used as a proxy for duck, goose, turkey eggs. Quail eggs were dropped off.

3.1.7 Focus on specific raw materials

For a few food items among the most important ones in French consumption, we conducted an in-depth analysis of origin of related raw materials. This can be seen as a focus laboratory that could pre-figure the future development of the next versions of Agribalyse database. It also provides LCIs with improved DQR for those "emblematic" products. Table below shows the list of food items included in this exploratory work.

Table 8: Selected specific raw materials

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

- More accurate consumption mix

For all the food items in Table 9, This experimentation has been worked out with technical institutes in order to deepen the understanding and check for available data on consumption breakdown.
The consumption mixed was build based on : France Agrimer (France Agrimer, 2019); Trademap (ITC, 2019) and expert judgment to combine national production data and imports. Breakdowns were established according to the order of preference in the figure below.
Detailed results for those raw materials are provided in Annex 3.

- Differentiated values for one product category,

Only for tomatoes and strawberries, we explored some product variation, and our capacity to provide differentiated values for one product category. to distinguish on- and off- season origin of products, and destination of raw material - whether it was for direct consumption or for processing. We created 4 versions for tomatoes and for strawberries:

  - fresh tomatoes / fresh strawberries for direct consumption
  - Tomatoes / strawberries for processing
  - On-season tomatoes / strawberries
  - Off-season tomatoes / strawberries

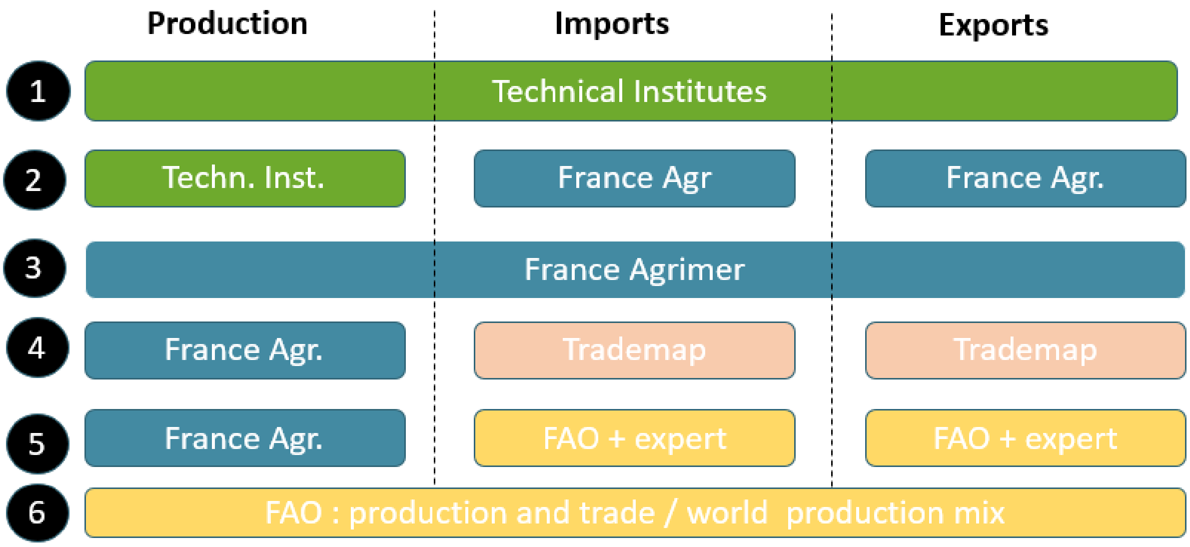

Figure 8: Order of preference for origin of data to constitute consumption breakdowns for the specific raw materials dealt with. FAO is data from FAOSTATS, FranceAgr. Stands for "France Agrimer".

- **Distinction between "for direct consumption" and "for processing"**

The environmental impact varies depending on the food item purpose.
The country of origin, the harvesting, the cultural techniques and varieties are different between a tomato for direct consumption or for processing.

This distinction between "for direct consumption" and "for processing" has been made for 4 products in AGRIBALYSE 3:

- Beef,
- Chicken,
- Tomatoes, and
- Strawberries.

We considered that tomatoes "for processing" are produced in non-heated greenhouses.

For example,
Fresh tomatoes are assumed to be produced in non-heated greenhouse and in two different countries (France and Morocco):

- 66% from **non-heated greenhouse**, produced in **France**, and
- 34% from **non-heated greenhouse**, produced in **Morocco**.

Processed tomatoes are assumed to be produced in non-heated greenhouse and in three different countries (France, Italy and Spain):

- 18% from non-**heated greenhouse**, produced in **France**,
- 46% from non-**heated greenhouse**, produced in **Italy**, and
- 36% from non-**heated greenhouse**, produced in **Spain**.

Two different datasets have been created for "fresh tomato" and "processed tomato".

- **Distinction between on and off season**

  Depending on consumption season, the cultural practices and origins of food item may vary.
  This distinction between "in season" and "off season" has been made for two products in AGRIBALYSE 3:
  - Tomatoes (fresh), and
  - Strawberries.

  For example,
  The production of "in-season" tomatoes is totally from **soil-based** (which is a strong approximation) and from **non-heated greenhouse**, in France.

  Off-season tomatoes are assumed to be produced in both heated and unheated greenhouse and in two different countries:
  - 38% from **heated greenhouse**, produced in **France**, and
  - 62% from un**heated greenhouse**, produced in **Spain**.

  Two different datasets have been created for "in-season" and "off-season" tomatoes.

For AGRIBALYSE 3.1, the eggplant and cucumber consumption mixes could be distinguished between "season" and "out of season" using agricultural production data corresponding to these productions (proxy tomato or courgette under CTIFL recommendations) . These distinctions did not, however, lead to a distinction of CIQUAL products, but it was hypothesized that seasonal products are used for fresh vegetables while out-of-season products are used for vegetables in industry.

- **Meat**

Production datasets are from Agribalyse 1.4.
Pork is 100% from France both for direct consumption and for processing.
For beef and chicken, a distinction was made between meat for direct consumption and meat for processing and catering.
- For direct consumption they are assumed to come 100% from France.
- For processing, breakdown is described in the table below, based on the references mentioned in Annex 3.

Table 9: description of breakdown of origin for beef and chicken

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

3.2 Processes (Food Industry)

- **Geographic location**

Except for drying (see below), we assume that all processing happens in France, both for ingredients and transformed products as well as for recipes.

- **Order of choice**

If existing, Agribalyse 1.4 datasets related to food processing are disregarded, as they are dedicated to animal feed or are coproducts of animal feed production, rather than human food.
For processes, decreasing order of preference is:
Acyvia >ecoinvent 3.8> WFLDB 3.5

Acyvia processes used are disaggregated ones (PDi), as they provide decomposition of the value chain.

We focus on most important operations and parameters for the modeling: hitting/drying/cooling operations, processes ratio/yields. On the opposite, mechanical operation (slicing, pressing etc.) have been given less attention.

For processed raw materials and recipes, the “inedible part” ratio is in principle applied at this stage. For meat with bone, the “inedible part” ratio is split between “slaughtering plant” and “at consumer”, for example:

- Pork chop, raw [chop bone goes up to consumer]

For recipes, “raw to cook” ratio applies at this process stage. There is however one exception to this : pasta. Indeed, pasta in itself is a recipe, as it contains a mixture of several ingredients:

- Fresh eggs pasta is a mixture of durum wheat semolina, wheat flour, eggs and water.

However, the “cooked pasta” in the database (CIQUAL items 9816, 9822, 9871) are assumed to be cooked at consumer.

Water use for fruits and vegetables washing has not been accounted for in this version of Agribalyse, except for new datasets created by external companies, that could include this step. This is a limitation of the database.

For a few processes, known to have little environmental impact, we had to use dummies (empty processes), so that the operation is visible although we do not account for their impact. This includes mainly operations about removing the inedible part of raw materials such as : unshelling, peeling, pitting etc. The complete list of gate to gate dummy processes is provided in Annex 10.1. Like for water consumption, some new datasets added over AGRIBALYSE updates can include this step.

3.2.1 Drying

Table below describes the processes used for drying.

Table 10: list of raw material dried, and assumptions for drying

Raw material	Dataset	Value chain covered	Database
Fish	*Ignored*	N/A	

	Only one CIQUAL item concerned : "cod, salted, dry"[18]		
Coffee	Transformation into freeze-dried soluble coffee, green coffee, per kg product (WFLDB)/GLO U	Gate-to-gate process	WFLDB 3.5
Tea	Tea, dried {RoW}| tea production, dried | Cut-off, S	Cradle to gate	ecoinvent 3.8[1]
Eggs (white, yolk, white and yolk)	Whey powder production, processing/FR U	Gate to gate	AGRIBALYSE
Milk (depending on fat content)	Skimmed milk, powder, at feed, plant /FR U	Gate to gate	AGRIBALYSE[19]
Vegetables, fruits and nuts	Water evaporated, Drying process, Vacuum rotary, 1 kg water AGB(3.0) /FR U	Cradle to gate	Newly created dataset see Annex 18 [20]
Apricots, herbs, figs, prune, raisin	[Dummy] Sun drying, at processing/FR U	Cradle to gate	AGRIBALYSE

[1] *ecoinvent 3.8 dataset is cradle to gate; it does not account for specific French raw material nor electricity consumption mixes.*

For all vegetable and fruits food items, we assume the drying process happens at farm. Cradle to gate processes have been created accounting for mass balance, including water evaporated. Mass balance between fresh and dried vegetables and fruits have been calculated using the CIQUAL water content for fresh and dried items. Annex 8 details the computation for all dried fruits and vegetables.

example: water content for fresh banana is 75,8 g/100g and for dried banana is 3g/100g.

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

meaning we need 4,01 g of fresh banana as input to obtain 1g of dried banana as output.

3.2.2 Dairy products

Table below presents the datasets used for each dairy product cradle to gate processing. Ewe's and goat cheese datasets are built by adapting cow milk data from ACYVIA. Milk ratios for each dairy products are adapted based on ACTALIA expertise and data.

Annex 9 for more information.

Table 3 : Dairy products processed food items

Food items	Dataset(s) and proxies	Comment	Database
Soft cow cheese Semi soft cow cheese	cheese production; from raw milk, soft cheese; French production mix, at plant; PDi	Milk yield adapted for each cheese (ACTALIA)	ACYVIA
Hard, semi hard cow cheese	cheese production; from raw milk, hard cheese; French production mix, at plant, PDi	Milk yield adapted for each cheese (ACTALIA)	ACYVIA
Soft ewe's cheese	Adapted dataset from "cheese production; from raw milk, soft	cow milk changed to ewe's milk; milk yield updated to	Adapted from ACYVIA

[18] Il est traité comme de la "morue, crue", sans tenir compte du sel et du séchage
[19] Attention jeu de données destine à l'alimentation animale.
[20] Ce jeu de données a été créé à l'origine pour le séchage des algues et a été appliqué au "séchage des fruits" comme proxy. Le jeu de données sur le séchage est basé sur la déshydratation rotative sous vide, qui n'est pas la technologie la plus couramment utilisée pour d'autres produits que les algues. Par exemple, d'après (Sanjuán et al., 2014), le séchage des fruits se fait au four pendant une période importante (~ quelques semaines). Par conséquent, l'utilisation de ce séchage spécifique à l'algue n'est pas totalement adapté

Food items	Dataset(s) and proxies	Comment	Database
Semi-soft ewe's cheese	cheese; French production mix, at plant, PDi"	4.2 kg_{milk}/kg_{cheese} and mass balance adjusted on whey Milk yield adapted for each cheese (ACTALIA)	
Hard ewe's cheese Semi-hard ewe's cheese	Adapted dataset from "cheese production; from raw milk, hard cheese; French production mix, at plant, PDi"	cow milk changed to ewe's milk; milk yield updated to 6.55 kg_{milk}/kg_{cheese} and mass balance adjusted on permeate Milk yield adapted for each cheese (ACTALIA)	Adapted from ACYVIA
Soft goat cheese Semi-soft goat cheese	Adapted dataset from "cheese production; from raw milk, soft cheese; French production mix, at plant, PDi"	cow milk changed to goat milk; milk yield updated to 7.65 kg_{milk}/kg_{cheese} and mass balance adjusted on whey Milk yield adapted for each cheese (ACTALIA)	Adapted from ACYVIA
Hard goat cheese Semi-hard goat cheese	Adapted dataset from "cheese production; from raw milk, hard cheese; French production mix, at plant, PDi"	cow milk changed to goat's milk; milk yield updated to 11.2 kg_{milk}/kg_{cheese} and mass balance adjusted on permeate Milk yield adapted for each cheese (ACTALIA)	Adapted from ACYVIA
Butter - Unsalted - Salted	Butter, unsalted, at dairy (WFLDB 3.5)/GLO U Butter, salted, at dairy (WFLDB 3.5)/GLO U	Milk yield adapted for each butter, french milk consumption mix is used and French electricity is used (ACTALIA)	WFLDB 3.5[1]
Cream	Cream, from cow milk {RoW}| yogurt production, from cow milk | Cut-off, S	Milk yield adapted for each cream, ingredients are removed, french milk consumption mix is used and French electricity is used (ACTALIA)	ecoinvent 3.8[2]
Milk - Whole - Semi skimmed - Skimmed	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 for each milk (ACTALIA)	ACYVIA ACYVIA ACYVIA
Baby milk, ready for feed	*Proxy: Whole milk (see above)*		ACYVIA
Baby milk, powder	*Proxy; Skimmed milk powder, at feed plant/FR*	Animal feed dataset	Agribalyse 1.4
Condensed milk	Concentrated milk, 25% dry matter, whole milk, unsweetened, at dairy (WFLDB 3.5)/GLO	Milk yield adapted for condensed milk, french milk consumption mix is used	WFLDB 3.5[1]

Food items	Dataset(s) and proxies	Comment	Database
		and French electricity is used (ACTALIA)	
Yogurt	Yogurt, from cow milk {RoW}| production | Cut-off	Milk yield adapted for each cream, ingredients are removed, french milk consumption mix is used and French electricity is used (ACTALIA)	ecoinvent 3.8[2]

[1] WFLDB 3.5 dataset is cradle to gate; it does not account for specific French raw material nor electricity consumption mixes.
[2] ecoinvent 3.8 dataset is cradle to gate; it does not account for specific French raw material nor electricity consumption mixes.

3.2.3 Cereal and legumes products

Table 11 : Cereal and legume products processing

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 3.5)/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 3.5)/GLO	WFLDB 3.5[1]
Potato starch	Potato starch {RoW}| production	ecoinvent 3.8[2]
Maize starch	Maize starch {RoW}| production	ecoinvent 3.8[2]
Tofu	Tofu {RoW}| production	ecoinvent 3.8[2]
Plant-based beverages (soybean, oat, almond, coconut)	*Specific dataset created for each beverage for AGRIBALYSE 3.1*	Adapted from ecoinvent 3.8

[1] WFLDB 3.5 dataset is cradle to gate; it does not account for specific French raw material nor electricity consumption mixes.
[2] ecoinvent 3.8 dataset is cradle to gate; it does not account for specific French raw material nor electricity consumption mixes.

3.2.4 Coffee, chocolate, tea, pasta

Table below provides description of chocolate, coffee, tea and pasta datasets.

Table 12 : Coffee, chocolate, tea, pasta

Food items	Dataset(s)	Database	Comments
Coffee grinding	Roasting and grinding, green coffee (WFLDB 3.5)/GLO U	WFLDB 3.5	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 3.5	Process used is a gate-to-gate process. Consumption mix of coffee raw material is accurate
Coffee spray drying	Transformation into spray-dried soluble coffee, green coffee, per kg product (WFLDB)/GLO U	WFLDB 3.5	Process used is a gate-to-gate process. Consumption mix of coffee raw material is accurate

Coffee, decaffeinated (all)	Same as coffee above, adding “Decaffeination, green coffee, supercritical CO2 process (WFLDB)/GLO U”	WFLDB 3.5	Processes used are gate-to-gate processes. Consumption mix of coffee raw material is accurate
Chicory powder, instant	Proxy “Transformation into spray-dried soluble coffee, green coffee, per kg product (WFLDB)/GLO U”	WFLDB 3.5	Processes used are gate-to-gate processes. Consumption mix of chicory raw material is accurate
Cocoa powder	Cocoa powder, at plant (WFLDB 3.5)/RER U	WFLDB 3.5[1]	
Cocoa butter	Cocoa butter, at plant (WFLDB 3.5)/RER U	WFLDB 3.5[1]	
Dark chocolate	Dark chocolate, at plant (WFLDB 3.5)/GLO	WFLDB 3.5[1]	
Milk chocolate	Milk chocolate, at plant (WFLDB 3.5)/GLO	WFLDB 3.5[1]	
White chocolate	White chocolate, at plant (WFLDB 3.5)/GLO	WFLDB 3.5[2]	
Pasta	Pasta, dried, from durum wheat, at plant (WFLDB 3.5)/GLO U	WFLDB 3.5[2]	
Tea	already dried at consumption mix		

1 Dataset calls “cocoa beans, sun dried, at farm (WFLDB 3.5)”, with a significant impact on Climate change due to Land Use Change.

3.2.5 Soups (dehydrated)

To model the dehydrated soups, stocks and broths, we used the drying process created when developing the Algae dataset, as follows:

Table 13 : Dehydrating processing applied to model dehydrated soups

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

The amount of input fresh soup is calculated based on a retailer dehydrated soup preparation sheet[1]: 11,7 g per 200 ml of water. In order to obtain 1 kg of reconstituted soup at consumer, 55 g of dehydrated soup and 945 ml of water are used. The equivalent amount of processed fresh soup used to make 1 kg of dehydrated soup is 1/0,055 = 18,09 kg.

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

Table 14 : Proxies for two dehydrated soups

Dehydrated soups (hydrated recipe not in CIQUAL)		Proxy	
Name	CIQUAL code	Name	CIQUAL code
Soup, cereals and vegetables, dehydrated and reconstituted, at plant (AGB 3.0) /FR U	25934	Soup, tomato and vermicelli, dehydrated, at plant (AGB 3.0) /FR U	25949

Soup, Moroccan, dehydrated and reconstituted, at plant (AGB 3.0) /FR U	25950	Soup, chorba frik, w meat and frik, at plant (AGB 3.0) /FR U (+ Dehydrating, processing, at plant "dummy process" (AGB 3.0) /FR U)	25915

3.2.6 Cooling and Freezing

For the products that require freezing, a specific dataset has been used to represent this step. Downstream processes such as transport and storage (distribution and retail) also account for the need of lower temperatures.

3.2.7 Sugar and sweets

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Table 15 : Other food items

food item	dataset name(s) /proxy(ies)	Database	Comment
Fructose	Glucose {RER}| glucose production	ecoinvent 3.8[1]	
White sugar	Sugar, from sugar beet {RoW}| beet sugar production	ecoinvent 3.8[1]	
Brown sugar	Sugar, from sugarcane {RoW}| cane sugar production with ethanol by-product	ecoinvent 3.8[1]	
Honey	Dummy input		

3.2.8 Canning

The following processes are used for canning:

Table 15 : canning datasets

process	dataset name(s) /proxy(ies)	Database	Comment
Corn canning	Canning corn, industrial, 1kg of canned product/ FR U	AGRIBALYSE 3	Dataset created by CTCPA for AGRIBALYSE 3.1
Ready meals canning	Canning ready meals, industrial, 1kg of canned product/ FR U	AGRIBALYSE 3	Dataset created by CTCPA for AGRIBALYSE 3.1
Root vegetables canning	Canning root vegetables, industrial, 1kg of canned product/ FR U	AGRIBALYSE 3	Dataset created by CTCPA for AGRIBALYSE 3.1
Vegetables canning	Canning vegetables, industrial, 1kg of canned product/ FR U	AGRIBALYSE 3	Dataset created by CTCPA for AGRIBALYSE 3.1
Fruit and vegetable canning	Canning fruits or vegetables, 1kg of canned product/ FR U	AGRIBALYSE 3	Newly developed dataset see Annex 18
Tuna canning	Canning Tuna, industrial, 1kg of canned product/ FR U	AGRIBALYSE 3	Dataset created by CTCPA for AGRIBALYSE 3.1
Sardine or mackerel canning	Canning sardine or mackerel, industrial, 1kg of canned product/ FR U	AGRIBALYSE 3	Dataset created by CTCPA for AGRIBALYSE 3.1
Fish canning, in brine	Fish canning, in brine/FR U	AGRIBALYSE 3, 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 1 kg of fish residues as waste.

Regarding canned legumes, they are cooked prior to being canned. In this specific case, the cooking itself (and related energy) has not been accounted for. However, the raw to cook ratio has been applied to those legumes, and the mass canned is the cooked one.

3.2.9 Recipes processing

- **Recipe pre-processing for ingredients**

Some of the ingredients used in the recipes are pre-processed before being mixed in the recipe with the other ingredients.
The different pre-processes are detailed in the table below:

Table 15 : Several preprocess definition for food category

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

Note: preprocesses and examples in the last column are not exhaustive.
Note: the products added in the updates of AGRIBALYSE (example AGRIBALYSE 3.1) may contain more precise modeling for these stages.

Other preprocesses are not considered in the recipe preprocesses but before in the value chain (at production):

- Slaughtering
- Grinding
- Drying.

The following preprocesses have been ignored:

- Cutting

Braising and grilling have been approached by cooking[21] preprocess.

Lastly, canning is also defined for fish, meat, and fruits and vegetables[21].

3.3 Recipes

In addition to raw ingredients and processes, about 1400 recipes can be found in the CIQUAL database. In order to implement these recipes as datasets in Agribalyse, the recipe composition needs to be collected (i.e: the part of each ingredients). Two sources of recipes were used:

- ANSES recipes (514)
- Retailer recipes (49)
- Recipes from public sources like Open Food Facts

[21] * LCI "Canning, fruits and vegetables" created for AGRIBALYSE 3, see Annex 18

- Existing LCA datasets for some industrial products (ex: cacao powder)

We used different sources for recipe composition:

- Retailer: industrial and recent recipe from France and thus, the most adapted for AGRIBALYSE 3,
- ANSES: home-made recipe from France, assumed to be similar as industrial ones and thus the second most adapted for AGRIBALYSE 3
- Open Food Facts : reciped found on sold products
- LCA existing dataset: recipe and dataset not specific to France (Cocoa powder, at plant (WFLDB 3.5)/RER U)

Some recipes had to be approached through proxies:

- Either by a dataset for a recipe existing in another LCA database (aggregated dataset), e.g. : CIQUAL item "Dark chocolate bar, more than 40% cocoa, for cooking (CIQUAL Code : 31085)" is approached by the dataset "Dark chocolate, at plant (WFLDB 3.5)/GLO U" from WFLDB. or
  - Or by approaching a CIQUAL item by another CIQUAL item (e : "Rillettes, fish; 8080 by Rillettes, tuna; 8082)

Some recipes were excluded because of their occasional consumption frequency or because there were average foods (from CIQUAL nomenclature) with no adapted exact recipe (84) (see § 3.3.6).

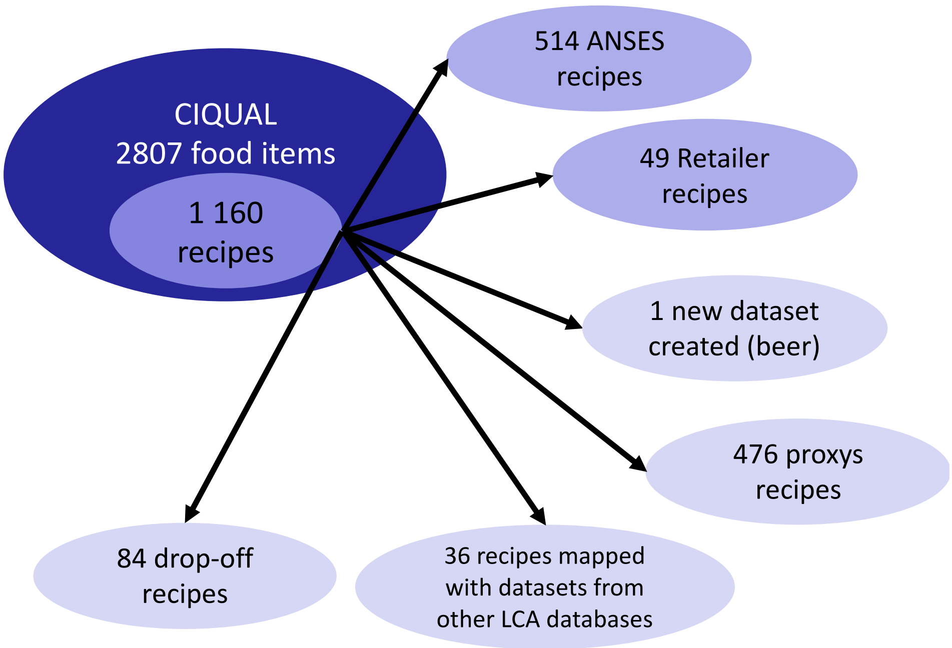

Figure 9: Recipes origin for AGRIBALYSE 3.0

3.3.1 95 % mass cut-off for recipes

A 95% mass cut-off has been applied for recipes. Hence, ingredients with a low mass were removed from the modeling (ex: salt, spices, additives etc.).

Remaining Ingredients after cut-off were then normalised to 100%.

Table 16: Example of "Puffed cereals textured bread" (7353) – Ingredient cut-off rules

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

For some products in particular, products representing less than 5% by weight may still have been counted (for example: chocolate milk: taking cocoa into account).

3.3.2 ANSES recipes

Despite being actually homemade recipes, ANSES recipes are assumed to be similar to industrial ones. ANSES recipes detail all ingredients composing a recipe and the proportion of each ingredient.
See list in Annex 11.

If the ingredient is cooked, the actual quantity of ingredient had to be computed as raw, using the raw to cook information. For most fruits and vegetables included in recipes, inedible losses also had to be applied upstream, prior to entering the recipe.

The datasets selected for meat entering a recipe as ingredient are all “without bone”. For chicken and beef, we used specific datasets “for processing” (cf. § “Specific raw materials), whereas for other meats we used similar datasets as “for direct consumption”.

N.B: We chose to stay consistent with ANSES recipes even when we suspect some mistakes in them (e.g : The recipe “ Poultry sausage” 30131 does not contains poultry but beef ; the recipes “Cocktail sausage” 30746 and “Strasbourg sausage” 30742 contain beef and pork - and not only pork). These limits are to be addressed in future updates.

3.3.3 Retailer recipes

Forty-nine (49) industrial recipes (corresponding to missing ANSES Recipes) have been supplied by a retailer. They are based on their own in-house brand. They correspond to the “most common” CIQUAL product on the market as much as possible. As for ANSES recipes, these recipes detail all ingredients and proportions.

See list in Annex 12.

3.3.4 Recipe Mapping

- **ANSES recipes and retailer recipes**

The ANSES recipes and the retailer recipes have been “directly” matched to CIQUAL recipes.

CIQUAL Recipe Name	CIQUAL Code	Matched ANSES or Retailer Recipe
Doughnut filled with jam	23881	Beignet fourré à la confiture de framboise

See list in Annex 13.

- **Remaining recipes after the mapping with ANSES and retailer recipes**

    - 1. Mapping with existing recipe datasets in LCA database.

    For remaining recipes, a research was done in the following LCA database: Acyvia, Ecoinvent 3.8, WFLDB and PEF and thirty-six (36) recipe datasets were identified and matched to CIQUAL recipes.

    See list in Annex 13.

    - 2. For missing recipes, proxies (476) were used:
        - Either by mapping with existing ANSES or Retailer recipes

For example:

CIQUAL Recipe Name	CIQUAL Code	Proxy from ANSES / Retailer Recipe.
Swedish toast, with linseeds	7409	Cereals sliced bread

- Or by mapping and replacing one or more ingredients in the recipe

For example:

CIQUAL Recipe Name	CIQUAL Code	Proxy from ANSES / Retailer Recipe	Modification in the proxy Recipe
Pizza, chicken	26272	Ham and cheese pizza	Replacing "ham" ingredient by "chicken"

3.3.5 New recipe dataset created

Regarding its consumption frequency and used in other recipes, we decided to create a new dataset for beer: beer, regular (4-5° alcohol) (CIQUAL Code: 5001) which is used as proxy for the six (6) other beers. The methodology is described in Annex 18.

3.3.6 Recipe drop-offs

Several recipes were excluded because of their occasional consumption frequency or because there were average foods in CIQUAL nomenclature with no adapted recipes. For instance, we do not provide an "average Paté" (drop off), but we have some specific ones (Pig paté etc.) See list in Annex 15.

3.3.7 Recipe processing

At plant, energy is used for processing the ingredients into a recipe.
Here below is the list of processes happening at plant and defined for CIQUAL recipes. Regarding the lack of data on industrial processing, we often used a proxy (see table below):

Table 17 : Dataset used for recipe processes

Process at factory	Dataset used

Cooking	*Cooking (AGRIBALYSE 3)
Boiling	*Cooking (AGRIBALYSE 3)
Roasting	Proxy cooking (AGRIBALYSE 3)
Braising	Proxy cooking (AGRIBALYSE 3)
Frying (incl. deep frying)	Proxy cooking (AGRIBALYSE 3)
Grilling	Proxy cooking (AGRIBALYSE 3)
Pre-cooking	Proxy cooking (AGRIBALYSE 3)
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	Dummy “Juicing, at processing (AGB 3.0) /FR U
Salting fish	Proxy "Salting meat" (ACYVIA)
Canning	Canning, fruits and vegetables (AGRIBALYSE 3) Fish canning

All process datasets are defined for 1kg of recipe.

N.B:

- Canning fruits and vegetables and Cooking are new datasets created specifically for AGRIBALYSE 3 (See Annex 18 and specific report of CTCPA for details on those datasets).
- Cooking is also considered (on top of the energy consumption in the dataset “cooking”) by the raw to cook ratio (mass balance with water evaporated).
- Mixing process (for doughs, biscuits etc.) was considered but the mixing process is a dummy.
- Cold and freezing operations are only considered during transportation, at retailer and at consumer. It is not included at the factory level (no impact considered for the industrial process because of lack of dataset).

3.4 Packaging

Production of packaging is accounted for as well as end of life of packaging. The geographical scope used is the world (mainly European datasets) for packaging production and France for packaging end of life.

- **Production**

For simplification, all B2B (business-to-business) packaging is not accounted for in this study. Regarding the B2C (business-to-consumer) packaging, only the production and forming of **primary** packaging is considered. Indeed, secondary and tertiary packaging are negligible in comparison to primary packaging regarding environmental impact due to the low weight of secondary and tertiary packaging when adjusted to the functional unit.[22]

[22] See p29, p35 and p43 of the report Life Cycle Assessment of example packaging systems for milk, WRAP, 2010

Primary packaging material is defined for each food group (i.e.: “cardboard” for “soups” CIQUAL sub-group).
For packaging mass ratio (i.e. the ratio between the packaging mass and the ingredient mass), FoodGES data are used.

See Annex 17 for the list of packaging chosen by food sub-groups.

Table 18 : Extract of the packaging materials and mass for food groups

Food item Sub-group	**Packaging material**	**Mass ratio** (packaging mass in kg / ingredient mass in kg)
Cheese	LDPE	0,05
Herb	Glass	0,05
Turkey ham	PS	0,05
Soups	Cardboard	0,1

<u>Assumptions</u>

- For simplification, we assume that all fruits had no packaging, and
- In case of composed packaging, only the heavier packaging is accounted for (e.g.: inner bag for cereals is not accounted for, the only packaging material considered for cereals is the “cardboard” box).

Background LCA data

- Materials

All packaging materials are available in the Ecoinvent database. Most plastics are taken at granulate production level. Secondary transformation (e.g. moulding) has negligible environmental impact as compared to the material extraction and first transformation.

When available, material grade is chosen accordingly to the packaging application. Chosen datasets are in the table below.

Table 19 : datasets for packaging materials

Packaging Material	**Dataset Name**	**Forming process**
Production of Cardboard (kg)	Corrugated board box {RER}| production | Cut-off, U	Included in the dataset
Production of Paper (kg)	Kraft paper, unbleached {RER}| production | Cut-off, U	Included in the dataset
Production of Chromium steel (kg)	Steel, chromium steel 18/8 {GLO}| market for | Cut-off, U	Impact extrusion of steel, cold, deformation stroke {RER}| processing | Cut-off, U
Production of Modified starch (kg)	Polylactide, granulate {GLO}| production | Cut-off, U	Extrusion of plastic sheets and thermoforming, inline {FR}| processing | Cut-off, U
Production of EPS (kg)	Polystyrene, expandable {RER}| production | Cut-off, U	Included in the dataset
Production of Glass (kg)	Packaging glass, white {RER w/o CH+DE}| production | Cut-off, U	Included in the dataset
Production of PP (kg)	Polypropylene, granulate {RER}| production | Cut-off, U	Extrusion of plastic sheets and thermoforming, inline {FR}| processing | Cut-off, U

Production of PET (kg)	Polyethylene terephthalate, granulate, bottle grade {RER}| production | Cut-off, U	Extrusion of plastic sheets and thermoforming, inline {FR}| processing | Cut-off, U
Production of LDPE (kg)	Packaging film, low density polyethylene {RER}| production | Cut-off, U	Thermoforming, with calendering {RER}| production | Cut-off, S
Production of HDPE (kg)	Polyethylene, high density, granulate {RER}| production | Cut-off, U	Extrusion of plastic sheets and thermoforming, inline {FR}| processing | Cut-off, U
Production of Steel (kg)	Steel, unalloyed {RER}| steel production, converter, unalloyed | Cut-off, U	Impact extrusion of steel, cold, deformation stroke {RER}| processing | Cut-off, U
Production of LPB (kg)	Liquid packaging board {GLO}| production | Cut-off, U	Included in the dataset
Production of PVC (kg)	Polyvinylchloride, suspension polymerised {RER}| polyvinylchloride production, suspension polymerisation | Cut-off, U	Extrusion of plastic sheets and thermoforming, inline {FR}| processing | Cut-off, U
Production of Aluminium (kg)	Aluminium, primary, ingot {RoW}| production | Cut-off, U	Impact extrusion of aluminium, deformation stroke {RER}| processing | Cut-off, U

A particular rule is put together for packaging related to “processes” (category 3) and “process + use” (category 4) food items for which the related process comes from Acyvia. In this case, Acyvia datasets already account for primary packaging, and this packaging has been kept as is. End of life of Acyvia packaging is accounted for at use stage.

For “recipe” type food items (category 5) that are related to ingredients, themselves stemming from Acyvia datasets, there is a sort of “double counting” of packaging that the user has to be aware of.
As an example, “ground beef” is an ingredient of CIQUAL item lasagna (ID number 25081). Acyvia dataset for ground beef includes packaging for consumer consumption (“Fresh ground beef production; industrial production; French production mix, at plant; 1 kg of fresh ground beef”). Lasagna dataset also accounts for this retail type packaging of ground beef which is inaccurate, and should be updated in later versions of this database.

- Packaging transport

Packaging dataset origin is Europe (RER) by default.

Table 20 : transport datasets for packaging

Packaging material	**Origin country**	**Dataset name**
All	RER	Transport, freight, lorry 16-32 metric ton, EURO6 {RER}| market for| Cut-off, U

- End of Life

After cooking and eating at the consumer, the last stage of the process to mouth is the end of life of the packaging material. In order to model French municipal waste management scenario, each material is treated via recycling, incineration and landfill with specific share.

Recycling rates are based on French Waste Observatory SINOE[23] (ADEME) except for steel packaging, for which we use data from FEDEREC, 2017 study[24] which seems more reliable. According to waste collection key figures from ADEME[25], household waste treatment is 32 % incinerated and 26 % is landfilled. We assume that depending on the recycling rate of each material, the remaining packaging waste share is either landfill or incinerated. For any material not recycled the end of life treatment is:

- 0,26/(0,26+0,32) = 45 % landfill
- And 55 % incinerated.

The table below summarizes the distribution between each end of life scenario for all materials. The formula used to calculate share between each process is detailed for PET and HDPE.

Table 21 : end of life scenario according to packaging material

Material	Recycling	Landfill	Incineration
Glass	85%	15%	N/A
Plastics (PET-HDPE)	57%	(1-0,57)*0,45 = 19%	(1-0,57)*0,55 = 24%
Plastic (others)	4%	43%	53%
Paper and Cardboard	65%	16%	19%
Aluminium	42%	26%	32%
Steel	76%	11%	13%
Chromium steel	76 %	24%	N/A

Note: incineration datasets for chromium steel and glass do not exist in Ecoinvent database.

End of life of packaging items approximated by ACYVIA is accounted for at use stage, for category 1 (raw), 2 (raw+use), 3 (processed), 4 (processed+use) products (see Table 3). For food items of category 5 (recipes), using ingredients that are linked to an ACYVIA process, disposal of the food item packaging is accounted for but not the packaging of the related ingredients.

Example in the recipe “Sandwich made with French bread, camembert cheese and butter”. The ingredient “Camembert cheese” is approached by the Acyvia dataset “Cheese production; from raw milk, soft cheese; French production mix, at plant; 1 kg of soft cheese (PGi)”. Disposal of the sandwich packaging is accounted for but not disposal of the camembert cheese package used in the recipe.

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[23] Page 5, Tableau de bord – Déchets d’emballages ménagers. SINOE, ADEME, 2017. Available at: https://www.sinoe.org/documents/consult-doc/idDoc/873

[24] Page 96, Évaluation environnementale du recyclage en France se la méthodologie de l’analyse de cycle de vie. FEDEREC, 2017. Available at: https://presse.ademe.fr/wp-content/uploads/2017/05/FEDEREC_ACV-du-Recyclage-en-France-VF.pdf

[25] Figure 35 page 42, https://www.ademe.fr/sites/default/files/assets/documents/dechets-chiffres-cles-edition-2016-8813.pdf

Background LCA data

Proxies regarding material type are given in the table below.

Table 22: End of life dataset proxies for packaging materials

Packaging material	Treatment	Dataset name
Disposal/waste processing of Cardboard (kg)	Landfill	Waste paperboard {CH}| treatment of, inert material landfill | Cut-off, U
Disposal/waste processing of Cardboard (kg)	Incineration	Waste paperboard {CH}| treatment of, municipal incineration with fly ash extraction | Cut-off, U
Recycling processing of Carboard (MJ)	Recycling	Electricity, low voltage {FR}| market for | Cut-off, U
Disposal/waste processing of Paper (kg)	Landfill	Waste paperboard {CH}| treatment of, inert material landfill | Cut-off, U
Disposal/waste processing of Paper (kg)	Incineration	Waste paperboard {CH}| treatment of, municipal incineration with fly ash extraction | Cut-off, U
Recycling processing of Paper (MJ)	Recycling	Electricity, low voltage {FR}| market for | Cut-off, U
Disposal/waste processing of Chromium steel (kg)	Landfill	Scrap steel {Europe without Switzerland}| treatment of scrap steel, inert material landfill | Cut-off, U
Disposal/waste processing of Chromium steel (kg)	Incineration	N/A
Recycling processing of Chromium steel (kg)	Recycling	Treatment of waste reinforcement steel {RER}| recycling | Cut-off, S
Disposal/waste processing of Modified starch (kg)	Landfill	Waste plastic, mixture {GLO}| treatment of waste plastic, mixture, unsanitary landfill, wet infiltration class (500mm) | Cut-off, U
Disposal/waste processing of Modified starch (kg)	Incineration	Waste plastic, mixture {CH}| treatment of, municipal incineration | Cut-off, U
Recycling processing of Modified starch (MJ)	Recycling	Electricity, low voltage {FR}| market for | Cut-off, U
Disposal/waste processing of EPS (kg)	Landfill	Waste polystyrene {GLO}| treatment of waste polystyrene, unsanitary landfill, wet infiltration class (500mm) | Cut-off, U
Disposal/waste processing of EPS (kg)	Incineration	Waste expanded polystyrene {CH}| treatment of, municipal incineration with fly ash extraction | Cut-off, U
Recycling processing of EPS (MJ)	Recycling	Electricity, low voltage {FR}| market for | Cut-off, U
Disposal/waste processing of Glass (kg)	Landfill	Waste glass {CH}| treatment of, inert material landfill | Cut-off, U
Disposal/waste processing of Glass (kg)	Incineration	N/A
Recycling processing of Glass (MJ)	Recycling	Electricity, low voltage {FR}| market for | Cut-off, U
Disposal/waste processing of PP (kg)	Landfill	Waste polypropylene {GLO}| treatment of waste polypropylene, unsanitary landfill, wet infiltration class (500mm) | Cut-off, U
Disposal/waste processing of PP (kg)	Incineration	Waste polypropylene {CH}| treatment of, municipal incineration with fly ash extraction | Cut-off, U
Recycling processing of PP (MJ)	Recycling	Electricity, low voltage {FR}| market for | Cut-off, U
Disposal/waste processing of PET (kg)	Landfill	Waste polyethylene terephtalate {CH}| treatment of waste polyethylene terephthalate, sanitary landfill | Cut-off, U
Disposal/waste processing of PET (kg)	Incineration	Waste polyethylene terephtalate {CH}| treatment of waste polyethylene terephthalate, municipal incineration with fly ash extraction | Cut-off, U
Recycling processing of PET (MJ)	Recycling	Electricity, low voltage {FR}| market for | Cut-off, U
Packaging material	Treatment	Dataset name
Disposal/waste processing of LDPE (kg)	Landfill	Waste polyethylene {GLO}| treatment of waste polyethylene, unsanitary landfill, wet infiltration class (500mm) | Cut-off, U
Disposal/waste processing of LDPE (kg)	Incineration	Waste polyethylene {CH}| treatment of, municipal incineration with fly ash extraction | Cut-off, U
Recycling processing of LDPE (MJ)	Recycling	Electricity, low voltage {FR}| market for | Cut-off, U
Disposal/waste processing of HDPE (kg)	Landfill	Waste polyethylene {GLO}| treatment of waste polyethylene, unsanitary landfill, wet infiltration class (500mm) | Cut-off, U
Disposal/waste processing of HDPE (kg)	Incineration	Waste polyethylene {CH}| treatment of, municipal incineration with fly ash extraction | Cut-off, U
Recycling processing of HDPE (MJ)	Recycling	Electricity, low voltage {FR}| market for | Cut-off, U
Disposal/waste processing of Steel (kg)	Landfill	Scrap steel {Europe without Switzerland}| treatment of scrap steel, inert material landfill | Cut-off, U
Disposal/waste processing of Steel (kg)	Incineration	Scrap steel {Europe without Switzerland}| treatment of scrap steel, municipal incineration | Cut-off, U
Recycling processing of Steel (kg)	Recycling	Treatment of waste reinforcement steel {RER}| recycling | Cut-off, S
Disposal/waste processing of LPB (kg)	Landfill	Waste plastic, mixture {GLO}| treatment of waste plastic, mixture, unsanitary landfill, wet infiltration class (500mm) | Cut-off, U
Disposal/waste processing of LPB (kg)	Incineration	Waste plastic, mixture {CH}| treatment of, municipal incineration | Cut-off, U
Recycling processing of LPB (MJ)	Recycling	Electricity, low voltage {FR}| market for | Cut-off, U
Disposal/waste processing of Aluminium (kg)	Landfill	Municipal solid waste {GLO}| treatment of municipal solid waste, unsanitary landfill, wet infiltration class (500mm) | Cut-off, U
Disposal/waste processing of Aluminium (kg)	Incineration	Scrap aluminium {Europe without Switzerland}| treatment of scrap aluminium, municipal incineration | Cut-off, U
Recycling processing of Aluminium (kg)	Recycling	Treatment of aluminium scrap {RER}| post-consumer, prepared for recycling, at refiner| Cut-off, S
Disposal/waste processing of PVC (kg)	Landfill	Waste polyvinylchloride {GLO}| treatment of waste polyvinylchloride, unsanitary landfill, wet infiltration class (500mm) | Cut-off, U
Disposal/waste processing of PVC (kg)	Incineration	Waste polyvinylchloride {CH}| treatment of, municipal incineration with fly ash extraction | Cut-off, U
Recycling processing of PVC (MJ)	Recycling	Electricity, low voltage {FR}| market for | Cut-off, U

Recycling packaging material is modelled via the stock method. It is collected and transported to a sorting centre (18 km[26]). Material to be recycled is prepared for recycling at the sorting centre. Recycling preparation impacts are neglected as it is assumed in FEDEREC, 2017[27]. The end of life of recycled material ends with the supply of scrap material for recovery.

- **Packaging end of life transport:**

The following assumptions have been chosen:

- Transportation mode : Truck EURO 5, 16-32 tons RER
- Distance: 18 km for collection from household to sorting centre.

3.5 Distribution and retail

Distribution and retail phases are modelled predominantly based on PEF default data from the PEF guidance document (European Commission, 2018). Default data are therefore defined for cooling, freezing, lighting and heating during those stages. These parameters depend on the defined storage time as well as the products density, i.e. the volume that the product occupies per kg product (Charrondiere et al., 2012). The use of storage time and density as parameters to estimate the energy use is elaborated in the text box below.

Products density

How product's life time and density relate to the energy consumption at the distribution:

The energy requirement of products at distribution are determined in unit energy per m^3, in the PEF Guidance Document. So, each product needs to be allocated some occupied space and time. An average distribution centre can store 60000 m^3 of product. The storage period on a year basis is 52 weeks, i.e., 3120000 m^3-weeks/year. The total capacity is then allocated with the following storage volumes and times:

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

Density used is presented in the Table below. For fruits and vegetables, FAO Density database Version 2.0 from FAO INFOODS database (Charrondiere, U. R., Haytowit, D., & Stadlmayr, 2012) has been used. Large groups are made to assign density to all fruits, vegetables. Other density (for liquids) are presented in Table 6 (see section 2.6.3 Density for liquids).

[26] Page 194, Bio Intelligence Service, AJI-Europe, BP2R. 2012. Transport et logistique des déchets – Rapport final. ADEME. 281 pages.

[27] Page 55, Évaluation environnementale du recyclage en France se la méthodologie de l'analyse de cycle de vie. FEDEREC, 2017. Available at: https://presse.ademe.fr/wp-content/uploads/2017/05/FEDEREC_ACV-du-Recyclage-en-France-VF.pdf

Table 23 : assumptions for product density according to categories and type of food item

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 agrumes
	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, nuts and seeds and corn…
	Spinach	0,118	Proxy for lettuce, endives, cress, sorrel, mushrooms (very light food)
	Chili	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)
	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	

Some densities were evaluated by the french technical institute CTCPA, available in the methodological report[28].

- **Losses**

Losses for distribution and retail are accounted for at retail (conservative option), according to data in Annex 3 of OEFSR ((Quantis et al., 2015), recalled in the table below.

Table 24 : Losses at Retail

[28] COLOMBIN Margaux, AUDOYE Pauline, FARRANT Laura, LABAU Marie-Pierre, CTCPA, juillet 2022. Rapport Méthodologique pour les produits élaborés CTCPA AGRIBALYSE V3.1 : INVENTAIRES PRODUITS, PROCEDES ET DONNEES SUR LES PERTES ET LE STOCKAGE. 79 pages.

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%

For distribution at retail assignment for recipes (category 5) is made according to table below.

Table 25 : Losses at retail – assignment of recipe food products

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%

The losses associated with certain products have been adapted under the recommendations of the CTCPA: to find out more, refer to the associated methodological report.

3.5.1 Distribution

An average distribution centre can store 60,000 m^3 of product. The storage period on a year basis is 52 weeks, i.e., 3,120,000 m^3-weeks/year. PEF default cooling and freezing energy requirements per m^3 are used to compute the values used presented in Table 26 below. Distance to distribution is assigned according to (ADEME & AFNOR, 2012). Distribution parameters were adapted for products created by CTCPA.

Table 26 : Overview of defaults used for distribution phase

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 (middle)	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 (middle)	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 (middle)	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

Values for density are needed for using the PEF defaults. We estimated density for each CIQUAL items (See page 52).

Table 27: Calculated energy demand, water use and R404a emissions per cubic meter of product for distribution phase

Type of delivery	Storage volume (volume/ product)	Storage time (weeks)	Storage demand (m^3-week)	Lighting (kWh/m3)	Heating (MJ/m3)	Cooling (kWh/m3)	R404a (kg/m3)	Water use (L/m3)
Ambient (middle)	4	4	16	4.61	55.38	NA	NA	1.872
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

- **Ambient storage:** ambient storage time can be different depending on the food category. We thus decided to define ambient storage time (short, middle or long) as listed below:

Table 33: Ambient storage time depending on food group

CIQUAL sub-groups	**Ambient long** (4 weeks at retail and 4 weeks at distribution centre (DC))	**Ambient middle** (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, crepe 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. legumes	x		
0204. fruits		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 under the recommendations of the CTCPA: to find out more, refer to the associated methodological report.

- Food losses end-of-life

In France, "Garot law (2015) prevents retailers from throwing away food which is not suitable for sale but which can be eaten. We assume that it represents a significant part of food waste at distribution.

We thus decided to model the food losses end of life as follow:

- 50% cut-off[29] (food given away, no impact)
- 30% incinerated[30]: Biowaste {GLO}| treatment of biowaste, municipal incineration | Cut-off, S
- 16,6% digesting[30]:Biowaste {RoW}| treatment of biowaste by anaerobic digestion | Cut-off, S
- 3,4% composting[30]: Biowaste {RoW}| treatment of biowaste, industrial composting | Cut-off, S

For drinks it will be disposed as:

- 100% waste water: Wastewater, from residence {RoW}| market for wastewater, from residence | Cut-off, S

3.5.2 Retail (supermarket)

PEF default cooling and freezing energy requirements per m^3 are displayed in Table 33 and used to compute the values used presented in Table 34 below.

Table 28 Overview of data used for retail phase

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 (middle)	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 (middle)	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

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

[30] 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

Table 29: Calculated energy demand and R404a emissions per ton of product for retail phase

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

3.6 Transport along the value chain

- **Raw material transport to processing plant /distribution center (except fish and dry fruits)**

The logistics from agricultural production to processing are as a baseline determined on the basis of the country mixes. For some country-crop combinations more specific transport scenarios are defined such as soybeans from Brazil. We used data from different sources (depending on the country) to estimate distances and transport modalities of country-crops combinations (see Table 31 below), according to (Wageningen University, 2013).

The transport model consists of two parts. First the distance within the country of origin (where the crop/livestock is grown) is estimated, it is assumed that the crops are transported from growing areas to central collection hubs (i.e: the geographical midpoint of the country) (1). From there, the crops are subsequently transported to the processing country (2).

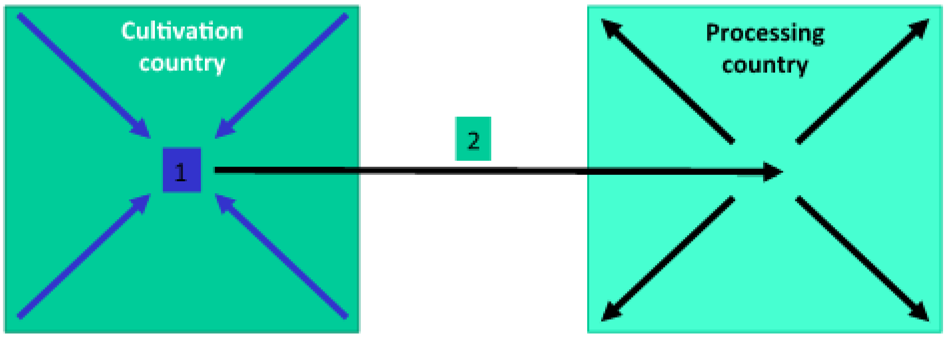

Figure 10: Generic transport model from a central hub in land of cultivation to the location in a processing country.

Datasets for refrigerated vehicles have been used depending on the food items according to the table below.

Table 30 : Datasets for refrigerated vehicles

	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

(1) Transportation in the origin country from growing areas to central collection hubs

For domestic transport and within the EU, EuroStat (European Commission, 2014) provides detailed statistics for average transport modes and distances for goods within a country. These data have been used as proxy for the average distance and mode of transport of crops. For the United states, the average distance and transport mix is based on the GREET model (Elgowainy et al., 2014). For countries outside the EU, distances are based on literature when available or expert judgment based on past experience (these distances have often been carried over from the Feedprint method (Vellinga, T.V., Blonk, H., Marinussen, M., van Zeist, W.J., de Boer, 2012).

Table 31 : References for transportation modelling

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

(2) Importation to France (transportation from growing country to processing country)

We simplify with the hypothesis that the processing country is always France. Data on the transport mix from EuroStat (European Commission, 2014) are used (modal split; e.g 10% of goods is transported by truck, 50% rail, 30% inland waterways, 10% short sea shipping). The transport distance is estimated using google maps (the distance between geometric centres).

Specific case: for Kenyan French bean and mangoes, transportation mode is plane. We duplicated the dataset French bean and Mango in AGRIBALYSE 3, kept the same CIQUAL Code and changed the name for:

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

- **Raw material transport – dry products**

As presented in section 3.2.1, dry fruits and vegetables are assumed to be dried on their farming location. In order to avoid a transport gap, an additional transport has been added of 5000 km by boat for dry products.

For fish and meat, they are assumed to arrive as "raw materials" to France, the inedible parts removed in France, and the drying happening in France.

- **Raw material transport (fish)**

Transport for fish from France is accounted for from harbor to plant or distribution. For fish from Europe, it is assumed to be 1000 km in refrigerated truck and 10 000 refrigerated ship for fish from the rest of the world (RoW).

- **Pre-processed ingredient transport**

  We assumed the distance between pre-processed ingredients place and recipe place is 0 km.

- **Transport – from processing to recipe**

For food items that are recipes (category 5) using ingredients that are raw materials (category 1) and / or processed raw materials (category 3) we assume there is no transport between processing to recipes. The only exception is the transport of alcohol (wines and brandy) from cellar to plant, assuming transport happens within France, on the same modelling principles as the ones presented in **Erreur ! Source du renvoi introuvable.Erreur ! Source du renvoi introuvable.**.

- **Downstream transport – distribution and retail**

Downstream transport includes transportation from processing place to distribution centers and from distribution centers to retailer (see Figure below). It does not account for transport from retailer to consumer (limitation of our study).

All transport distances are aligned with PEF Guidelines and OEFSR (Quantis et al., 2015). Post processing stages are located in France. Since ecoinvent datasets are not French specific, European and Swiss datasets are selected.

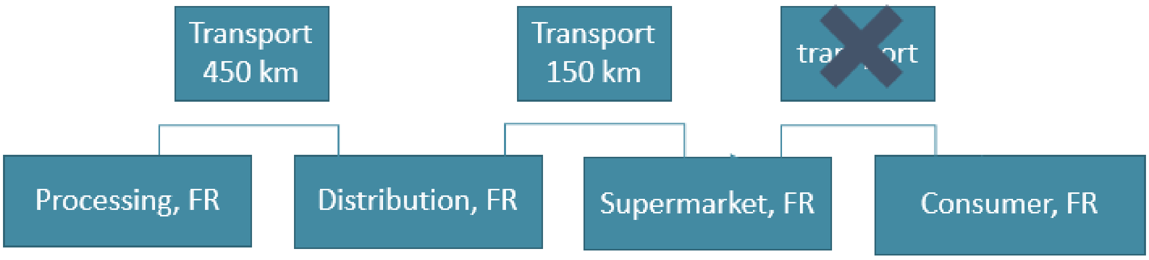

Figure 11: Downstream transportation

- **Background datasets**

All transportation modes are integrated in the database based on country codes so as to give a precise distance at each stage.
Regarding air, rail and water transportation, Ecoinvent databases provides with global (GLO) dataset. Each comes in a reefer version (cooling and freezing), which includes refrigeration process.
We consider two types of boats: barge and ocean ship. Barge is specific to transport from Europe to France while Ocean ship is used for worldwide imported products.
Road transportation comes in multiple versions depending on characteristics described in the table below.

Table 32 : Road transportation specification choices (ecoinvent 3.8)

Characteristics	**Range - options**	**Value selected**	**Comment**
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 tons 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[31]

The choice of European emission standard brings uncertainties for transportation abroad. EURO5 standard is specific to Europe in the recent years. Applying such standard worldwide is inaccurate because the evolution of the fleet does not ensure standard improvement. However, road transportation from farm to plant or seaport/airport in a foreign country is not more important than transportation distances within Europe.

Dataset origin only concerns truck transport. Barge and rail transport only take place in Europe. Other transportation modes are only available in GLO version (see Table below).

Table 33 : Distribution and retail transport datasets

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

3.7 Use phase

We do not account for avoidable food losses at consumer (at home).

All items chilled or frozen during transportation are considered respectively stored at fridge and freezer at consumer.

Food preparation methods and product characteristics with regards to inedible parts and raw-to-cooked ratios are determined for the consumption stage. At this point, the pre-defined packaging material is also disposed. The disposal scenario depends on the type of packaging. Food preparation at consumer is modelled according to default data modelled by Blonk Consultants and which relate on the defined preparation/ cooking scenarios per product. The type of preparation is based on most common practices per food type.

- Definition of preparation scenarios per product:

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

For recipe, we chose a minimum preparation (only reheating) at use phase because recipes are already cooked at plant.

Table 34 : Overview of product preparation scenarios at consummer

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

We model the inedible losses end of life at consumer as follow[32]:

- 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 drinks it will be disposed as:

- 100% wastewater: Wastewater, from residence {RoW}| market for wastewater, from residence | Cut-off, S

[32] ADEME 2019, Résultats de la Campagne nationale de caractérisation des déchets ménagers et assimilés de 2017

Energy for cooking

Energy for cooking is determined by several factors, such as the:

- Type of preparation technique, i.e. nine preparation techniques are considered (Table 35)
- Mass of food (and water) input for preparation (Table 38)
- Electricity and natural gas share to the energy consumed (Table 35, Table 360 and Table 41)

Some types of food preparation, such as the deep frying or microwaving are assumed to use 100% electricity. The rest are using a ration of 40% and 60%, for electricity and natural gas respectively (ADEME & AFNOR, 2012). The type and amount of energy consumed is given in Table 35, Table 360 and Table 41.

Table 35 Overview of preparation techniques and amount of input per kg of input

Preparation technique	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 40 for cooking times*	(60%)	Yes 0,005kg sunflower oil	-
Boiling	(40%) *Refer to Table 41 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)[33]	n/a	-	-
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 was approached by water cooking.

Table 36 Baking time on low and high heat for "Pan frying" preparation times

(e.g.: meat is cooked during 4 min at low heat, 600W and during 7 minutes at high heat, 3500W.)

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

Table 37 Boiling time and added water per kg of product for "Boiling" preparation option

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

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

Table 38: Inputs and added water for beverages prepared at consumers

Beverage	Input (kg/kg)	Water added	Comment
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

Two datasets are used to model the energy input needed to prepare food at 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)

AGB 3.1 is a rather complex database, with a large extent of products covered and using different background databases. Furthermore, approximations and "dummy process" are used. Therefore, the Data Quality Rating (DQR) system has a crucial role. A custom made system was developed to manage efficiently and consistently the DQR at the database level. It is in line with PEF approach, but adapted to our scope.

On one hand, the developed DQR system tries to account for this complexity and non-homogeneity. On the other hand, it shows limitations due to technical limitations and possible subjective interpretation. Such limitations will be clearly explained along this chapter and sub-chapters.

Taking into account the DQR is crucial for a proper use of data. DQR >3 should be considered with great care because they do not allow accurate comparison. They must be used only as "background systems", or be adjusted to correspond better with the user situation.

The Data Quality Rating (DQR) for AGB 3.1 is inspired by the PEFCR guidance ((European Commission, 2018) ch.7.19). Four Data Quality Indicators (DQI's) are considered for the DQR measurement:

- Precision (P)
- Time representativeness (TiR)
- Geographical representativeness (GR)
- Technological representativeness (TeR)

The 4 DQI's are evaluated for the most important life cycle stages (cradle to consumption). In general, 7 main life cycle stages are identified (Figure 12):

1. production of raw material from cradle to market mix formation
2. processing of raw material
3. mixing of processed ingredients (recipe formation)
4. packaging
5. distribution
6. retail at supermarket
7. preparation and consumption.

For each life cycle stages the 4 DQI's should be attributed considering specific characteristics (**Erreur ! Source du renvoi introuvable.**).

Some specific input (e.g. transportation) and some parameters (allocation factors and mass changing ratios such as raw-to-cooked) are considered separately, and the 4 DQI's are specifically rated. Additionally, use of approximations (proxies) is considered at some specific life cycle stages. Proxy are connected to penalty on DQI's. In total 18 different criteria (life cycle stages, additional parameter & inputs) are therefore rated (Figure 12 and Table 43) .

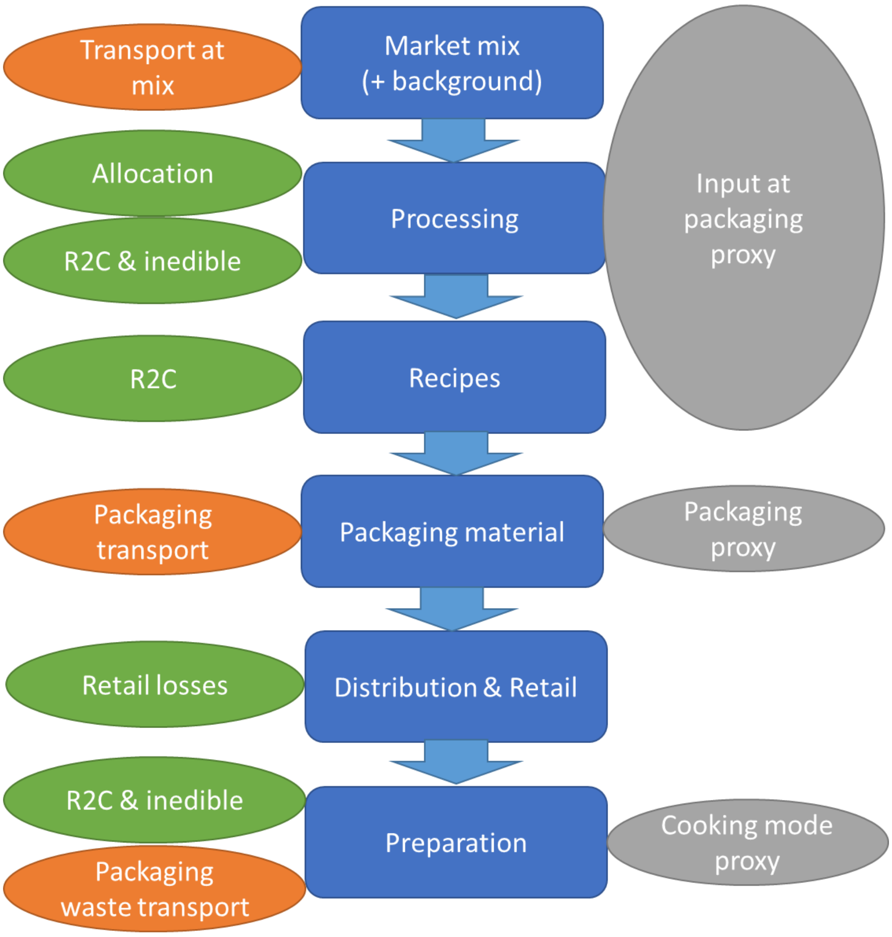

Figure 12: Visualization of all 18 criteria considered for DQR calculation : main life cycle stages (blue boxes), additional parameters (green boxes), transportation (orange boxes) and penalty criteria (grey boxes). Distribution and retail account fo 2 different stages but are merged in the figure.

These 18 evaluations are merged together into one final DQR score through a weighted average. Weighting factors (WFs) are estimated based on a contribution analysis[34] of each of the 15 stages impact to the overall impact. The process for calculating the final product DQR is summarized in the figure below:

[34] For agenda reasons, the contribution analysis is based on "ILCD 2011 Midpoint+ (adjusted for biogenic CO2)" indicators, then converted into a single score according to PEFCR guidance (European Commission, 2018). In the future, the contribution analysis should be done directly on PEF indicators instead of ILCD.

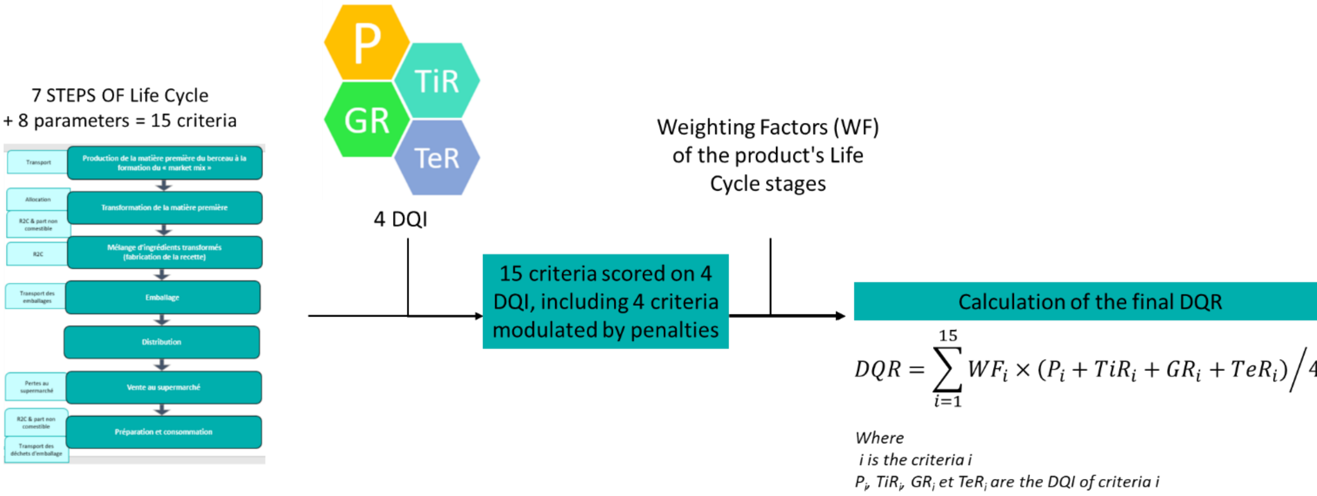

Figure 13 Process for calculating the final product DQR

To reduce the amount of calculations, the WFs is defined at a group level rather than the product level. Final products of AGB3.1 are divided in 21 food category groups (Table 42). For each category group one representative product is selected, and a contribution analysis is performed. The calculated WFs are then used for all the other products in the same food category group. The representative product is selected based on the completeness of its datasets: without use of proxies or dummies. It also considers the fact that as many of the 15 criteria (blue, orange, green) as possible are included in its life cycle. For example, most fruit enter directly packaging after the market mix stage (since they are not processed). Still, there are products in the fruit category group (e.g. fruit salads) that have a processing and recipe stages. Therefore, it was prioritised a processed fruit rather than a raw fruit as representative product for the fruit category group (ex: "Apple compote (H)" is selected rather than raw apple).

The use of category group WFs instead product specific WFs lead to a certain degree of uncertainty in the DQR system. In future updates, effort should be put on automatizing the calculation of WFs in order to permit computation of product specific WFs.

Table 39 shows an example with the final DQR calculated from the WFs and DQIs of each of the 15 steps. The example is based on the product "Chicken burger , fast foods restaurant (H)". The WFs shown in the first line are based on the "sandwiches" category group (cf. Table 41Table 42 WF calculation for the representative product: "Sandwich made with French bread, chicken, raw vegetables (lettuce & tomato) and mayonnaise (H)"). The DQI's shown in line 2 to 5 are assessed for each of the 14 stages, based on Table 40. For each DQI a weighted average (based on WFs) is calculated in line 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).

Table 39 Example of DQR calculation of the product “Chicken burger , fast foods restaurant (H)” (CIQUAL: 25502).

N°	Sandwiches category group	Mix	Mix transport	Process	Process allocation	Process R2C & inedible	Recipe	Recipe R2C	Packaging material	Packaging transport (PEF)	Distribution (PEF)	Retail (PEF)	Retail losses	Preparation transport (PEF)	Preparation cooking mode	Preparation R2C & allocation	Total
1	WF	22.6 %	0.5%	6.4%	1.3%	21.2%	24.9%	7.4%	2.4%	0.1%	4.1%	3.5%	4.7%	0.0%	0.9%	0.0%	100.0 %
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	2.08
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	2.84
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	1.54
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	3.27
10	**Average Final DQR**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**2.4**

1

Table 40 DQI notation for life cycle steps.

Life cycle stage	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 is between 50% and 70% & origin is industry data	3	Data between 5 and 7 years old	3	Production datasets corresponding to similar product to that included in the scope of the dataset, different practices but small change in yield	3	Data are partially based on FR trade statistics, proxies used are not from the same region (non-EU)	3
	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

Life cycle stage	Precision (P)		Time representativeness (TiR)		Technological representativeness (TeR)		Geographical representativeness (GR)	
	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/ calculated/literature and externally verified	1	Data no older than 3 years	1	Process is exactly the same as the process in scope & the input product is the one required for the output in scope for the dataset	1	Data are based on FR production, no proxies are used	1
	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

Life cycle stage	Precision (P)		Time representativeness (TiR)		Technological representativeness (TeR)		Geographical representativeness (GR)	
	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 a 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

Life cycle stage	Precision (P)		Time representativeness (TiR)		Technological representativeness (TeR)		Geographical representativeness (GR)	
Packaging	Coverage % of the packaging mass is 100%	1	Data no older than 3 years	1	The type of packaging raw materials is exactly the same as the one in scope of the dataset	1	Packaging is based on FR market, no proxies are used	1
	Coverage % of the packaging mass is > 90%	2	Data between 3 and 5 years old	2	The type of packaging raw materials is included in the mix of technologies in scope of the dataset	2	Packaging is based on EU market	2
	Coverage % of the packaging mass is > 80%	3	Data between 5 and 7 years old	3	The type of packaging raw materials used are only partly included in or are similar to the scope of the dataset	3	Packaging is based on EU country market	3
	Coverage % of the packaging mass is between 50% and 80%	4	Data between 7 and 10 years old	4	The type of packaging raw materials used are different from those included in the scope of the dataset, good proxy according to expert judgement	4	Packaging is based on a non-EU country, but there are sufficient similarities based on expert judgement	4
	Coverage % of the packaging mass is <50%	5	Data older than 10 years	5	The type of packaging raw materials used are different from those included in the scope of the dataset, bad proxy according to expert judgement / double counting of packaging	5	Packaging is based on a non-EU country	5
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	5	Data are based on a non-EU country	5

Life cycle stage	Precision (P)		Time representativeness (TiR)		Technological representativeness (TeR)		Geographical representativeness (GR)	
					according to expert judgement / double counting of packaging			
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 in the scope of the dataset (expert judgement)	5	The process modelled takes place in a non-EU country	5
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

Life cycle stage	Precision (P)		Time representativeness (TiR)		Technological representativeness (TeR)		Geographical representativeness (GR)	
	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

2

Life cycle stages and additional parameters

In this section, the life cycle chain is analyzed stage by stage, from cradle to consumer. The life cycle stages, additional parameters and eventual penalty are explained. The way of assigning DQI's to these 15 stages are also described.

The first life cycle covers the market mix formation and the production of raw materials. For example, in the production chain of apple, the first life cycle stage does not only include the mix of apples from various world regions, but also the cultivations and all the inputs connected to such systems. This makes the rating of this life cycle stage particularly important and open to subjective interpretations. Such simplification was necessary, due to the different background databases involved in AGB 3.0. Peculiarity in life chain structure of such background databases make the individuation of generic life cycle stages for the DQR system impossible. The precision (P) and geographical representativeness (GR) indicators refer to the coverage of the market mix and the origin of trade data. The time representativeness (TiR) and technological representativeness (TeR) indicators refer to the production of raw materials from background databases.

When the market mix is not expressly indicated, but a raw material is directly used in processes or recipes, the raw material process is scored to give a quality rate of both the raw material production and market mix representation. For example, many beef-based products use a background dataset from ACYVIA database35 directly, without an intermediate market mix formation. Such process is based on French production systems, but in reality beef from other countries is also consumed in France (around 25% according to statistic). Therefore, the precision (P) considers this aspects, even though a market mix is not expressly modeled (P=3, Coverage % of the market mix is >70% & origin is statistics, see Table 40).

In the overall database, the transportation requirements at market mix are generated based on the same source and with the same background processes. Therefore, the quality of the transportation at market mix is evaluated separately (**Erreur ! Source du renvoi introuvable.**), and always the same DQI's are given.

The processing life cycle stage is rated based on the data used for energy use, auxiliary material use, and use of proxy (Table 40). The use of dummy service processes at this stage is penalised (+1 in P and TeR).

At the processing life cycle stage, mass-changing-factors such as the inedible losses or raw-to-cooked ratios (R2C) are considered separately and the 4 DQI's are given. For example, the drying of fruit (e.g. apple) reduces the mass by 8.4 times. This a rather large change of mass, and largely influence the final impact. To this raw to cook factor the 4 DQI's are given based on **Erreur ! Source du renvoi introuvable.** Since all the R2C and inedible losses are based on the same source, always the same DQI's are assigned.

[35] Fresh ground beef production; industrial production; French production mix, at plant; 1 kg of fresh ground beef (PDi)

The quality of the allocation factor at processing stage is also considered separately. For example, prices are used in the flour processing to estimate the values of the two co-products: flour and bran. Such prices are rated on the four DQI's based on Table 40. In this example, since the same allocation factors (based on wheat) are used for all different kind of flours, the precision (P) and technological representativeness (TeR) indicators for wheat will be lower (higher quality) than for other cereals.

The recipe life cycle stage focuses mainly on the data relative to the recipe formulation and energy use. The quality of mass-changing-factors (raw to cook ratio) is also considered separately at recipe stage, as explained before for the processing stage.

The DQI's at packaging are assigned considering the characteristic of the packaging material. The transportation of packaging material is always based on the same source (European Commission, 2018) and is therefore considered separately, and always scored with same DQI's (**Erreur ! Source du renvoi introuvable.**).

In some cases, the same recipe or processed food is used for different packaged food products. This often involves proxies. To account for this, the food "at packaging" which are then used as inputs in recipes but as proxies are identified, and a penalty is given to the DQI's (+1 in P and TeR in case of good proxy that is similar to the actual dataset in scope, +2 in P and TeR in case of bad proxy). For example, "Apple compote, at plant (AGB 3.0) /FR U", a processed product, enters different packaged products. When it is used by "Apple compote (H)" no penalty is applied. When it is used as input for the product "Baby food jar without banana", it is considered as proxy similar to the product in scope. When used as input for the product "Baby food jar with banana" the maximum penalty is assigned. This a relevant point of approximation in the life cycle chain; this penalty results to be therefore crucial.

The choice of the packaging type also involves the use of proxies. This is accounted with a penalty to the packaging DQI's (+0.5 in P and TeR in case of proxy that is similar to the actual dataset in scope, +1 in P and TeR in case of proxy that is not similar from the dataset in scope). For example, the use of a PET bottle for tonic drinks can be considered a good proxy to the dataset in scope, since most of the tonic drinks in France are commercialised in plastic bottle (and only a minority in cans). For energy drinks the situation in different: since the large majority of energy drinks are canned, the use of PET bottles means a poor proxy. Only the category groups where the packaging stage has a WF of more than 12.5% are considered for this latter packaging analysis and penalty. This threshold was define so to select an appropriate number of products for detailed analysis.

Distribution stage, retail stage and transportation of waste material at consumer are based on data deriving from the same source (European Commission, 2018), therefore the same DQI's is assigned for all products (Table 40).

The quality of mass-changing-factors at retail (mass losses) and consumption (R2C and inedible factors) is considered separately, similarly to the processing and recipe stages.

The type of preparation at the consumer home is often a proxy, therefore a penalty system is included (+0.5 in P and TeR in case of proxy that is similar to the actual dataset in scope, +1 in P and TeR in case of proxy that is not similar from the dataset in scope). Only the category group where the preparation stage has a weighting factor of more than 12.5% are considered for the preparation penalty.

Weighting factors (WFs) calculation.

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

Table 41 shows an example of how the WFs are calculated. The final DQR is calculated for a representative product (in this case "French bread sandwich, chicken, raw vegetables (lettuce and tomato) and mayonnaise" CIQUAL: 25476). These WFs will be applied to all the products in the group that are represented by this product, modulo a recalculation on a 100 basis when steps are missing on the life cycle of the product in question.

Table 41 : Example of weighting factors (WF) calculation for the category sandwiches, based on the representative product "French bread sandwich, chicken, raw vegetables (lettuce and tomato) and mayonnaise" (CIQUAL: 25476)..

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	$Parameter_{Losses}$=0.95	58.56*(1-$Parameter_{Losses}$)/ $Parameter_{Losses}$	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	48.64[b]*(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 $Mass_{output}$ = 0.62 is the mass output ratio of the allocated product (0.62 kg meat/kg of broiler).	33.12*$Mass_{output}$*(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%

[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 a life cycle stage, the calculation of its contribution is straightforward. For example, at distribution the impact contribution is due to the various energy input (light and heating), transportation and water use. As explained before, in some cases the transportation is considered separately. Therefore, the contribution of transportation to the final impact is extrapolated and a separate WF is assigned.

Since at the processing stage energy use in the representative product was often a dummy service process (ex: mechanical operations), a 0% WF at processing stage was initially calculate for all 21-category group. This induce a bias: even though high DQI's were assigned to the processing stage (low quality), these were not considered in the final DQR due to a 0% WF. To avoid this, a default 5% WF at processing is assumed. In reality the contribution of energy use at processing can greatly vary between product groups and between products in the same group. In future updates, priority should be set on estimating default WFs at processing that are category group specific. Alternatively, efforts should be put on modeling energy use at processing in order to reduce the number of dummies used at processing (possibility at least to focus on the 21 representative products).

An important choice is made at the recipe stage. Only one main ingredient is selected to identify the previous life cycle stages. This means that the previous life cycle of minor ingredients (e.g. salt used in sausages) is not considered. Instead, the impact of these ingredients is allocated to the recipe stage at WF calculation. This was necessary, due to complexity of the recipe formulation (up to 10 different ingredients). The identification of the most contributing input is based on a contribution analysis using the ILCD single score methodology, corrected for negative emissions due to uptake-of-carbon, as explained before. For example, in the case of "Soup, Asian style with noodles", six different ingredients are mixed and cooked. The main contributing ingredient is the shrimp fillet (67% of the recipe single-score impact), therefore its previous life cycle stages are considered representative for this recipe. It should be considered a priority to upgrade the DQR system in order to include the life cycle stages of all ingredients used at recipe.

The contribution of mass changing parameter and allocation it is more complicated to calculate. Indeed, contribution analysis performed in SimaPro spreads the impact of change in mass to the previous life cycle stages. To calculate such contributions specific equation were developed. The impact of raw to cooked ratios and inedible losses (always expressed as OUT/IN ratios) are calculated in the following way:

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

Where:

- $I_{parameter}$ is the impact (ILCD single score) due to the mass-changing parameter;
- I_{input} is the impact (ILCD single score) of the main material input, the one interested by the change in mass;
- $parameter$ is the mass-changing parameter. It is always expressed as ratio of output divided by the input. It can be mass losses (e.g. during retail and distribution), Raw to Cook ratio (e.g. during preparation at consumer) or inedible losses (e.g. at industrial peeling plant).

In case of allocation:

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

Where:

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

Since the allocation represents an avoided impact allocated to a co-product (basically a negative impact) it should be summed up to the final impact during the contribution analysis. The same goes for positive R2C ratios (water uptake from pasta or dilution of instant coffee). Furthermore, to avoid an overallocation to the additional parameters, a maximum acceptable value has been set at 50%. This is relevant for highly diluted beverages at consumer.

When a specific product does not have a stage (e.g. processed product not mixed in a recipe, fish fillet) or does not have an additional parameter (e.g. raw to cooked at preparation, raw apple), then the WF is set at 0%, and all the other WFs are normalised (re-calculated to sum up to 100%).

Table 42 Weighting factors for 21 category groups (beverages 2 differ because they are dried powder then diluted at consumer).

Crop group	Mix	Mix transport	Process	Process allocation	Process R2C /INEDIBLE	Recipe	Recipe R2C	Packaging material	Packaging transport (PEF)	Distribution (PEF)	Retail (PEF)	Retail losses	Preparation transport (PEF)	Preparation cooking mode	Preparation R2C /INEDIBLE
mixed salads	17%	0%	5%	1%	16%	37%	4%	2%	0%	6%	5%	5%	0%	1%	0%
soup	18%	0%	5%	0%	26%	32%	15%	0%	0%	0%	1%	1%	0%	0%	0%
dishes	22%	3%	5%	0%	42%	16%	0%	1%	0%	3%	2%	5%	0%	1%	0%
sandwiches	23%	0%	5%	1%	22%	25%	8%	2%	0%	4%	4%	5%	0%	1%	0%
miscellaneous	41%	0%	5%	0%	0%	30%	5%	2%	0%	4%	3%	4%	0%	7%	0%
Vegetables & potatoes	11%	2%	5%	0%	0%	0%	0%	5%	0%	10%	16%	3%	0%	28%	20%
legumes	27%	1%	5%	0%	0%	0%	0%	3%	0%	5%	6%	2%	0%	5%	48%
fruits	25%	2%	5%	0%	1%	35%	0%	4%	0%	12%	10%	4%	0%	3%	0%
nuts & seeds	46%	0%	5%	0%	46%	0%	0%	0%	0%	0%	0%	2%	0%	0%	0%
Pasta & rice	37%	0%	5%	0%	4%	29%	0%	4%	0%	7%	6%	4%	0%	2%	0%
other cereal products	25%	0%	5%	0%	0%	16%	41%	1%	0%	1%	6%	4%	0%	0%	0%
meat	51%	0%	5%	0%	13%	3%	19%	0%	0%	1%	1%	5%	0%	2%	0%
fish	23%	3%	5%	1%	44%	0%	0%	0%	0%	1%	1%	3%	0%	2%	17%
eggs	47%	0%	5%	0%	5%	26%	2%	2%	0%	3%	3%	5%	0%	2%	0%
Milk, cheese & dairy	64%	0%	5%	0%	0%	18%	0%	1%	0%	3%	3%	5%	0%	1%	0%
beverages 1	36%	2%	5%	0%	0%	14%	0%	28%	2%	7%	4%	1%	0%	1%	0%
beverages 2	9%	0%	5%	0%	15%	18%	0%	0%	0%	0%	0%	0%	0%	3%	48%
Confectionary & ice cream	53%	1%	5%	0%	2%	10%	6%	8%	0%	3%	7%	4%	0%	0%	0%
butters	91%	0%	5%	0%	0%	0%	0%	1%	0%	1%	1%	0%	0%	0%	0%
oils	86%	3%	5%	0%	0%	0%	0%	2%	0%	1%	2%	1%	0%	0%	0%
baby food	12%	1%	5%	0%	24%	28%	8%	2%	0%	3%	9%	4%	0%	2%	0%

The two figures below show the distribution of DQR scores :

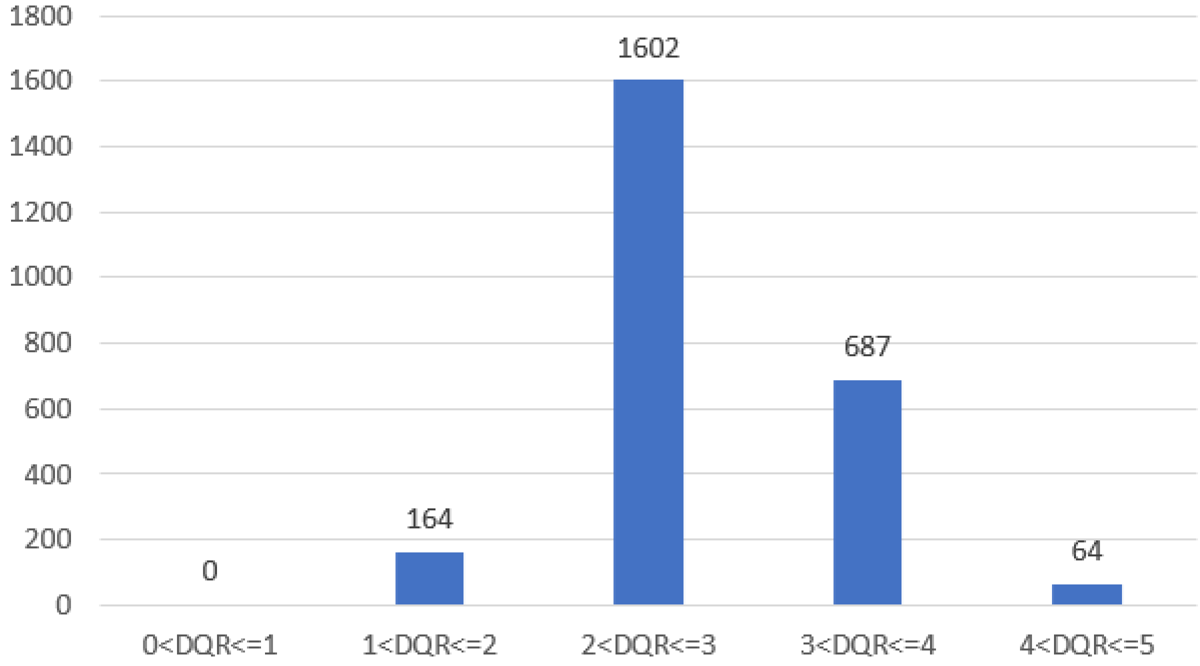

Figure 14: Distribution of datasets according to their DQR

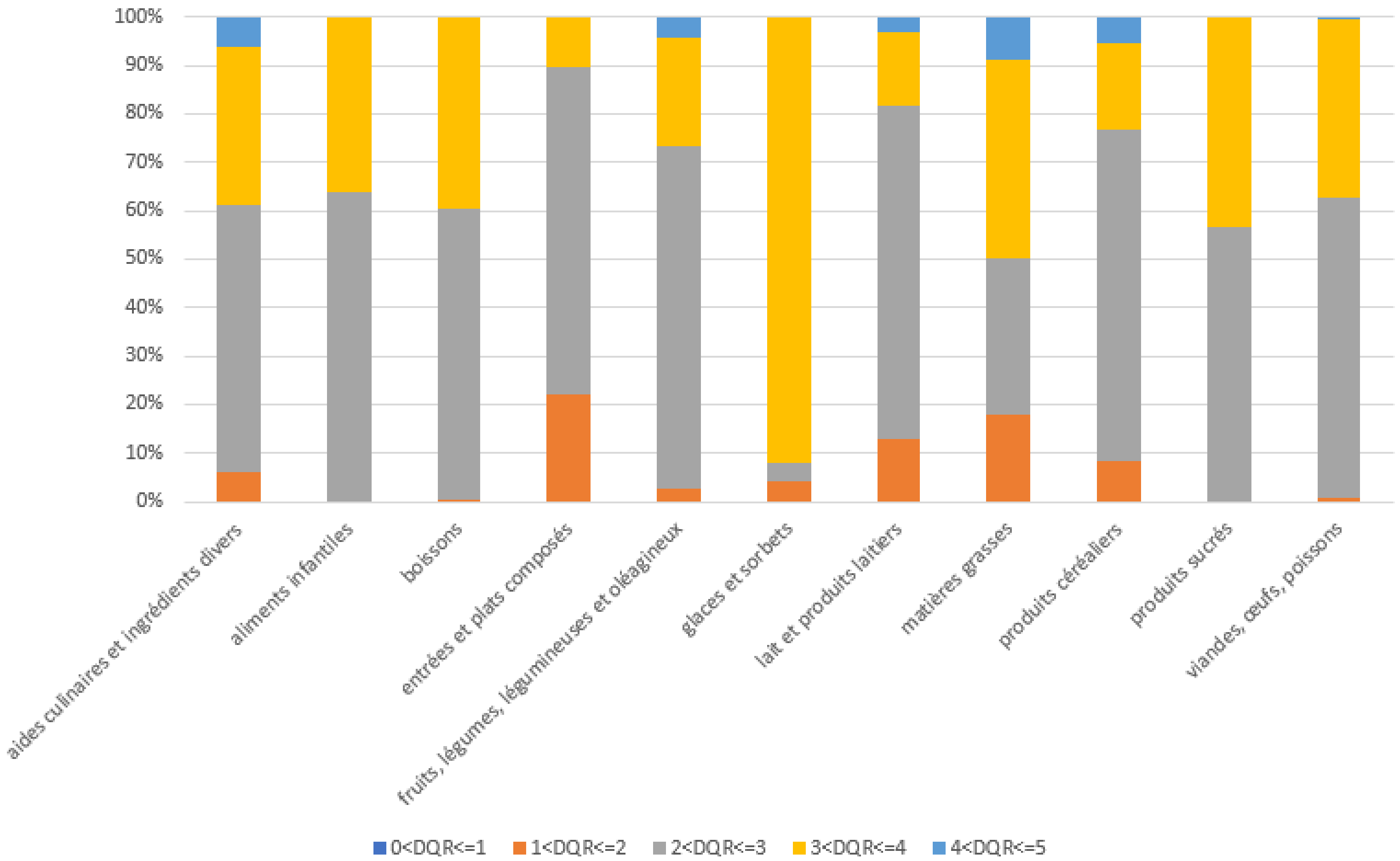

Figure 15: Distribution of data quality scores by product category

5 Outlook

Two years after the publication of AGRIBALYSE 3.0, this innovative database is now widely used in the French food sector for sustainability analysis. Agribalyse 3.1 version brings a number of improvements previously identified as important. This work for continuous improvement of the database will go on in coming years, thanks to the scientific consortium “Revalim”, as well as the many feedbacks from users.

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Abbreviations and acronyms

ADEME	Agence de l'Environnement et de la Maîtrise de l'Énergie (French Environmental Protection Agency)
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
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)
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
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)
AGB 1.3	Agribalyse 1.3
AGB 1.4	Agribalyse 1.4
Acyvia	French Food cradle to processing gate LCI database
CIQUAL	Public French food nutritional composition table developed and maintained by ANSES
WFLDB	World Food LCA Database

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