



D2.1 ANALYSIS OF CURRENT MULTI-LAYER FOOD PACKAGING IN THE WASTE STREAMS IN EUROPE

Associated Task(s): T2.1

Analysis of state-of-the-art multi-layer food packaging materials in the waste stream in Europe and their collection, sorting, and recycling today; sourcing of representative sample materials



Lead Partner: SUEZ

Partners involved: SUEZ

Dissemination Level: Public

Date: 28.02.2022 (revised version 14.04.2022)

History Log

Version Number	Date	Organisation name	Comments
0.1	23-02-2022	SUEZ	First version for review
0.2	25-02-2022	Fraunhofer IVV	1 st review
0.3	28-02-2022	BayFOR	2 nd review
0.5	28-02-2022	SUEZ	Final version
1.1	03-04-2023	SUEZ	Revision according to reviewer comments

Quality Review

Quality Check	Date	Status	Comments
Nelly Freitag	25-02-2022	reviewed	corrected
Esra Küçükpinar	28-02-2022	reviewed	corrected
Melanie Schulte	28-02-2022	reviewed	corrected
Esra Küçükpinar	05-04-2022	reviewed	corrected
Verena Bürger-Michalek (BayFOR)	12-04-2023	reviewed	formatting

Disclaimer

This document reflects only the authors' view and not those of the European Commission. This work may rely on data from sources external to the members of the CIRCULAR FoodPack project consortium. Members of the Consortium do not accept liability for loss or damage suffered by any third party because of errors or inaccuracies in such data. The information in this document is provided "as is" and no guarantee or warranty is given that the information is fit for any particular purpose. The user thereof uses the information at its sole risk and neither the European Commission nor any member of the CIRCULAR FoodPack Consortium is liable for any use that may be made of the information.



PUBLISHABLE EXECUTIVE SUMMARY

In the frame of CIRCULAR FoodPack project, the composition of flexible packaging waste was determined in the sorted bales of representative sorting sites in three European countries, Belgium, France, and Germany. This present study was performed from June 2021 to February 2022 as part of the task 2.1 of the Work Package 2 – Collection and Sorting. The aim of this study is to support the development of an efficient Tracer-Based-Sorting (TBS) process that enables the reliable sorting of food grade Multi-Layer Composite (MLC) from post-consumer flexible packaging and a Sensor-Based-Specification (SBS) to characterise and select fractions from current End-of-Life (EoL) packaging management most suitable for downstream recycling.

Five types of materials' bales and a batch of sorted refusals were studied; in Belgium and France, flexible packaging are currently sorted in one type of materials' bales. In Germany 3 types of bales are sorted, considering their material composition: the Low-Density PolyEthylene (LDPE) films sorted in a specific stream of plastic films with the sorting fraction reference number 310, flexible polyolefin plastic materials (trays and labels) in the specific reference with the sorting fraction number 323-2 and the mixed plastics – lightweight packaging under the sorting fraction reference number 352.

Quantities of 60kg to 200kg of packaging waste were sampled from the different materials' bales and bulk of refusals, and characterised, following the recommendations of European and French standards dedicated to household waste in bulk and bales. To assess the composition of the packaging waste, the samples were manually sorted and classified according to a first level of classification: Food / Non-Food packaging and then according to the type of contents leading to the sub-categories identified in both categories. 13 sub-categories were identified in the Flexible Food Packaging, and 10 sub-categories in the Flexible Non-Food Packaging waste.

The mass percentages of flexible packaging determined in the Belgian, French, and German 310 bales were respectively 76%, 93% and 81%, which correspond to the highest quantities of flexible materials in bales and mainly to PE fractions of non-food packaging (more than 80%). The two other German bales, with the sorting fraction numbers 323-2 and 352, presented lower quantities of flexible packaging with respectively 49% and 27%, and with more food packaging (51% and 60%) in comparison to German 310. The sorted refusals of the French sorting site presented only 13% of flexible packaging, and it consisted of mainly food packaging (65%). The quantities of recovered lightweight, flexible plastic packaging are directly linked to the household packaging collection rates, managed by Extended Producer Responsibility (EPR) schemes in these European countries.

Concerning the food packaging categories, the same main sub-categories (frozen food bags, packaging of bakery products, ready meals, fresh products, meat and fish products) were identified in the Belgian, French, and German 310 bales with similar order of magnitude in mass % (between 1% and 4%). Only for ready meals, and sweets and snacks packaging, more waste was present in the German and Belgian bales respectively. The 2 German bales, with the reference sorting fraction numbers of 323-2 and 352, consisted the packaging of ready meals, fresh products, pet food, instant dry products, dairy products, coffee, tea and cocoa products, and mostly, the sweets and snack products with the highest mass % for the food categories (respectively 8.7% and 11.4%).



The non-food flexible packaging constitutes the main proportions of the Belgian, French, and German 310 bales with 3 major sub-categories: industrial films packaging, collection bags due to the collection modes established in these countries, and secondary packaging for beverages. Some features were also noted with the presence of plastic tarps in the Belgian bale due to the possibility to dispose such waste in the blue collection bags in Belgium; and the higher mass % of industrial films in the German reference 310.

Regarding the proportions of printed and not printed fractions of flexible packaging, a global trend is observed among the 3 European countries: food packaging are mainly printed ones and non-food packaging are composed of 2 groups of sub-categories, which are mostly printed ones and not printed ones. The not printed non-food packaging corresponds to industrial films, tarps, collection bags and small carrier bags, which are mainly PE fractions. For both packaging categories sorted in the bales of the 3 EU countries, a de-inking / delamination process step will be mandatory to recover the transparency of PE films as much as possible.



TABLE OF CONTENTS

List of figures	6
List of tables	6
Abbreviations	8
1. Introduction	9
2. Sampling and Characterisation Methods and Materials	10
2.1. Sampling and Characterisation Methods.....	10
2.2. Materials – Flexible Plastic Packaging Waste.....	12
2.2.1 Flexible Plastic Packaging - Food Categories	12
2.2.2 Flexible Plastic Packaging - Non-food Categories	14
3. Flexible Packaging waste in France.....	15
3.1. Country Overview of the Collection and Sorting of Flexible Packaging Waste.....	15
3.2. Composition of the Flexible Packaging Waste in France	16
3.2.1 Description of the Sorting Site	16
3.2.2 Samples of Waste Characterised.....	17
3.2.3 Characterisation Results of the 2 Bales of Films Packaging.....	18
3.2.4 Results of the Characterisation of the Sorting Refusals Fractions.....	20
4. Flexible Packaging waste in Belgium	22
4.1. Country Overview of the Collection and Sorting of Flexible Packaging Waste.....	22
4.2. Composition of the Flexible Packaging Waste in Belgium.....	22
4.2.1 Description of the Sorting Site	22
4.2.2 Samples of Waste Characterised.....	23
4.2.3 Results of the Characterisation	23
5. Flexible Packaging waste in Germany	26
5.1. Country Overview of the Collection and Sorting of Flexible Packaging Waste.....	26
5.2. Composition of the Flexible Packaging Waste in Germany	27
5.2.1 Description of the Sorting Site	27
5.2.2 Samples of Waste Characterised.....	27
5.2.3 Results of the Characterisation	28
5.2.4 Composition of flexible plastic packaging in the bale 310 – Plastic Films	29
5.2.5 Composition of flexible plastic packaging in the bale 323-2 – Flexible polyolefin items	30
5.2.6 Composition of flexible plastic packaging in the bale 352 – Mixed Plastics-Lightweight packaging.....	31



5.2.7	Overall composition: food / non-food flexible packaging waste in the 3 different plastic fractions	32
5.2.8	Composition of the food flexible packaging waste in the three different plastic fractions.....	33
5.2.9	Composition of the non-food flexible packaging waste in the 3 different plastic fractions.....	34
5.2.10	Composition of the printed and not printed packaging waste in the 3 different plastic fractions	35
6.	Comparison of the composition of flexible packaging waste in the 3 European countries.....	37
6.1.	Overall composition: food / non-food flexible packaging waste.....	37
6.2.	Composition of the food flexible packaging waste in the 3 EU sorting sites	37
6.3.	Composition of the non-food flexible packaging waste in the 3 EU sorting sites	38
7.	Conclusions	40
8.	Annexes	42
8.1.	Annex 1: Sorting guide proposed by CITEO and adapted by Paris municipality	42
8.2.	Annex 2: Sorting guide proposed by Fost Plus.....	43
8.3.	Annex 3: Specifications of German bales: Fractions n°310, 323-2 and 350	44



LIST OF FIGURES

Figure 1: Example of a flexible packaging bale after opening	10
Figure 2: Global view of the working zone during a characterisation campaign at SUEZ - CIRSEE	11
Figure 3: Typical process of Materials Recycling Facilities (SUEZ)	17
Figure 4: View of the LDPE Films bales from the French sorting site	18
Figure 5: View of the residues of packaging received from the French sorting site.....	18
Figure 6: Global composition of flexible packaging in the French bales	19
Figure 7: Composition of printed and not printed packaging in the different categories – French sorting site	20
Figure 8: View of the flexible packaging bales received from the Belgium sorting site.....	23
Figure 9: Global composition of flexible packaging in the Belgian bale	23
Figure 10: Composition of printed and not printed packaging in the different categories – Belgian sorting site.....	25
Figure 11: Views of the LDPE Films bale from the German sorting site, classified as 310	28
Figure 12: Views of the two bales: 323-2 and 352 received from the German sorting site	28
Figure 13: Comparison of the food /non-food packaging categories in the 3 German plastic bales fractions	33
Figure 14: Comparison of the composition of Food Packaging in the 3 German plastic bales fractions.....	34
Figure 15: Comparison of the composition of Non-Food Flexible Packaging in the 3 German plastic bales fractions	35
Figure 16: Composition of printed and not printed fractions of the food packaging in the 3 German bales	36
Figure 17: Composition of printed and not printed fractions of the non-food packaging in the 3 German bales	36
Figure 18: Comparison of the Food/Non-Food Flexible Packaging composition from the 3 EU sorting sites	37
Figure 19: Comparison of the Food Flexible Packaging composition from the 3 EU sorting sites	38
Figure 20: Comparison of the Non-Food Flexible Packaging composition from the 3 EU sorting sites	39

LIST OF TABLES

Table 1: Quantities of flexible packaging waste collected from the 3 sorting sites, then sampled and characterized	12
Table 2: Different sub-categories of Flexible Food Plastic Packaging in Belgium, France, and Germany	13
Table 3: Different subcategories of Flexible Non-Food Plastic Packaging in Belgium, France and Germany	14
Table 4: Flexible Plastic Packaging - Food and Non-Food categories – French sorting site.....	19
Table 5: Flexible packaging in the refusals - Food and Non-Food categories – French sorting site	21



Table 6: Flexible Plastic Packaging - Food and Non-Food categories – Belgian sorting site.....	24
Table 7: Quantities of waste sampled and characterised in the three types of German bales .	29
Table 8: Flexible Plastic Packaging - Food and Non-Food categories – Plastic Films ref 310 – German site.....	29
Table 9: Flexible Plastic Packaging - Food and Non-Food categories – Flexible Polyolefin Items ref 323-2 - German site.....	30
Table 10: Flexible Plastic Packaging - Food and Non-Food categories – Mixed Plastics ref 352 - German site.....	31



ABBREVIATIONS

CEN/TR	Comité Européen de Normalisation (European Committee for Standardization) - Technical Report
EN	European Norm
EoL	End-of-Life
EPR	Extended Producer Responsibility
LDPE	Low Density PolyEthylene
MLC	Multi-Layer Composite
MLP	Multi-Layer Packaging
MRF	Materials Recycling Facility
NF	French Norm
NIR	Near-InfraRed
PE:	PolyEthylene
PET	PolyEthylene Terephtalate
PP	PolyPropylene
PMD ⁺	Plastic bottles & flasks, Metal packaging, Drinks' cartons, films, and flexible packaging
PVC	PolyVinylChloride
SBS	Sensor-Based-Specification
SOA	State-Of-the-Art
TBS	Tracer-Based-Sorting
VAT	Value Added Tax
WP	Work Package
ZSVR	Zentrale Stelle Verpackungsregister



1. INTRODUCTION

This Deliverable is linked with the Work Package (WP) 2 – Collection and Sorting; it concerns the analysis of the current sorted fractions of flexible plastic packaging produced by sorting centres in three different European countries: Belgium, France, and Germany.

In addition to the characterisation of these plastic waste fractions, SUEZ is also providing samples for analyses and tests that are planned in WP2 and WP3; the data collected from the characterisation will support these tests, linked with the objectives of both WPs. The origin and the sourcing of the samples (manual picking, contained in what type of waste stream, contained in what sorted fraction) are documented in the present Deliverable D2.1. The samples will serve as back-up examples for the State-Of-the-Art (SOA) flexible packaging and will be provided to IRIS for Task 2.6 and to WP3 partners (UGENT, KREYEN and Fraunhofer) to research Multi-Layer Packaging (MLP) specific behaviour in their respective processes.

The objective of WP2 is to develop an efficient Tracer-Based-Sorting (TBS) process that enables the reliable sorting of food grade Multi-Layer Composite (MLC) from post-consumer flexible packaging waste. Sensor-Based-Specification (SBS) will also be studied to characterise and select fractions from current End-Of-Life (EoL) packaging management, i.e., items that are not marked yet, most suitable for downstream recycling. The type of flexible packaging waste which will be used for the development of both sorting technologies were firstly studied to assess their composition in terms of food and non-food categories in waste feedstock collected and sorted in Belgium, France, and Germany. The characterisation results are presented in this deliverable.

The methodology of sampling and characterisation are described in Chapter 2. The total mass of the characterised waste used for the analysis of the state-of-the-art multilayer food packaging materials is summarised in Section 2.1. The identified sub-categories for food and non-food packaging are described in Section 2.2. The composition of the flexible packaging from the outputs of the three sorting sites are then detailed individually and compared to assess the similarities and the differences among the European countries in Chapter 3, 4, and 5.

In WP2 of CIRCULAR FoodPack project, SUEZ sources general packaging waste batches to be used as background packaging waste for the TBS sorting trials. In preparation of TBS sorting trials in Task 2.5 and in WP6, tracer marked multi-layer food packaging is mixed into the representative background material and stored for some time to reflect possible interaction and cross contamination with filled goods. This representative background packaging waste to be used for TBS trials has been selected based on the characterisation results of this study. Based on this, SUEZ has already provided 600 kg of French flexible packaging waste as background material for the TBS sorting trials, and will still provide more than 1.6 t within the next periods of the project to WP6 (Task 6.4 and Task 6.2). In total, collection of packaging waste has reached already up 3.3 tonnes in the first 18 months of the project and will account for more than 5 tonnes until the end of the project.



2. SAMPLING AND CHARACTERISATION METHODS AND MATERIALS

2.1. SAMPLING AND CHARACTERISATION METHODS

The task 2.1 started in June 2021 with the organisation of the sampling campaigns and the visit of the sorting centres in France, Belgium, and Germany until August 2021, to ensure that all types of flexible packaging waste were collected and sorted in the selected sites. The sorting sites in France and in Belgium were selected as they implemented the sorting process dedicated to flexible packaging, linked with the extended collection of lightweight packaging established recently in some regions of these countries. In Germany, the extended collection of flexible packaging has already been implemented for some years; the sorting site was chosen as representative of the existing sorting process for the studied packaging.

For the definition of the sample's types and quantities, and the management of the sampling plan, the EN 14899 standard – “Characterisation of waste - Sampling of waste materials - Framework for the preparation and application of a sampling plan” was used as the reference, with the support of two technical reports:

- CEN/TR 15310-2, 2007 – “Characterisation of waste - Sampling of waste materials - Part 2: Guidance on sampling techniques”, and
- CEN/TR 15310-5, 2007 – “Characterisation of waste - Sampling of waste materials - Part 5: Guidance on the process of defining the sampling plan”

In addition, the French standard, NF X30-437 (2009) – “Household waste and related refuse – Constitution and characterisation of a sample from a batch of household and related waste”. As the objective was to characterize the categories of flexible packaging present in the sorted materials bales, masses between 60 kg and 200 kg were sampled from the bales according to the presence of flexible packaging waste in the bales. The lowest quantities (around 60Kg) corresponded to bales containing more than 90% of flexible packaging, and the highest quantities were for bales with less than 50% of flexible packaging. These quantities correspond to the recommendations of the European and French standards cited above, in order to ensure the representativeness of the samples compared to the distribution of waste in the bales and in the sorting refusals. The extraction of packaging waste from the compacted bales was performed by manual sorting after opening the bales (Figure 1).



Figure 1: Example of a flexible packaging bale after opening

The characterisation method used for the present study of flexible packaging is based on three references:

- the French standard, NF X30-408 (2020) – “Household waste – Characterisation method – Bulk product analysis”,
- the French standard, NF X30-472 (2014) – “Household waste and related refuse – Characterisation of sorting refusals”,
- the MODECOM™ 2017 methodology, developed by ADEME, the French Environment and Energy Management Agency, for the characterisation of household waste.

The organization of the sampling in the bales and the workplace for the characterisation were designed and implemented according to the cited references and as shown in Figure 2. The two main steps of the characterisation methodology are visual inspection and manual sorting of each packaging type present in the bulk sample put on the sorting table, and then the mass measurements of each packaging category were performed.



Figure 2: Global view of the working zone during a characterisation campaign at SUEZ - CIRSEE

Concerning the sorting refusals studied, the sampling on-site followed the same methodology as described above and was based on the European standards dedicated to the characterisation of waste and on the French standard, NF X30-437 (2009).

All bales and samples have been received at CIRSEE - SUEZ, from the end of July to mid-November 2021, from the 3 sorting centres. The quantities of packaging waste received per bale or batches of samples and the quantities of samples characterized are presented in the table below. The total quantity of waste collected from the 3 sorting sites is around 2.7 tonnes managed in bales for the transport. Further quantities will be provided during the upcoming project periods to support the tasks in WP3 and WP6. At the end of the project, the collected background packaging waste by SUEZ will account for up to 5 tonnes as targeted in WP2 Task 2.1 of the Description of Action (DoA).

Table 1: Quantities of flexible packaging waste collected from the 3 sorting sites, then sampled and characterized

Materials bales references	Mass of the bales received	Mass of samples used for the characterisation	Mass of flexible packaging	Mass % flexible packaging
Flexible Packaging waste from Belgium				
Plastic films	400 kg	180 kg	138 kg	76.7 %
Flexible Packaging waste from France				
Plastic films	560 kg	277 kg	257 kg	92.8 %
Flexible Packaging waste from Germany				
Plastic films – ref 310	550 kg	64 kg	51,9 kg	81.0 %
Flexible polyolefin items – ref 323-2	720 kg	108 kg	52,6kg	48,6 %
Mixed plastics – lightweight - ref 352	440 kg	190kg	51,4 kg	27.0 %
Total masses of samples	2 670 kg	819 kg	551 kg	-

2.2. MATERIALS – FLEXIBLE PLASTIC PACKAGING WASTE

The samples of packaging waste characterised were sorted and classified according to a first level of classification: Food / Non-Food packaging and then according to the type of contents leading to the sub-categories identified in both categories of Flexible Plastic Packaging and described below, respectively in the Section 2.2.1 for food packaging and in the Section 2.2.2 for non-food packaging.

2.2.1 Flexible Plastic Packaging - Food Categories

13 sub-categories were identified in the Flexible Food Packaging waste during the characterisation campaigns; they are presented in Table 2.


Table 2: Different sub-categories of Flexible Food Plastic Packaging in Belgium, France, and Germany

Flexible Plastic Packaging - Food categories		
		
Dairy product	Coffee, tea, cocoa	Bakery products
		
Pet food, pet supplies	Frozen food	Fresh products (fruits, vegetables)
		
Nutriments, instant dry products	Meat and fish products	Other liquid and pasty food
		
Colour mesh bag	Ready meals	Sweets, snack products
		
Small freeze bags		

2.2.2 Flexible Plastic Packaging - Non-food Categories

10 sub-categories were identified in the Flexible Non-Food Packaging waste during the characterisation campaigns; they are presented in Table 3.

Table 3: Different subcategories of Flexible Non-Food Plastic Packaging in Belgium, France and Germany

Flexible Plastic Packaging – Non-Food categories		
		
Collection bags (Yellow/Blue)	Small bags	Secondary packaging films – (newspaper)
		
Carrier bags	Bags above 25L	Plastic tarps
		
Secondary packaging films (care products)	Secondary packaging films (Beverage)	Secondary packaging films (Industry)
		
Secondary packaging films (toilet paper rolls)		

3. FLEXIBLE PACKAGING WASTE IN FRANCE

3.1. COUNTRY OVERVIEW OF THE COLLECTION AND SORTING OF FLEXIBLE PACKAGING WASTE

The Extended Producer Responsibilities (EPR) system, which manages the collection of this packaging waste in France, is **CITEO** (French Eco-Organism). It was established by producers and importers to collectively meet the EPR as stated in the Waste Law (n°75-633, the 15 July 1975) and more particularly by its implementing decree (n°92-377, the 1st April 1992) about the implementation of household packaging sorting. It is a non-for-profit company governed by a board of directors, who are themselves appointed by producers and importers. Thanks to the law on Circular Economy (n°2020-105, of the 10th February 2020) passed in 2020, this system EPR is developing even further and modifying and strengthening the EPR system with ten new sectors.

CITEO is a member of Pro-Europe (Packaging Recovery Organisation Europe), which gathers 31 EPR-organisations using the Green Dot. This European umbrella organisation for the packaging and packaging waste recovery systems mainly use the Green Dot trademark at a national level.

The main goal of CITEO is to implement the Circular Economy law. To achieve this goal, they focus on the coordination and implementation of various tasks such as:

- modernising collection, sorting, and recycling while controlling costs,
- working with municipalities and other parties to compensate for the collection or processing of (separated) waste packaging,
- providing business services and solutions, by supporting, eco design and R&D,
- mobilising people through communication campaigns to recycle more,
- consolidating all data, and
- establishing the rates and collecting contributions from producers and importers.

The packaging accepted in the collection system are described by CITEO through a digital sorting guide for public, named "le Guide du tri", which can be uploaded on smartphones, and on brochures designed for communication by municipalities, like the example of Paris city in Annex 1: Sorting guide proposed by CITEO and adapted by Paris municipality.

The packaging waste collected are household packaging, completely emptied: flexible and rigid plastic, paper, cardboard, drinking cardboards, and metals (aluminium, steel), without glass bottles (separate collection).

The flexible packaging waste has been collected since 2015 with the implementation of the extended collection in France. In 2020, more than 50 % of the French regions put in place the extended collection. The target is to achieve 100 % of all regions by the end of 2022. In cities where it has already been implemented, 3.6 kg of additional packaging waste are collected per year and per habitant, of which 2.5 kg are additional plastic packaging waste. This new collection strategy needs to modify the processes of all sorting plants. By the end of 2020, 60 sorting plants out of 170 adapted their sorting processes to receive new packaging waste and to sort out new types of materials including flexible plastic packaging.



In general, the collection of packaging waste is managed either directly from bins with yellow lids or in yellow transparent bags and sometimes, by drop-off recycling containers for packaging, depending on the means put in place by the municipalities. The collection in yellow bags presents a significant impact on the composition of the flexible packaging, as the bags are PE films, which are classified in the sorted categories. The other impact concerns the sorting plants, as they must use specific equipment at the beginning of the sorting processes to be able to open the bags. In France, CITEO proposes to support the municipalities financially in the deployment of yellow bins to the households, as the National Institute for Research and Safety (INRS – recommendation R437), recommends collection in bins, to improve working conditions (musculoskeletal disorders, etc.) and due to the increasing packaging weight of multi-materials, including paper and cardboard. In other EU countries, paper and cardboard are not collected with the packaging.

3.2. COMPOSITION OF THE FLEXIBLE PACKAGING WASTE IN FRANCE

3.2.1 Description of the Sorting Site

The SUEZ sorting site selected for the sourcing of flexible plastic packaging is managing the extended collection of packaging; it is in the West of France. This sorting plant treats about 28 000 tonnes of packaging waste per year, coming from 12 municipalities; 4 municipalities cover 50 % of the whole waste feedstock. The packaging waste are collected by yellow bags for around 2 000 tonnes per year and the rest (26 000 tonnes per year) by bins with yellow lids.

The Figure 3 presents a diagram of a conventional sorting plant (or Materials Recycling Facility - MRF) for household packaging, with typical sorting technologies used in Europe. MRFs are designed to sort the various collected recyclable materials into different types, or “streams”. The separated packaging products are then transported to manufacturers for reprocessing into new products.





Figure 3: Typical process of Materials Recycling Facilities (SUEZ)

The flexible plastic packaging currently sorted for recycling and put in bales by the sorting plant represent about 2 % of the total waste flow, which correspond to about 550 tonnes per year. The other flow of flexible packaging sorted out by the process is considered as residues and sold for thermal valorisation to an Energy-from-Waste-plant in the same industrial zone.

The sorting process line dedicated to flexible plastic packaging is composed of ballistic separation, wind sifters, one NIR sorting equipment focusing on polyethylene (PE) films and a last step of manual sorting for quality control. It should be noted that through the sorting and separation of the PE film fractions, only formats above A4 can be collected, which is larger than most flexible food packaging.

On the PE Film sorting line, the flexible films < 60 mm (functional mesh size for NIR sorting of plastic films), black products, nested, sealed trays, and PVC materials are sorted as refusals.

The flexible plastic packaging are sorted into a single reference of bales (specifications from CITEO), with the following composition: the flexible PE coloured and transparent films with a minimum content of 95% of PE films and bags (sachets, wrapping films...).

3.2.2 Samples of Waste Characterised

4 bales of films packaging (low compressed ones), of about 140 kg each, were received in July 2021 at SUEZ CIRSEE research centre (Figure 4) from the sorting site and another 143 kg of sorting refusals in October 2021. These refusals were received in 2 pallet containers (Figure 5) after a random sampling of waste in the pile of sorting refusals on site.

2 bales for a total weight of 277 kg were characterised in July and August 2021, to determine the composition in terms of packaging categories and impurities (other types of materials than plastic films). The total amount of refusals was also characterised to determine the fraction of flexible packaging sorted out by the process. All results are presented in the sections 3.2.3 and 3.2.4.



Figure 4: View of the LDPE Films bales from the French sorting site



Figure 5: View of the residues of packaging received from the French sorting site

3.2.3 Characterisation Results of the 2 Bales of Films Packaging

Out of the 277 kg of materials characterised, 257 kg of flexible plastic packaging were sorted out and classified, the 20 kg left were considered as non-compliant materials as not plastic films (rigid plastic materials, paper, cardboard, aluminium cans, etc.). The fraction of flexible plastic packaging corresponds to 93 % in mass of the analysed quantity. The results of the classification are presented in Figure 6 and detailed in Table 4; only the masses of the flexible packaging are reported.

Non-food packaging represents the major fraction of materials with 85 % (Figure 6), composed of secondary packaging films for beverages, industrial films, and collection bags (yellow and black) for 62 % in weight. Regarding this category, LDPE material is mainly represented.

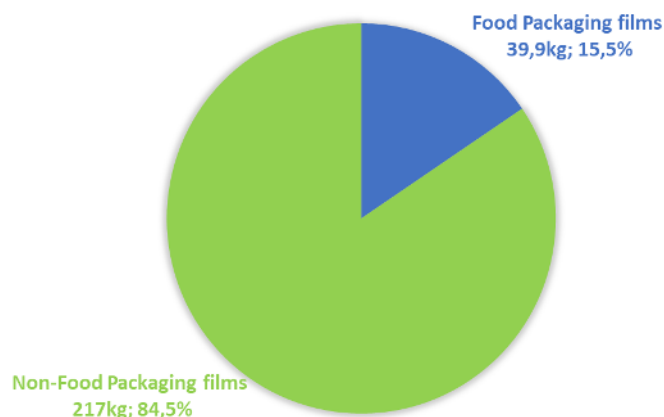


Figure 6: Global composition of flexible packaging in the French bales

With 15.5% in weight, the food-packaging category is mainly composed of packaging for frozen food, bakery products, meat and fish products, and ready meals, as indicated in Table 4.

Table 4: Flexible Plastic Packaging - Food and Non-Food categories – French sorting site

Flexible Packaging Categories	Masses (kg)	Mass %
Food Categories	39.9 kg	15.5%
Frozen Food	11.3	4.4
Bakery Products	5.2	2.0
Meat and Fish Products	4.6	1.8
Fresh products (fruits, vegetables)	4.5	1.7
Chilled convenience food and ready meals	3.6	1.4
Pet food, Pet supplies	3.0	1.2
Sweets, snack products	2.4	0.9
Nutriments, instant dry products	1.7	0.7
Dairy products	1.5	0.6
Small bags	1.0	0.4
Other liquid and pasty food	0.6	0.2
Coffee, tea, cacao	0.4	0.1
Cooked and sterilized food	0.1	0.0
Non-Food categories	217 kg	84.5%
Secondary packaging films (beverage)	59.0	23.0
Collection bags	52.3	20.4
Secondary packaging films (industry)	48.6	18.9

Carrier bags	14.9	5.8
Secondary packaging films (toilet paper rolls)	14.5	5.6
Bags above 25 Litres	10.0	3.9
Stretch / Bubble / Foam films	9.3	3.6
Secondary packaging films (Newspaper)	4.3	1.7
Secondary packaging (care products)	3.2	1.2
Detergents, cleaning agents	0.6	0.2
Medical and pharmaceutical products	0.3	0.1

Considering the whole categories, the packaging waste is mainly printed as shown in Figure 7 below. Out of 7 food-packaging categories, 4 ones are composed of more than 80 % of printed films. For the non-food categories, only 3 out of 11 contain printed films fractions and 2 of them, secondary packaging for personal care products and carrier bags/ bags above 25 litres, are mainly composed of printed films, more than 95 % and 90 % respectively.

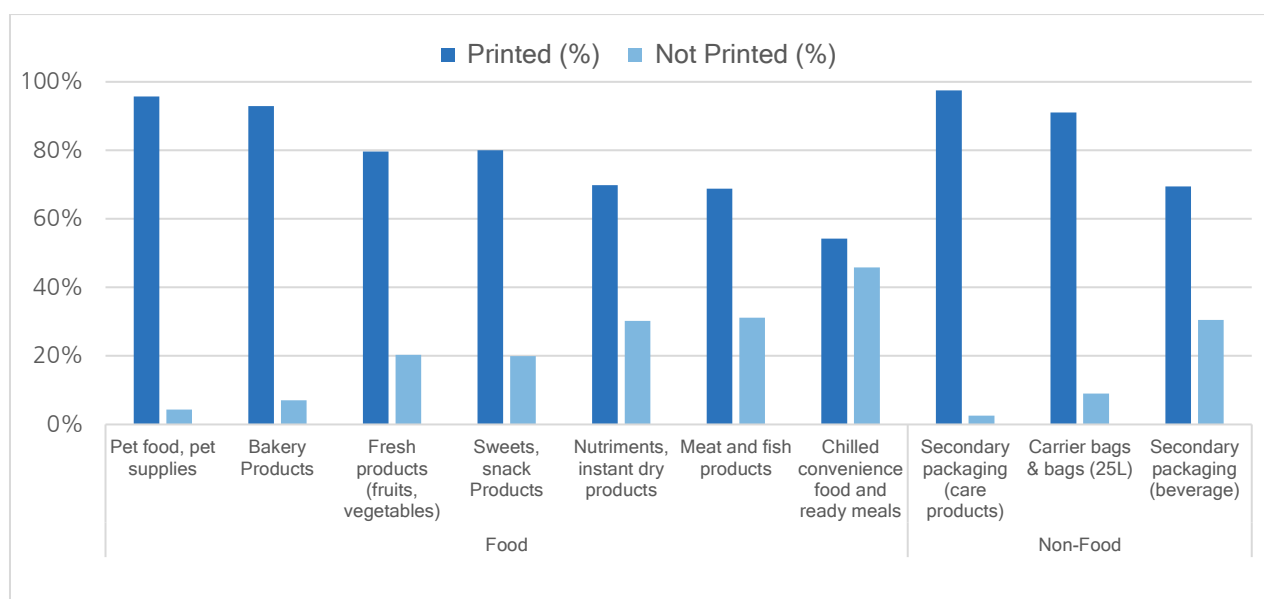


Figure 7: Composition of printed and not printed packaging in the different categories – French sorting site

3.2.4 Results of the Characterisation of the Sorting Refusals Fractions

The refusals fraction of 143 kg received from the sorting site in October 2021, contained 19,1 kg of flexible plastic packaging which were classified according to the food and non-food categories, and corresponding to 13,4% of the refusals. The results are detailed in Table 5 below.

The plastic packaging waste in the refusals is mainly composed of food packaging with more than 65 % in weight, with 2 major categories: packaging for meat and fish products, and pet

food and supplies; the rest concerns packaging of sweets and snack products, ready meals, bakery products and fresh products (fruits and vegetables). This category in the residues seems to contain more multi-layer composites packaging.

Table 5: Flexible packaging in the refusals - Food and Non-Food categories – French sorting site

Flexible Packaging Categories	Masses (kg)	Mass %
Food Categories	12.56 kg	65.8%
Meat and Fish Products	2.48	13.0
Pet food, Pet supplies	2.37	12.4
Sweets, snack products	1.16	6.1
Chilled convenience food and ready meals	1.14	6.0
Bakery Products	1.04	5.5
Fresh products (fruits, vegetables)	1.02	5.3
Other liquid and pasty food	0.89	4.7
Dairy products	0.81	4.3
Nutriments, instant dry products	0.70	3.7
Frozen Food	0.51	2.7
Coffee, tea, cocoa	0.45	2.4
Non-Food categories	6.52 kg	34.2%
Secondary packaging films (industry)	1.51	7.9
Carrier bags	0.93	4.9
Collection bags (yellow/black)	0.90	4.7
Secondary packaging films (newspaper)	0.80	4.2
Secondary packaging films (beverage)	0.80	4.2
Secondary packaging films (care products)	0.75	3.9
Secondary packaging (toilet paper rolls)	0.40	2.1
Bags above 25 Litres	0.27	1.4
Stretch / Bubble / Foam films	0.16	0.8

4. FLEXIBLE PACKAGING WASTE IN BELGIUM

4.1. COUNTRY OVERVIEW OF THE COLLECTION AND SORTING OF FLEXIBLE PACKAGING WASTE

In Belgium, the collection of household packaging is managed by the EPR non-for-profit organisation **Fost Plus**, set up and financed by industry. Fost Plus promotes, coordinates, and finances the selective collection, sorting, and recycling of household packaging waste. It cooperates with inter-municipalities, private waste management companies and recyclers to organise the collection and recycling of household packaging. This includes glass, paper-cardboard and PMD (Plastic bottles & flasks, Metal packaging and drinks cartons).

Fost Plus is a member of EXPRA: EPR Alliance for packaging, which gathers 26 EPR-schemes of 24 countries. EXPRA acts as the authoritative voice and common policy platform representing the interests of all its member packaging recovery and recycling organisations founded and run by or on behalf of obliged industry. As CITEO in France, Fost Plus is a member of PRO Europe: Packaging Recovery Organisation Europe.

Fost Plus is responsible for the collection and recycling of packaging materials for household wastes, this organisation finances and coordinates the following collections:

- The door-to-door collection of PMD,
- The collection of glass via the glass recycling bins or by door-to-door collection,
- The door-to-door collection of paper-cardboard.

It finances the collection of these waste and other packaging materials at recycling centres, including hard plastics, plastic film, Styrofoam, and small hazardous waste.

The packaging accepted in the collection system are described by Fost Plus on their website and through a sorting guide presented in Annex 2: Sorting guide proposed by Fost Plus. The extended collection of these PMD packaging, to films and flexible packaging was implemented in Belgium by the end of 2019. The collection of PMD is managed with blue bags since the end of 2019, provided by the municipalities and paid by the households. These bags are be sorted and mixed with films packaging waste. The extended collection of PMD⁺ packaging is totally implemented in Belgium since October 2021. According to Fost Plus, this will help to increase the recycling of plastic packaging from 41 % to 65 % and correspond to 8 kg of additional packaging waste collected per person per year.

4.2. COMPOSITION OF THE FLEXIBLE PACKAGING WASTE IN BELGIUM

4.2.1 Description of the Sorting Site

The representative sorting site contacted for the study of flexible packaging waste in Belgium manages around 30 000 tonnes of PMD⁺ packaging per year. Compared to the French sorting site with a similar capacity (28 000 tonnes per year), the Belgian sorting site does not receive any feedstock of paper and cardboard waste as they are collected in a separate and dedicated collection system and not included in the PMD⁺ fraction.

The sorting process line dedicated to flexible plastic packaging is like the one used in the French site, with a bag opener, 3 ballistic separation steps, wind sifters, two NIR sorting equipment focusing on PE and a last step of manual sorting for quality control. The only difference is the



size separation with a trommel for films above 300 mm at the beginning of the process. It should be noted that during the first sorting step with a NIR equipment, the flexible fractions below 60 mm are sorted out.

4.2.2 Samples of Waste Characterised

2 bales with low compression rate of about 200 kg were received in August 2021, at SUEZ CIRSEE research centre (Figure 8). One bale was characterised in September and October 2021, to determine the composition of packaging categories and the impurities fractions (other types of materials than plastic films). The results are presented in Section 4.2.3.



Figure 8: View of the flexible packaging bales received from the Belgium sorting site

4.2.3 Results of the Characterisation

180.7 kg of materials were characterised from the Belgian bale of flexible packaging; 42,7 kg were considered as non-compliant materials, 24 kg of these were mainly rigid plastic bottles and trays and 18.7 kg were fines of shredded films and plastics fractions. The fraction of flexible plastic packaging waste corresponded to a major part of the bale with 138 kg (76% in mass of the materials in the bale) and was mainly composed of non-food packaging (82 % in weight) as shown in Figure 9 below. This composition is equivalent to the one observed for the French flexible packaging bale with 85 % of non-food packaging (Figure 6).

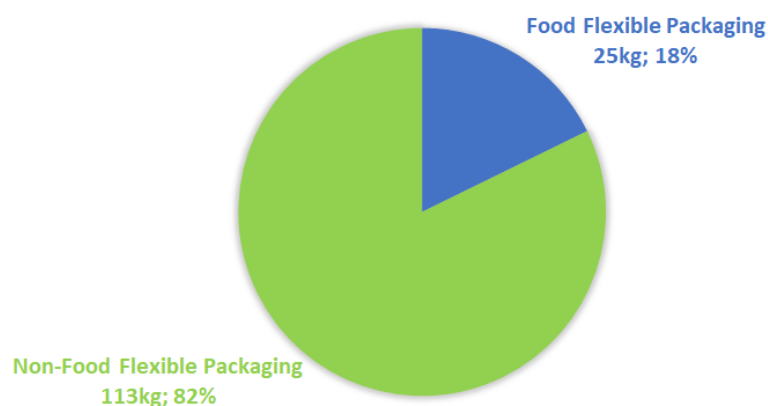


Figure 9: Global composition of flexible packaging in the Belgian bale

The composition of the flexible packaging waste within the food and non-food categories is presented in the Table 6; only the weight of the flexible packaging is reported without the impurities' fractions. As for the French bales, the food packaging categories are mainly the ones of frozen food, fresh products, ready meals, and bakery products. One sub-category, the "sweets and snack products" is more present in the sorted fraction of the Belgian bale.

Concerning the non-food categories, it is not surprising to find the collection blue bags at the first sub-category as they are used to collect the PMD⁺ waste packaging in Belgium. The other main sub-categories are industrial films, plastic tarps (industrial), and secondary packaging for beverages. All the 4 categories represent 68.5 % of the total amount of the plastic films in the bale. Regarding the non-food packaging, LDPE material is mainly represented.

Table 6: Flexible Plastic Packaging - Food and Non-Food categories – Belgian sorting site

Flexible Packaging Categories	Masses (kg)	Mass %
Food Categories	24.5 kg	17.8%
Frozen Food	4.0	2.9
Fresh products (fruits, vegetables)	4.0	2.9
Chilled convenience food and ready meals	3.6	2.5
Sweets, snack products	2.6	1.9
Bakery Products	2.3	1.7
Pet food, Pet supplies	2.3	1.7
Meat and Fish Products	2.0	1.5
Dairy products	1.2	0.9
Nutriments, instant dry products	1.2	0.9
Other liquid and pasty food	0.8	0.6
Coffee, tea, cocoa	0.3	0.2
Other packaging (shrink wrap, stretch films)	0.1	0.1
Non-Food categories	113.4 kg	82.2%
Collection bags (blue bags)	30.9	22.4
Secondary packaging films (industry)	25.0	18.1
Plastic tarp	21.0	15.2
Secondary packaging films (beverage)	17.6	12.8
Bags above 25 Litres	6.0	4.4
Small Carrier bags	4.2	3.1

Secondary packaging films (toilet paper rolls)	3.4	2.5
Stretch / Bubble / Foam films	3.4	2.5
Detergents, cleaning agents	1.5	1.2
Secondary packaging films (Newspaper)	0.3	0.2
Carrier bags	0.2	0.1

On the overall amount of packaging characterised in the Belgian bale, 14 sub-categories out of 23 are composed of printed and not printed packaging as shown in Figure 10; a major part of these sub-categories consists of printed ones. 8 sub-categories out of the 14 are composed of 80 % to 100 % of printed packaging, mostly in the food categories. 2 sub-categories of non-food packaging, secondary packaging for toilet paper rolls and care products, are 100 % printed.

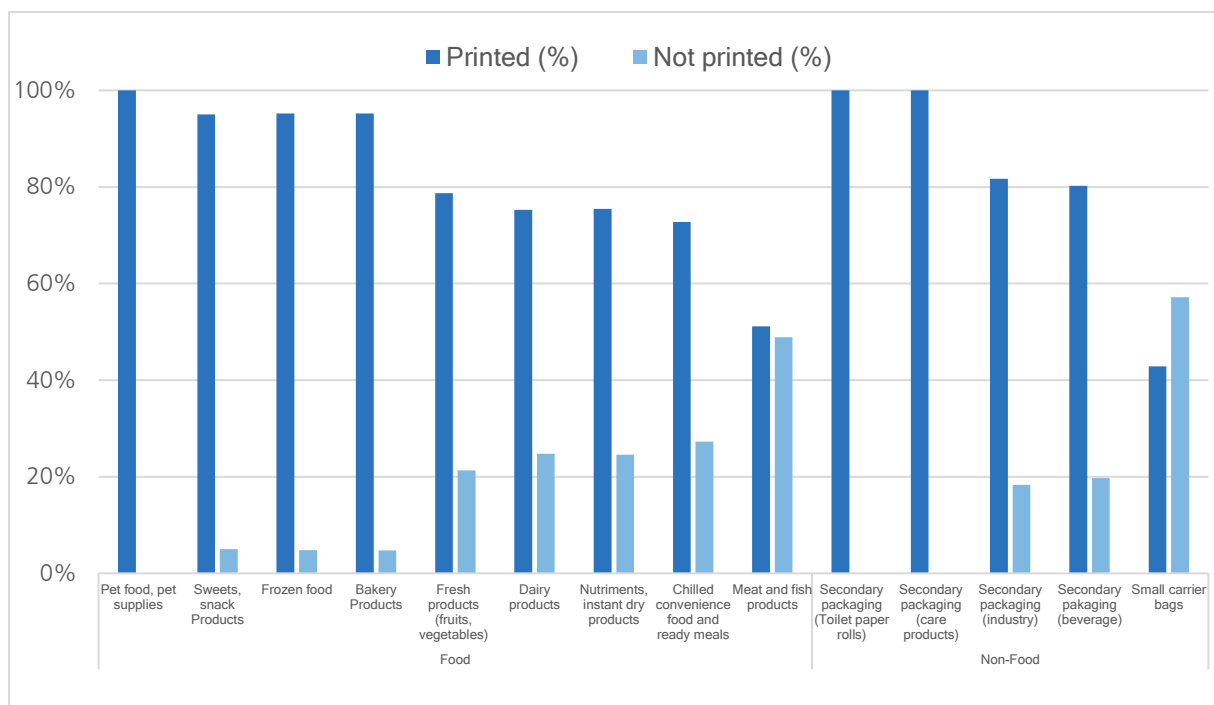


Figure 10: Composition of printed and not printed packaging in the different categories – Belgian sorting site

5. FLEXIBLE PACKAGING WASTE IN GERMANY

5.1. COUNTRY OVERVIEW OF THE COLLECTION AND SORTING OF FLEXIBLE PACKAGING WASTE

The collection of packaging waste in Germany is managed by an **EPR System**, which started as a monopoly of "Der Grüne Punkt" as an addition to the public waste management system. That is the reason why it is called "**Dual's System**". After the competition opening in 2003, other EPR-organisations entered the market. Since 2008, every manufacturer and distributor must license his sales and outer packaging at one of the nine dual systems, which are the following:

- BellandVision GmbH: www.bellandvision.de,
- Der Grüne Punkt – Duales System Deutschland GmbH: www.gruener-punkt.de,
- INTERSEROH Dienstleistungs GmbH: www.interseroh.com,
- Landbell AG: www.landbell.de,
- NOVENTIZ Dual GmbH: www.noventiz.de,
- Reclay Systems GmbH: www.reclay-group.com,
- Recycling Kontor Dual: www.rkd-online.de,
- Veolia Umweltservice Dual GmbH: www.veolia-umweltservice.de,
- ZENTEK GmbH & Co. KG: www.zentek.de.

Packaging must be licensed, when it predominantly ends-up as waste at households or places with similar waste (like restaurants, hospitals, or schools). The fees are used to pay for the collection, recycling and recovery of the collected waste.

To make sure that every manufacturer and distributor fulfils the obligation to license, there is a packaging law called "VerpackungsGesetz" (VerpackG; packaging act) since January 2019 (it is a successor of the VerpackVerordnung). In addition, there is an institution called "Zentrale Stelle Verpackungsregister" (ZSVR) where they also register and report the quantity of packaging they place on the market in a year. The dual systems also report to this institution about their licensed volume and the actually collected volumes; therefore, differences will attract attention and non-paying-producers can be recognised.

The ZSVR also calculates the market share of each EPR-organisation. This share is important for the payment of the collectors. Every year, one third of the counties in Germany is allocated for three years to one of the EPR-organisation. The appointed EPR-organisation must take care of the reconciliation with the local waste collector. Every EPR-organisation brings the collected packaging of its market volume from each country to a sorter and recycler.

At the end of each year, every EPR-organisation must verify the volume stream to the ZSVR to make sure that they fulfilled the required recycling quotes.

The packaging waste collected are lightweight household packaging, completely emptied: plastic, drinking cardboards, and ferrous metals and aluminium. This fraction is called "lightweight packaging" and is collected in the bags, comparably to other countries (French and Belgium). In Germany, a high percentage of the collected plastic bottles and drinking cans are collected through a deposit refund system. The main piece of legislation concerning packaging and including the deposit refund system is the German Packaging Ordinance: the

deposit of 0.25 EUR for one-way plastic bottles and drinking cans, 0.15 EUR for refillable bottles (plastic and glass) and 0.08 EUR for refillable, glass beer-bottles including VAT must be levied. Target applications are the following one-way beverage packaging: volumes between 0.1 litre and 3 litres and packaging made of materials, which are considered as "non-ecologically advantageous".

The packaging allowed to be collected by deposit systems are containing specific types of drinks including beer, soft drinks, and alcohol-containing drink mixes. There was a quota of 70 % of drinking packaging for 2021, which must be returnable. Due to the deposit system in place, less bottles and cans are collected in the household waste and arrive at sorting sites.

5.2. COMPOSITION OF THE FLEXIBLE PACKAGING WASTE IN GERMANY

5.2.1 Description of the Sorting Site

For the characterisation of the German packaging, the SUEZ sorting site contacted for the sourcing of bales has a nominal capacity of 85 000 tonnes per year of packaging waste collected with collection bags, without the ones already collected by the deposit refund system. The site provides different materials' bales according to the specifications of the EPR systems and "Der Grüne Punkt".

The sorting of flexible plastic packaging is based on the same process as the Belgian sorting site with a bag opener also allowing to extract bags and films above 300 mm size, followed by wind sifter, ballistic separation, 3 NIR sorting equipment for PE and polyolefins fractions and a control quality by visual inspection and manual sorting.

5.2.2 Samples of Waste Characterised

Flexible plastic packaging are sorted in 3 types of materials' bales considering their material composition:

- the LDPE films are sorted in a specific stream with the specification number 310 – "Plastic Films", corresponding to a purity of at least 92% in mass in the bales (Annex 3: Specifications of German bales: Fractions n°310, 323-2 and 350),
- a second fraction of flexible packaging are sorted with polyolefin plastic materials (trays and labels) in a specific reference 323-2 called flexible polyolefin items (Annex 3: Specifications of German bales: Fractions n°310, 323-2 and 350),
- a last fraction of flexible packaging is mixed with other lightweight plastic materials, in bales specified as "352 – Mixed plastics – Lightweight packaging" and adapted from the previous specification 350 presented in Annex 3: Specifications of German bales: Fractions n°310, 323-2 and 350. The specifications 352 are the same as the 350 ones.

These three types of bales have been received from the German sorting site, between September and October 2021, with the following amounts:

- "Plastic films" - reference 310: 1 bale of 550 kg as shown in Figure 11,
- "Flexible polyolefin items" - reference 323-2: 2 bales of 720 kg (Figure 12),
- "Mixed plastics – lightweight packaging" - reference 352: 2 bales of 440 kg (Figure 12).

The characterisation campaign started in November 2021 and ended at the beginning of February 2022.





Figure 11: Views of the LDPE Films bale from the German sorting site, classified as 310 compacted (left) and opened during the characterisation campaign (right)



Bale 323-2

Bale 352

Figure 12: Views of the two bales: 323-2 and 352 received from the German sorting site

5.2.3 Results of the Characterisation

Due to the occurrence of films packaging in the three types of bales, with a decreasing mass percent from the reference 310 to the 352 one, different quantities of waste were sampled in these bales, trying to reach a minimum amount of 50 kg of flexible packaging to be characterised. As the mass percent of flexible packaging was not known before sampling, the sampling plan adopted was based on iterative sequences of sampling followed by the characterisation of samples to reach a minimum total mass of 50kg of flexible packaging. The masses of waste sampled, and the ones of flexible packaging characterised are presented in Table 7.

Table 7: Quantities of waste sampled and characterised in the three types of German bales

Materials' bales references	Mass of the bales received	Mass of samples for characterisation	Mass of flexible packaging	Mass % flexible packaging
Plastic films – ref 310	550 kg	64 kg	51.9 kg	81.0 %
Flexible polyolefin items – ref 323-2	720 kg	108 kg	52.6kg	48.6 %
Mixed plastics – lightweight - ref 352	440 kg	190kg	51.4 kg	27.0 %

As expected, the mass percent of flexible packaging in this fraction decreases significantly from bale referenced 310 with 81% to the one 352 with only 27%; the types of packaging categories sorted for these bales are also different as presented in the next sections.

5.2.4 Composition of flexible plastic packaging in the bale 310 – Plastic Films

The composition of the bale 310 – Plastic Films is detailed in Table 8; it is mainly composed of non-food packaging (about 81 %), with two major categories, industrial films for 38 % and collection bags for 15 %, leading to about 54 % of the composition of the bale. The food categories correspond mainly to packaging for ready meals, frozen food, fresh products, and bakery products, for 67 % of the total mass of these categories.

Table 8: Flexible Plastic Packaging - Food and Non-Food categories – Plastic Films ref 310 – German site

Flexible Packaging Categories	Masses (kg)	Mass %
Food Categories	9.9kg	19.1%
Chilled convenience food and ready meals	2.2	4.3
Frozen Food	2.1	4.1
Fresh products (fruits, vegetables)	1.5	2.9
Bakery Products	0.9	1.7
Pet food, Pet supplies	0.7	1.3
Meat and Fish Products	0.6	1.2
Nutriments, instant dry products	0.6	1.2
Dairy products	0.5	1.0
Other liquid and pasty food	0.4	0.8
Sweets, snack products	0.3	0.6
Non-Food categories	42.0kg	80.9%
Secondary packaging films (industry)	19.9	38.2

Collection bags	8.0	15.4
Bags above 25 Litres	3.6	6.9
Secondary packaging films (toilet paper rolls)	2.6	4.9
Secondary packaging films (beverage)	2.5	4.9
Stretch / Bubble / Foam films	1.7	3.3
Plastic tarp	1.0	2.0
Small Carrier bags	1.0	2.0
Carrier bags	1.0	2.0
Secondary packaging films (care products)	0.7	1.3

5.2.5 Composition of flexible plastic packaging in the bale 323-2 – Flexible polyolefin items

The composition of the bale 323-2 – Flexible polyolefin items is detailed in Table 9. Both categories, food, and non-food, are equally represented in mass % in this fraction of materials. 4 sub-categories count for more than 64 % of this fraction, with the packaging of ready meals, sweets and snack products, fresh products, and frozen food. The non-food categories are represented mainly by industrial films, collection bags, similar to the bale fraction 310, and by the secondary packaging films of care products and beverage; these sub-categories account for 37 % of the whole fraction in the bale and for 77 % of the non-food categories.

Table 9: Flexible Plastic Packaging - Food and Non-Food categories – Flexible Polyolefin Items ref 323-2 - German site

Flexible Packaging Categories	Masses (kg)	Mass %
Food Categories	27.1 kg	51,5%
Chilled convenience food and ready meals	4.9	9.3
Sweets, snack products	4.6	8.7
Fresh products (fruits, vegetables)	4.3	8.2
Frozen Food	3.6	6.8
Nutriments, instant dry products	2,8	5.3
Dairy products	2.0	3.8
Bakery Products	2.0	3,7
Meat and Fish Products	1.5	2.8
Pet food, Pet supplies	0.8	1.6
Other liquid and pasty food	0.4	0.7
Coffee, tea, cocoa	0.3	0.6

Non-Food categories	25.5kg	48.5%
Secondary packaging films (industry)	10.8	20.5
Collection bags	3.5	6.7
Secondary packaging films (care products)	3.0	5.7
Secondary packaging films (beverage)	2.3	4.4
Carrier bags	1.7	3.2
Small Carrier bags	1.6	3.1
Stretch / Bubble / Foam films	1.1	2.1
Secondary packaging films (toilet paper rolls)	1.1	2.1
Plastic tarp	0.4	0.7

5.2.6 Composition of flexible plastic packaging in the bale 352 – Mixed Plastics-Lightweight packaging

The composition of the bale 352 – Mixed plastics – Lightweight packaging is presented in Table 10; the food categories represent the main fraction in this bale with 60 % in mass. Five sub-categories account for 66% of these fractions, with the packaging of sweets and snacks, fresh products, ready meals, pet food and supplies, and nutriments, instant dry products.

As for the two other bales/fractions (310 and 323-2), the non-food categories are still mainly represented by industrial films and collection bags, accounting for 23 % of the total mass and for 57 % of the non-food fraction. Two other sub-categories that contribute to the non-food fraction are carrier bags and secondary packaging for care products, reach 77 % of the total mass of this fraction.

Table 10: Flexible Plastic Packaging - Food and Non-Food categories – Mixed Plastics ref 352 - German site

Flexible Packaging Categories	Masses (kg)	Mass %
Food Categories	30.9 kg	60.1%
Sweets, snack products	5.9	11.4
Fresh products (fruits, vegetables)	4.4	8.6
Chilled convenience food and ready meals	4.1	7.9
Pet food, Pet supplies	3.1	5.9
Nutriments, instant dry products	3.0	5.9
Meat and Fish Products	2.5	4.9
Bakery Products	2.3	4.4
Dairy products	2.0	3.8

Coffee, tea, cocoa	1.8	3.5
Frozen Food	1.4	2.8
Other liquid and pasty food	0.5	1.0
Non-Food categories	20.5 kg	39.9%
Secondary packaging films (industry)	7.4	14.3
Collection bags	4.4	8.6
Carrier bags	2.3	4.5
Secondary packaging films (care products)	1.8	3.4
Small Carrier bags	1.3	2.5
Stretch / Bubble / Foam films	1.0	2.0
Secondary packaging films (toilet paper rolls)	1.0	2.1
Secondary packaging films (beverage)	0.8	1.5
Bags above 25 Litres	0.5	1.0

5.2.7 Overall composition: food / non-food flexible packaging waste in the 3 different plastic fractions

To give an overview of the composition of the three types of materials fraction studied from the German bales, the mass % of the food and non-food flexible packaging fractions are compared and presented in Figure 13 below. The non-food fraction constitutes the major fraction (above 80 %) of the plastic films bale referenced as 310, as the food fraction is the main fraction (60 %) of the lightweight packaging part of the mixed bale referenced 352. The food fractions seem to be constituted by a higher amount of multilayer composite packaging and mix of PE and PP which enter in the definition of bale 323-2 and 352. These compositions correlate with the purity levels targeted in the specifications of these 3 different plastic bales fractions, as described in the documents provided by “Der Grüne Punkt” and presented in Annex 3: Specifications of German bales: Fractions n°310, 323-2 and 350.

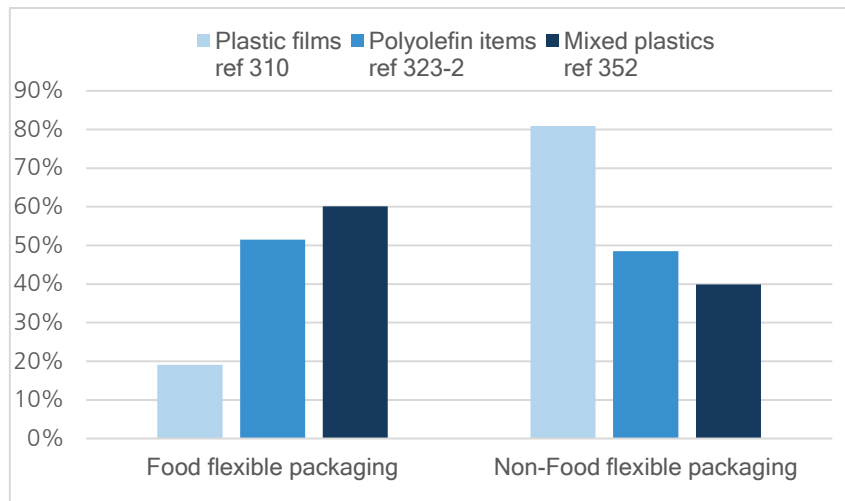


Figure 13: Comparison of the food /non-food packaging categories in the 3 German plastic bales fractions

5.2.8 Composition of the food flexible packaging waste in the three different plastic fractions

The mass % of the food sub-categories determined in the three different plastic bales fractions are presented in Figure 14; some sub-categories are present in all the bales with similar relative mass, like ready meals, frozen food, bakery products, dairy products, and fresh products. The various composition of individual packaging in a same sub-category could explain this distribution, meaning that pure PE or mono-material PE packaging are rather sorted into the reference 310 bale. In contrast, the other mono-material types and multi-layer packaging are sorted into the 2 other bales of fractions 323-2 for polyolefins and 352 for others (PET and multi-layer made with different plastic materials). This hypothesis is being investigated by the Fraunhofer Institute IVV in the WP3.

The three sub-categories pet food, sweets and snacks, and coffee, tea, cocoa packaging are mainly present in the bales of fractions 323-2 and 352, and not in the 310 one; they are mainly constituted by multi-layer packaging and metallised ones, which do not correspond to the specifications of the plastic films (reference 310).

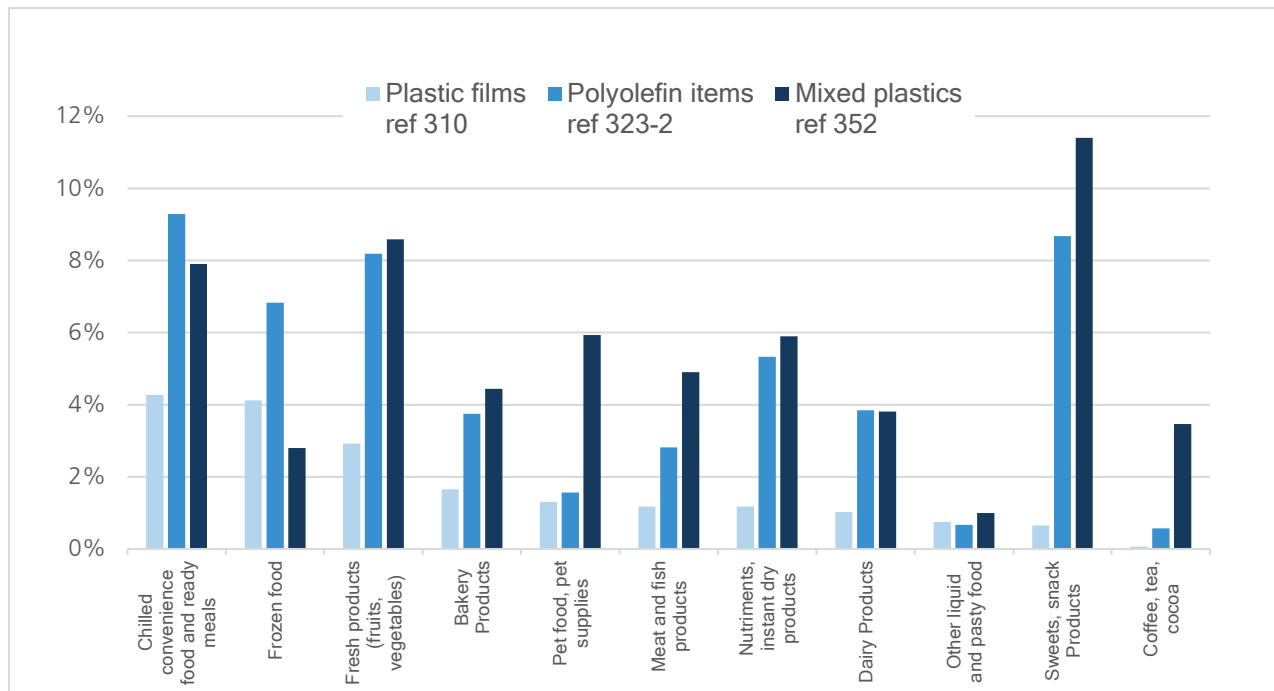


Figure 14: Comparison of the composition of Food Packaging in the 3 German plastic bales fractions

5.2.9 Composition of the non-food flexible packaging waste in the 3 different plastic fractions

Figure 15 present the mass % of the non-food sub-categories determined in the three different plastic bales fractions; industrial films, also called secondary packaging and collection bags, are the 2 main fractions of the non-food packaging in the 3 types of bales. For the other sub-categories, the distribution changes among the 3 bales, as bags, plastic tarps and secondary packaging for toilet paper rolls and beverage, which are constituted mainly of PE, are more obviously present in the PE films fraction 310. In contrast, small and standard carrier bags, and secondary packaging for care products were found mainly in the bales 323-2 and 352; carrier bags are made of either PE and PP, and packaging of care products seem to be mainly multilayers. This hypothesis will be validated by the chemical analyses performed by the Fraunhofer Institute IVV and presented in the deliverable D3.1 - Database of studied waste fractions, their analytical results.

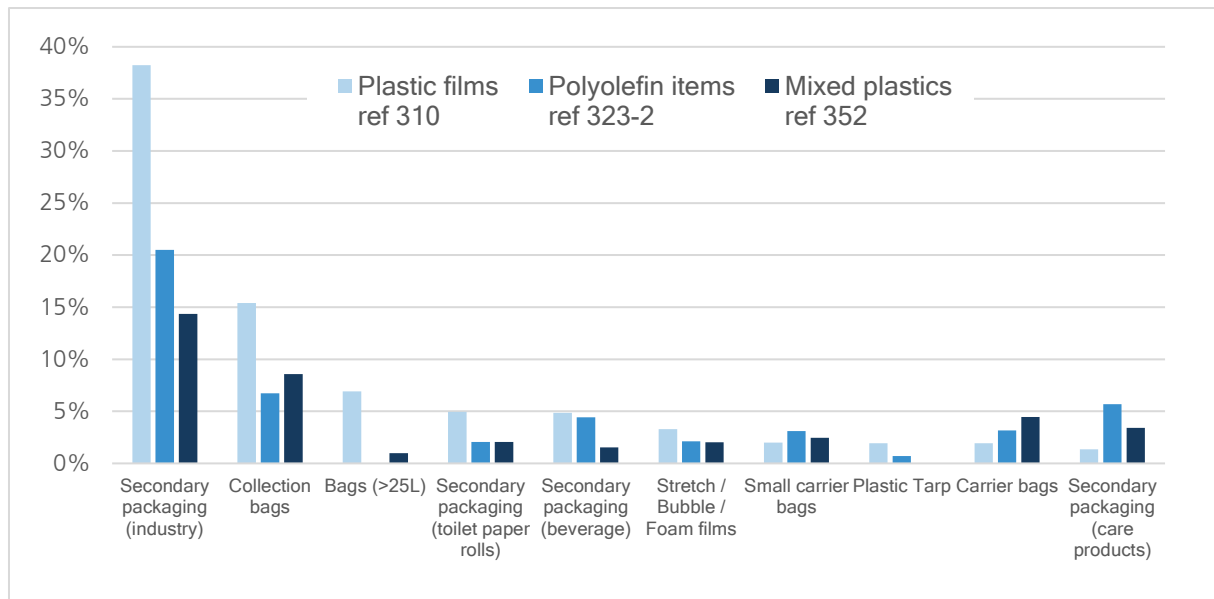


Figure 15: Comparison of the composition of Non-Food Flexible Packaging in the 3 German plastic bales fractions

5.2.10 Composition of the printed and not printed packaging waste in the 3 different plastic fractions

In each sub-categories of flexible packaging, the printed and not printed fractions were also characterised; the results obtained for the three German plastic fractions are compared in Figure 16 for food packaging and in Figure 17 for non-food packaging.

4 sub-categories of food packaging are 100% made of printed packaging: bakery products, frozen food, sweets and snack products, and small freeze bags. They are present in all three types of plastic fractions. The small freeze bags always contain a printed zone dedicated to mark the type of food to be filled before freezing, even if the rest of the bag is transparent; therefore they were classified as printed. The other food packaging is also mainly printed ones, with an increasing mass % in the plastic fractions from the bale reference 310 to the 323-2 one and then to the 352 one, except for the category fresh products, showing a decrease in the printed fractions. It seems that the flexible packaging present in the bale 310 are more PE based and, in the 323-2 and 352 bales, polyolefin and other plastic types are represented respectively. On the contrary, the fresh products' fraction of the bale 352 corresponds to transparent PET films, which could explain the increasing not printed fraction for this food sub-category.

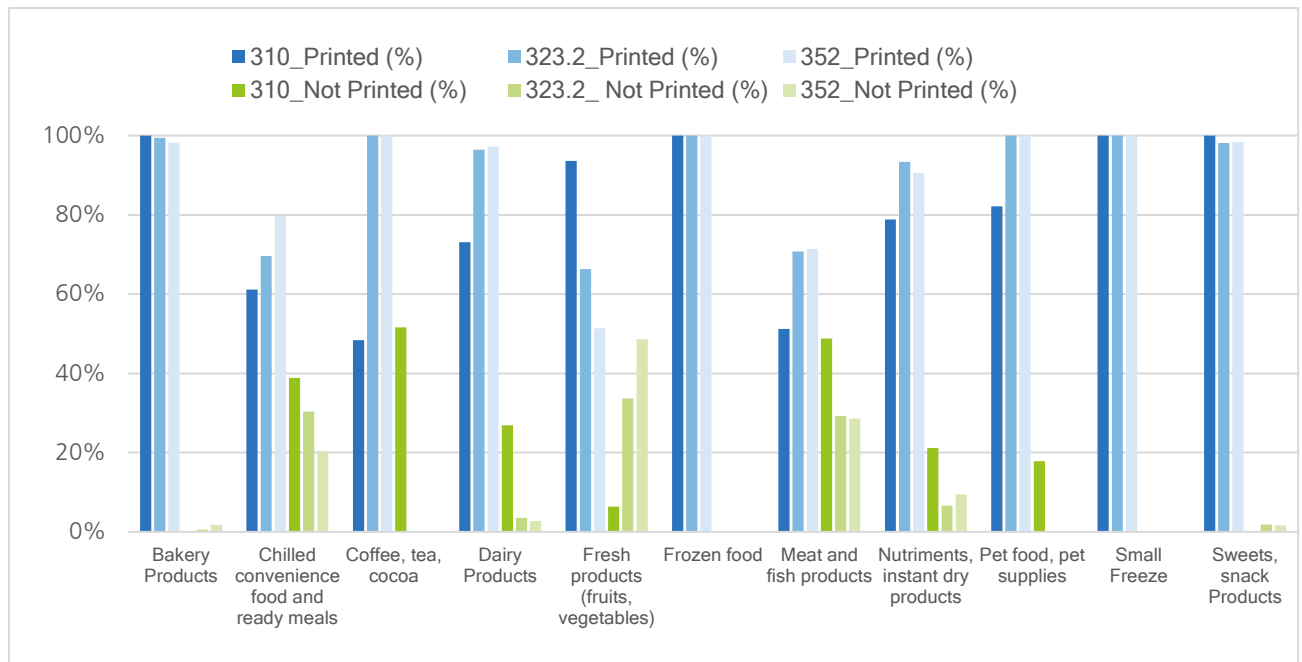


Figure 16: Composition of printed and not printed fractions of the food packaging in the 3 German bales

The non-food packaging fractions are constituted similarly in the three types of German plastic bales, with an equal proportion of sub-categories with printed and not printed fractions. 5 sub-categories out of 10, mainly bags, tarps and industrial films, contain between 80 % and 100 % of not printed fractions whereas 4 out of 10 contain between 80 % to 100 % of printed fractions (secondary packaging for care products and toilet paper rolls, bags, and carrier bags). Only one subcategory, the secondary packaging for beverages, presents a mix of printed and not printed fractions, at same proportions in the three German plastic bales.

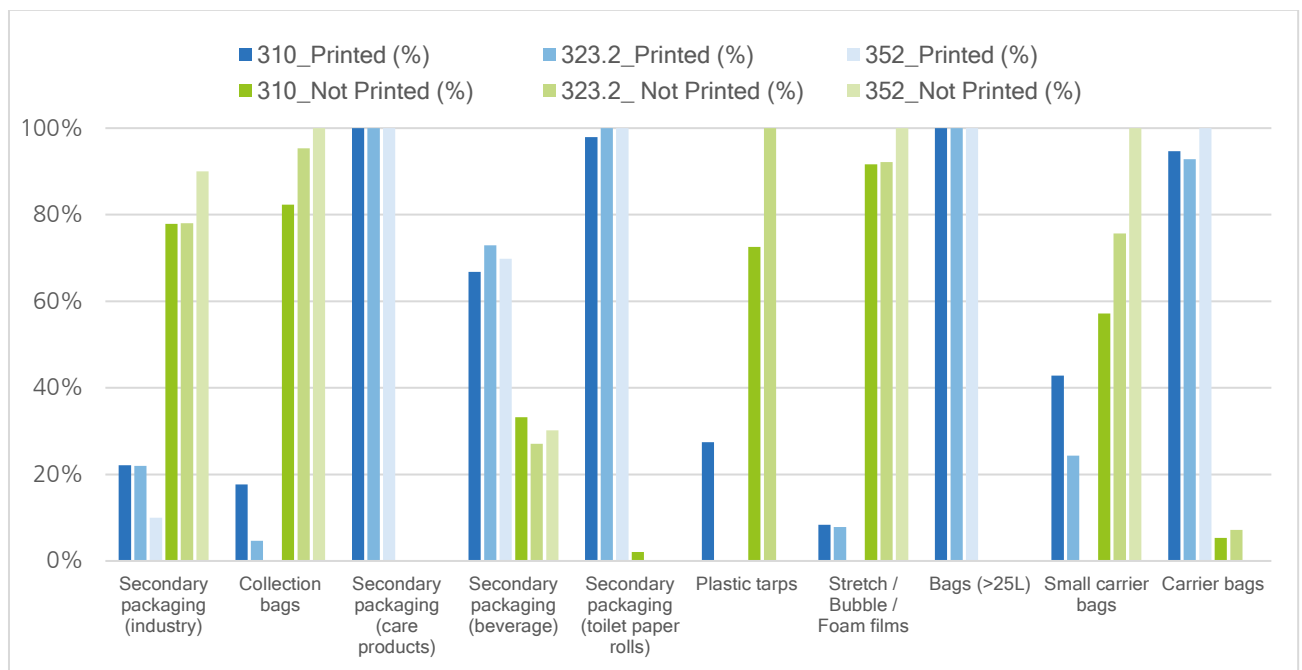


Figure 17: Composition of printed and not printed fractions of the non-food packaging in the 3 German bales

6. COMPARISON OF THE COMPOSITION OF FLEXIBLE PACKAGING WASTE IN THE 3 EUROPEAN COUNTRIES

All the results obtained on the classification of flexible packaging from the studied fractions of the 3 sorting sites are combined in this paragraph to appraise the trends and check if there are some similarities. The results of the overall compositions of food and non-food are first presented and then the comparison of the sub-categories in both categories.

6.1. OVERALL COMPOSITION: FOOD / NON-FOOD FLEXIBLE PACKAGING WASTE

The comparison of the food and non-food flexible packaging composition are presented in Figure 18, for the 3 sorting sites; the distribution in the French and the Belgian bales are the same as the German plastic films reference 310, with a major fraction of non-food fraction with 80 % and more. As the other packaging waste fractions are not managed in bales in France and in Belgium, unlike in Germany, they are mostly used as combustible for thermal valorisation.

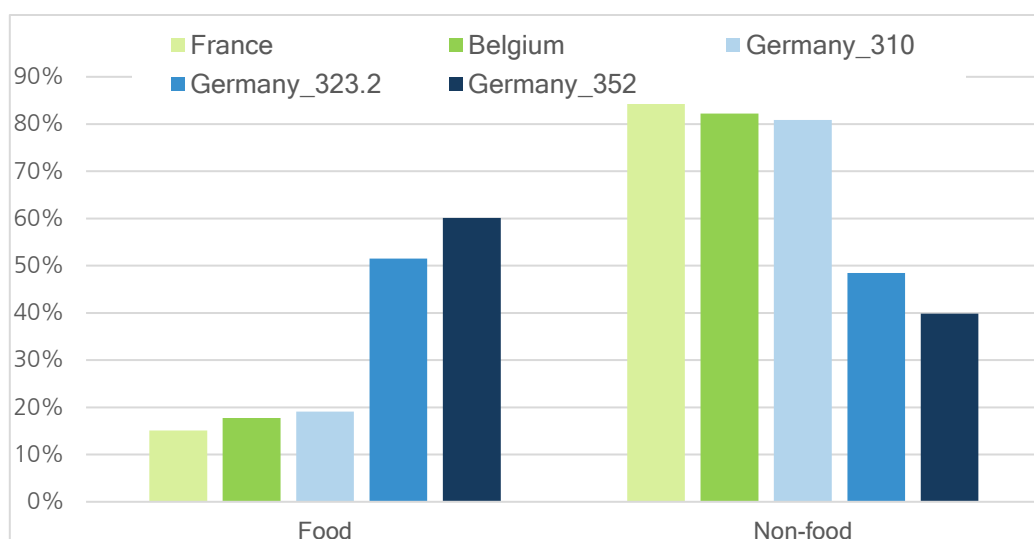


Figure 18: Comparison of the Food/Non-Food Flexible Packaging composition from the 3 EU sorting sites

6.2. COMPOSITION OF THE FOOD FLEXIBLE PACKAGING WASTE IN THE 3 EU SORTING SITES

Figure 19 presents the types of food flexible packaging classified in the different bales of the 3 European sorting sites. The same main sub-categories were identified, like frozen food bags, packaging of bakery products, ready meals, fresh products, meat and fish products, etc. in the French, Belgian and German 310 reference, with similar order of magnitude in mass %, except for ready meals and sweets and snacks packaging, which are more present in the German and in the Belgian bales respectively.

The 2 German bales, with the references 323-2 and 352, concentrate the packaging of ready meals, fresh products, pet food, instant dry products, dairy products, coffee, tea and cocoa products, and mostly, the sweets and snack products, with the highest mass % for the food categories.

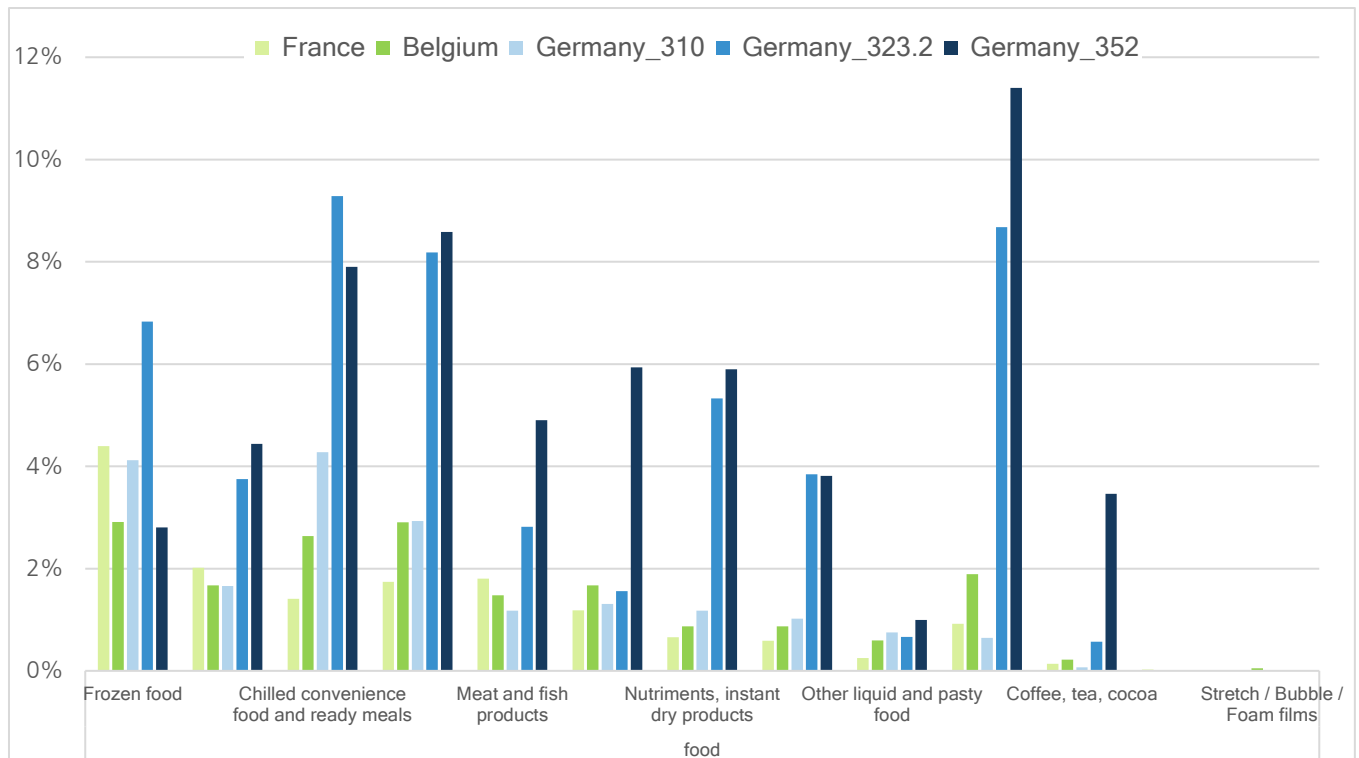


Figure 19: Comparison of the Food Flexible Packaging composition from the 3 EU sorting sites

6.3. COMPOSITION OF THE NON-FOOD FLEXIBLE PACKAGING WASTE IN THE 3 EU SORTING SITES

The comparison of the non-food packaging mass % identified in the bales of the 3 EU sorting sites is presented in Figure 20. This confirms that the same 3 main sub-categories present in all the bales of the 3 countries are industrial films packaging, collection bags due to the collection modes established in these countries, and secondary packaging for beverages.

Figure 20 also shows some features like the presence of plastic tarps in the Belgian bale due to the possibility to dispose such waste in the blue collection bags in Belgium. The higher mass % of industrial films in the German reference 310, compared to the French and the Belgian bales, with bigger and thicker films in the German bale, leads to the higher masses measured in this bale.

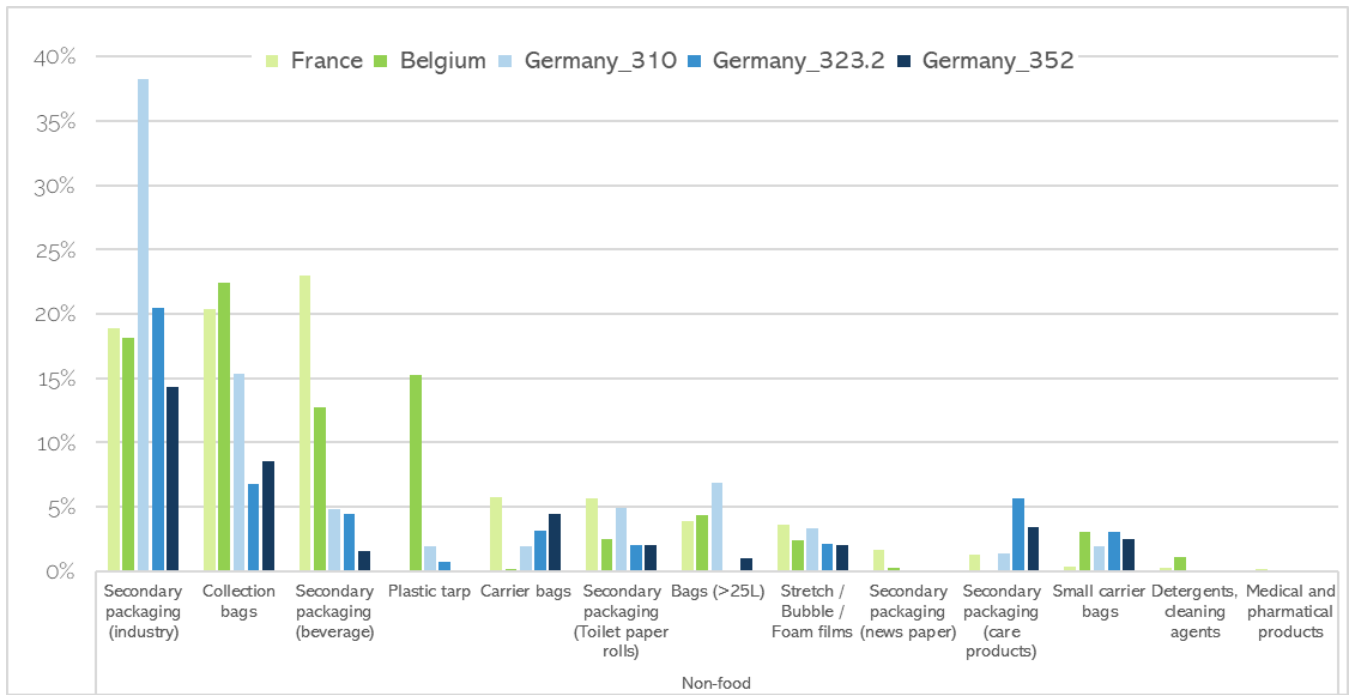


Figure 20: Comparison of the Non-Food Flexible Packaging composition from the 3 EU sorting sites

7. CONCLUSIONS

In the frame of Circular FoodPack project, the composition of flexible packaging waste was studied in the outputs of three sorting sites in Europe, France, Belgium, and Germany, selected as representative of the existing sorting processes used in many EU countries. The collected packaging waste sampled for this study corresponded to the current waste feedstock collected in these countries, where the collection of lightweight packaging is now implemented with the extended collection system put in place by EPR systems.

From June to December 2021, several quantities of packaging waste, between 60 kg to more than 200 kg, were sampled and characterised, from 6 materials' bales (weighing between 140 kg and 740 kg) from the three countries. Sorting refusals (143 kg) sampled at the French sorting site, were also characterised. The films and lightweight packaging waste collected in France and Belgium are sorted in two distinct outputs: films bales and sorting refusals, whereas the films and packaging waste collected in Germany is sorted in three types of bales: plastic films with the reference 310, flexible polyolefin items under the reference 323-2 and mixed plastics – lightweight packaging under the code 352.

The compositions of the French and Belgium bales are comparable to the German reference 310, in terms of food and non-food packaging proportions, with more than 80% of non-food fractions and the predominant sub-categories of industrial films packaging, collection bags and secondary packaging for beverages. This is due to the similar specifications of the materials' bales asked by EPR systems in the three countries (above 90% of PE films), and consequently, equivalent sorting process design in the three sites.

The two German bales, with the reference 323-2 and 352, concentrate the food packaging, respectively 51% and 60% in mass, for ready meals, fresh products, pet food, instant dry products, dairy products, coffee, tea and cocoa products, and mostly, the sweets and snack products. Very few quantities of these food packaging fractions were identified in the French, Belgian and German 310 bales and they were **more present in the sorting refusals of the French sorting site (65%)**, due to the removal of small format (below A4) at the beginning of the sorting processes. Based on the sorting processes used in the three sorting sites focusing mainly on the PE fractions, and also to a less extent on the polyolefin items and mixed plastics fractions, it can be deduced that the material composition of the food packaging is more multi-layers or not only polyolefin. This hypothesis will be confirmed by the chemical analyses of representative samples from all categories performed by the Fraunhofer Institute in the WP3 of the project.

As the mass % of flexible packaging decreases significantly in the German bales referenced 323-2 and 352, with respectively 48 % and 27 %, the recovery of these fractions from the bales must be benchmarked; the polyolefin fraction in the bale 323-2 presents a real interest and the quality of this fraction needs to be assessed.

Regarding the proportions of **printed and not printed fractions of flexible packaging**, a global trend is observed among the three European countries: **food packaging are mainly printed, and non-food packaging can be separated into two groups of mostly printed packages and not printed ones**. The not printed non-food packaging corresponds to industrial films, tarps, collection bags and small carrier bags, which are mainly PE fractions. For



both packaging categories sorted in the bales of the three EU countries, a de-inking / delamination process step will be mandatory to maintain the transparency of PE recyclates' films.

In summary, a total mass of 2670 kg has been provided by SUEZ to the partners in WP2 and WP3. Out of this waste, SUEZ has characterised about 820 kg of flexible packaging waste in total as described in Chapter 2. The characterised sample quantities correspond to the recommendations of the European and French standards, as cited in Section 2.1, ensuring the representativeness of the characterised samples for the considered flexible packaging waste in bales and in the sorting refusals.

Based on the results of this study, the French flexible packaging waste has been selected to be used as the background waste during the sorting trials of WP6 Task 6.4 (Loop3) and for the trials in Task 6.2 (Loop1). The French flexible packaging waste has already been and will still be provided to WP6 during the second period of the project (> 2200 kg). With this, the amount of the collected waste by SUEZ will reach up to 5 tonnes in total until the end of the project.



8. ANNEXES

8.1. ANNEX 1: SORTING GUIDE PROPOSED BY CITEO AND ADAPTED BY PARIS MUNICIPALITY

IT'S EASY, ALL PACKAGING AND PAPER CAN BE RECYCLED!

• IN THE YELLOW BIN •

COMPLETELY EMPTIED AND PLACED LOOSELY INTO THE BIN!



PAPER, CARDBOARD PACKAGING AND CONTAINERS



PLASTIC BOTTLES AND VIALS



METALLIC PACKAGING

NEW



ALL OTHER PLASTIC AND METALLIC PACKAGING (STEEL, ALUMINIUM, ETC.)

• IN THE WHITE BIN •

COMPLETELY EMPTIED!



GLASS BOTTLES AND JARS



WHATEVER IS LEFT OVER AFTER RECYCLING

• IN THE GREEN BIN •









8.2. ANNEX 2: SORTING GUIDE PROPOSED BY FOST PLUS

Sorting PMD in a blink of an eye! 😊

PLASTIC PACKAGING



Bottles Flasks

NEW



Trays and containers



Jars, pots and tubes



Films and bags

METAL PACKAGING



Cans and tins



Aerosols spray cans



Trays



Lids and caps

DRINK CARTONS



NOT ALLOWED IN THE NEW BLUE BAG

- ✗ Packaging made of a combination of materials (e.g. plastic film layer + aluminium film layer) which cannot be separated, like some juice pouches, fruit purée or wet pet food pouches etc. 
- ✗ Packaging with child-resistant fastenings 
- ✗ Packaging featuring one of these pictograms 
- ✗ Packaging of motor oil and lubricants, pesticides, fuels, adhesives, paints and varnishes, silicone sealants
- ✗ Packaging with a volume of more than 8 litres
- ✗ Polystyrene 
- ✗ Other items 

ATTENTION!

-  Do not put items inside one another or put filled, tied up bags into the PMD bag.
-  Do not hang anything on the outside of the bag.

Rules for good recycling

- Empty packaging completely. 
- Flatten plastic bottles lengthwise, put the cap on. 
- Place films and containers separately in the bag. 



Any doubts about sorting correctly?
Go to betersorting.be



8.3. ANNEX 3: SPECIFICATIONS OF GERMAN BALES: FRACTIONS N°310, 323-2 AND 350



Product Specification 04/2009 Fraction-No. 310

Sorting fraction:	PLASTIC FILMS								
<p>A Specification/Description</p> <p>Used, residue-drained, system-compatible items made of plastic film, surface > DIN A4, e.g. bags, carrier bags and shrink-wrapping film, incl. secondary components such as labels etc.</p> <p>The supplement is part of this specification!</p>									
<p>B Purity</p> <p>At least 92 % by mass in accordance with the specification/description.</p>									
<p>C Impurities</p> <table> <tr> <td>Max. total amount of impurities</td> <td>8 % by mass</td> </tr> </table> <p>Metallic and mineral impurities with a unit weight of > 100 g are not permitted!</p> <table> <tr> <td>Other metal items</td> <td>< 0.5 % by mass</td> </tr> <tr> <td>Other plastic items</td> <td>< 4 % by mass</td> </tr> <tr> <td>Other residues items</td> <td>< 4 % by mass</td> </tr> </table> <p>Examples of impurities:</p> <ul style="list-style-type: none"> - Glass - Paper, cardboard - Composite paper/cardboard materials (e.g. beverage cartons) - Aluminised plastics - Other materials (e.g. rubber, stones, wood, textiles, nappies) - Compostable waste (e.g. food, garden waste) 		Max. total amount of impurities	8 % by mass	Other metal items	< 0.5 % by mass	Other plastic items	< 4 % by mass	Other residues items	< 4 % by mass
Max. total amount of impurities	8 % by mass								
Other metal items	< 0.5 % by mass								
Other plastic items	< 4 % by mass								
Other residues items	< 4 % by mass								
<p>D Delivery form</p> <ul style="list-style-type: none"> - Transportable bales - Dimension and density of the bales must be chosen so as to ensure that a tarpaulin truck (loading area 12.60 m x 2.40 m; lateral loading height min. 2.60 m) can be loaded with a minimum loading of 23 t - Dry-stored - Produced with customary bale presses - Identified with DSD bale label stating the sorting plant no., fraction No. and production date 									



**Product Specification 03/2018
Fraction-No. 323-2**

Sorting fraction: Flexible polyolefin items

A Specification/Description

Used, residue-drained, system-compatible, flexible items made of polyolefin (PE, PP) that are typical for packaging such as films, carrier bags (incl. aluminised films) and plastics made of Polyolefins that are dimensionally stable such as trays, covers incl. secondary components such as lids, labels etc.

The supplement is part of this specification!

B Purity

At least 90 % by mass according to specification/description.

C Impurities

Max. total amount of impurities 10 % by mass

Metallic or mineral impurities with a unit weight of > 100 g are not permitted!

PET items < 5 % by mass

EPS items < 0,8 % by mass

Paper, cardboard, carton, liquid packaging boards < 3 % by mass

Other residues < 3 % by mass

Other metal items < 1 % by mass

Examples of impurities:

- Glas
- Other plastic items
- Other materials (e.g. rubber, stones, wood, textiles, nappies)
- Compostable waste (e.g. food, garden waste)

D Form of Delivery

- Transportable bales
- Dimension and density of the bales must be chosen so as to ensure that a tarpaulin truck (loading area 12.60 m x 2.40 m; lateral loading height min. 2.60 m) can be loaded with a minimum loading of 21 t
- Dry-stored
- Produced with customary bale presses
- Identified with DSD bale label stating the sorting plant no., fraction no. and production date



The bales specified as "352 - Mixed Plastics - Lightweight Packaging" are adapted from the specifications 350 - Mixed Plastics. The specifications 352 are the same as 350 ones.



**Product Specification 03/2018
Fraction-No. 350**

Sorting fraction:	MIXED PLASTICS
--------------------------	-----------------------

A Specification/Description

Used, residue-drained, system-compatible items made of plastics that are typical for packaging (PE, PP, PS, PET) incl. secondary components such as lids, labels etc.

The supplement is part of this specification!

B Purity

At least 90 % by mass according to specification/description.

C Impurities

Max. total amount of impurities 10 % by mass

Metallic or mineral impurities with a unit weight of > 100 g are not permitted!

Paper, cardboard < 5 % by mass

Other metal items < 2 % by mass

PET bottles, transparent < 4 % by mass

PVC items other than packaging < 0.5 % by mass

Other residues < 3 % by mass

Examples of impurities:

- Glass
- Composite paper/cardboard materials (e.g. liquid packaging boards)
- Other materials (e.g. rubber, stones, wood, textiles, nappies)
- Compostable waste (e.g. food, garden waste)

D Form of Delivery

- Transportable bales
- Dimension and density of the bales must be chosen so as to ensure that a tarpaulin truck (loading area 12.60 m x 2.40 m; lateral loading height min. 2.60 m) can be loaded with a minimum loading of 21 t
- Dry-stored
- Produced with customary bale presses
- Identified with DSD bale label stating the sorting plant no., fraction no. and production date

