Valorisation appropriate waste streams

Deliverable D6.1

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List of abbreviations

ABPR	Animal By-Products Regulations
AD	Anaerobic digestion
DOA	Description of Action
EU	European Union
EFSA	European Food Safety Authority
FAO	Food and Agriculture Organisation of the United Nations
FA	Framework for Action
FUSIONS	Food Use for Social Innovation by Optimising Waste Prevention Strategies
PWP	Pilot Working Platform
UNEP	United Nations Environment Programme
WP	Work Package
WRAP	Waste Resources Action Programme

1 Executive Summary

1.1 Objectives of work

REFRESH is an EU H2020 funded research project taking action against food waste. Twenty-six partners from 12 European countries and China are working towards the project's aim to contribute towards Sustainable Development Goal 12.3 of halving per capita food waste at the retail and consumer level and reducing food losses along production and supply chains, reducing waste management costs, and maximizing the value from un-avoidable food waste and packaging materials.

REFRESH runs for 4 years (until June 2019) and an overarching aim of the project is to develop the blueprint for a pan-European Framework for Action (FA), the end result being a blueprint which:

- demonstrates the impact a Framework for Action can have;
- shows how best to make a pan-European Framework for Action work; and
- shows that such a Framework for Action would be viable / useful at an EU level.

This piece of analysis sits within REFRESH Work Package 6: Valorisation of waste streams and co-products. One of the key objectives of this Work Package is to increase the exploitation of food and packaging waste by helping business stakeholders to identify waste streams appropriate for valorisation regarding a) their robustness of supply, quality and composition and b) for which products and outputs might be realised that are technologically feasible, economically viable, legislatively compliant and environmentally sustainable / beneficial.

The wider research and analysis covered in this report, and the methodology used to refine it is therefore integral to the longer term aims of the project.

1.2 Approach

In order to develop a list of the priority waste streams, the first task was to identify the top food products for EU-28 based on sales volume and environmental impact. Eighty food products were identified to ensure the list would be pan-European and cover as many food groups as possible. Much work has already been carried out in this area by organisations such as WRAP, FAO and UNEP and the related EU FP7 project FUSIONS. These data sources were analysed and then combined to give an average ranking across all data points using a scoring process.

This initial list of 80 food products was subject to further interrogation between the key partners within the Work Package and a decision was taken to remove 17 products due to variable composition and the fact that their ingredients were already covered within the remaining 63 products. Examples of removed products are ‘canned soup’ or ‘canned ready meals’. These products could contain differing ingredients, meaning it was not possible to adequately define the product to determine its composition.

The next step was to look at the waste materials arising, primarily from the manufacturing process, for each of the remaining products. A number of referenced data sources were screened and interrogated resulting in the construction of a large and comprehensive spreadsheet of prioritised waste streams. Important at this stage was consistent referral to commercial data sources which helped to ensure the spreadsheet only included processes that were either at advanced demonstration stage or commercially available.

This comprehensive waste stream list was then subject to further reduction through a sequential scoring exercise undertaken by the task members. The first element applied a simple scoring system to 6 questions covering aspects such as high volume, existing valorisation route, unavoidable in nature, etc. and then the selection from the top-scoring waste streams was further refined by a series of 4 indicator questions. The 4 indicator questions covered policy restrictions, seasonality, susceptibility to rapid spoilage and geographical dispersion. The purpose of this exercise was to reveal any obvious issues with the spreadsheet, and to help identify where the scoring system may have misplaced waste streams due to a clear lack of evidence e.g. lack of knowledge of the degree of centralisation of the waste stream and existing management routes.

Finally, at the end of this scoring process, the task team used an internal (project team) review to:

- independently evaluate the scoring process
- provide constructive feedback on the process used

Where differences were apparent between the peer reviewers scores and the WP6 team scores, these were investigated further and adjusted using a consensus view. The same peer reviewers were also involved in narrowing down the comprehensive waste stream list to a final medium list of waste streams. Using the earlier scoring system, the team focused only on the top scoring waste streams [73 across all product categories], and identified where streams were similar and could be amalgamated or where duplication occurred. At the end of this exercise, a final list of 37 priority waste streams was created. The resultant list includes well-known examples of spent grains and other organic waste streams from the production of alcoholic beverages (ales, lagers, cider, wines and spirits), press cakes from vegetable oil processing and meat & dairy side-streams such as slaughter by-products and whey protein. Fruits & vegetable waste streams which are often considered to have lower environmental impacts are represented by apple pomace, orange peel / juicing residues and tomato pomace.

1.3 Next steps

This piece of work forms the first part of a two-step process to categorise and record the valorisation approaches and technologies currently used to exploit the top impacting waste streams. This first step has provided a systemic method to identify then prioritise the top waste streams across the EU, which has resulted in the 37 waste streams referenced above. The next step, which will be reported in a successive Project publication under WP6, is to use the waste hierarchy to identify and collate the types of methods and approaches currently applied to

exploit these priority waste streams. Following further refinement, this will produce an output identifying the top 20 waste streams.

Key to this next step is seeking interaction with industry, particularly through the route of the National Piloting Working Platforms in the REFRESH piloting countries (NL, DE, HU, ES). These will provide the team with guidance on business and consumer acceptance of these waste streams. A number of approaches are to be evaluated, and further literature reviews will be undertaken to identify new technologies and approaches that are not currently in widespread use by industry. This information will feed into the construction of a compositional database, which will be made available via a 'Centre of Excellence' – an online resource developed within the REFRESH Project.

2 Introduction

2.1 REFRESH

REFRESH is an EU Horizon 2020 funded research project taking action against food waste. Twenty-six partners from 12 European countries and China are working towards the project's aim to contribute towards Sustainable Development Goal 12.3 of halving per capita food waste at the retail and consumer level and reducing food losses along production and supply chains, reducing waste management costs, and maximizing the value from unavoidable food waste and packaging materials.

This piece of work sits under Work Package 6 entitled "Valorisation of waste streams and co-products".

2.2 Aim of Work Package

This piece of analysis sits within REFRESH Work Package 6: Valorisation of waste streams and co-products. One of the key objectives of this Work Package is to increase the exploitation of food and packaging waste by helping business stakeholders to identify waste streams appropriate for valorisation regarding a) their robustness of supply, quality and composition and b) for which products and outputs might be realised that are technologically feasible, economically viable, legislatively compliant and environmentally sustainable / beneficial.

Furthermore, the WP concentrates on valorising post-consumer putrescible waste and aims to help policy makers to identify and implement improvements to the legislature that will reduce unneccessary restrictions on valorisation. This includes use of former foodstuffs in animal feed production, whilst maintaining appropriate safety and quality standards.

This report describes the findings on the selection of top waste streams. This selection enables the identification of key waste streams that have a significant environmental impact, and will contribute, based on current knowledge, to develop the most effective approaches in valorising former foodstuff/products. This selection is performed via the following steps:

- a: Identify top 80 foodstuffs for EU-28 based on sales volume and environmental impact.
- b: Identify and estimate waste volumes from these streams. Where available, information on seasonality and geographical information is included in the overview.
- c: evaluate the need for improved valorisation considering policy recommendations (WP3), socio-economic modelling (WP4) and evaluation of environmental impacts and life cycle costs (WP5). These insights provide additional selection criteria for the waste. Examples are waste streams which can be reduced through improved chain management, business and consumer behaviour (WP1, WP2), restrictions by policy/regulation or those streams that cannot be valorised in an environmentally sustainable manner (e.g. due to dispersed geographical coverage, propensity for rapid spoilage, etc.).

2.3 Methodology

2.3.1 Selection of top 80 products

In order to target the efforts of the REFRESH project, a selection process was undertaken to identify the most significant waste streams with respect to European consumption and environmental impact.

The first stage of this process was to identify the top 80 foodstuffs consumed in the EU-28. Data sources used for this exercise were as follows: the aggregate consumption calculated from the average consumption per capita per day for seventeen member states reported in the EFSA Food Consumption database (EFSA 2015), the rankings for each food product in the WRAP Product Sustainability Forum Knowledge Base with respect to (i) weight, (ii) CO_2 emissions, (iii) energy use and (iv) water use (WRAP 2016), the EU food supply quantities reported in the FAOStat Food Balance Sheets for 2011 (FAOSTAT 2015), the UK annual greenhouse gas emissions and annual UK sales volumes for each food product reported in the WRAP publication *An initial assessment of the environmental impact of grocery products* (WRAP 2013).

The rankings for each data source were corrected for the maximum ranking score from that data source before combining to give an average ranking across all available data points. The list of 80 priority food products is given in Annex A.

2.3.2 Deriving a comprehensive waste stream list

The top 80 food products covered a wide range of product categories and includes simple one ingredient products as well as products made from complex components.

Table 1: Food products excluded from further study

Product name	
Canned vegetables	Canned meat products
Canned ready meals	Canned soup
Chilled desserts	Chilled soup
Concentrates	Condiment sauces
Deli food incl. cooked meats	Functional drinks
Infant formula	Other hot drinks
Other non-alcoholic drinks	Pickled products
Pizza, chilled & frozen	Ready meals, chilled & frozen
Wet cooking sauces	

At this point, the decision was taken to remove 17 of the food products from the process due to variable composition and the fact that the ingredients were covered elsewhere within the remaining list of 63 products. For example, in the case of canned soup or canned ready meals, these could be meat-based or entirely vegetable-based and therefore contain differing ingredients. As a result, it is not possible to adequately define the product to determine its composition (for inclusion in the Food Waste Compositional Database) or the resultant waste streams arising from its manufacture and sale. The 17 products removed from the process are shown in Table 1.

Waste materials arising mainly from the manufacturing process for each of the products in the list of remaining priority food products were identified using referenced data sources and a very large and comprehensive spreadsheet was constructed. For each of the listed waste streams for each product, published commercial literature and web sources were screened to identify where specific waste streams are already being used for valorisation processes. Commercial data sources were used in preference to more academic research literature to ensure that the spreadsheet only includes those valorisation options that have moved beyond academic laboratory scale investigations. This is an important step. Literature searching quickly reveals a wealth of academic work in waste stream valorisation. This can be very useful work but by consistently using commercial evidence to support the prioritisation exercise, the spreadsheet only includes processes that have moved to late pilot scale or to demonstration.

A version of the comprehensive waste stream spreadsheet is included in Annex B. It includes a long list of 291 waste streams covering the remaining priority products.

2.3.3 Identifying the top 40 priority waste streams

The comprehensive waste stream list was then subjected to a sequential scoring exercise. The first stage of this was to apply a simple scoring system to 6 questions:

- Is the waste stream present in high volumes?
- Is the waste stream unavoidable and post farm-gate?
- Is there an existing valorisation route other than AD?
- Can the waste stream be reduced significantly by improved chain management?
- Can the waste stream be reduced significantly by changes in business behaviour?
- Can the waste stream be reduced significantly by changes in consumer behaviour?

Using a weighted scoring method, a score from a numeric priority scale of 0, 1 or 3 was applied to these questions for each waste stream. 0 indicates a low or nil response, 1 uncertainty where there was mixed or contradictory evidence from literature sources or expert opinion and 3 a positive or high response. These

scores were then added and a cumulative score for each waste stream was calculated. Waste streams were then ranked by score on these first 6 questions.

The selection from the top-scoring waste streams was further refined by a series of 4 indicator questions:

- Is valorisation of the waste stream likely to be subject to ABPR restrictions?
- Is the waste stream centralised or dispersed geographically?
- Is the waste stream subject to rapid spoilage?
- Is the waste seasonal?

The purpose of these clarifications was to reveal obvious issues with the spreadsheet and to help identify where the scoring system may have misplaced waste streams due to a lack of clear evidence. Where obvious misplaced streams appeared the scoring system was revisited and amended where appropriate.

2.3.4 Internal (project team) review

At the end of this scoring process, the task team used an internal peer review to independently evaluate the scoring process and to provide constructive feedback on the process that had been used. Two peer reviewers undertook a separate but identical scoring exercise and came up with a very similar prioritised waste stream listing. Where differences emerged between the peer reviewers scoring and the WP6 team scores these were investigated and the wastes stream priorities adjusted using a consensus view.

The same peer reviewers were also then involved in narrowing the comprehensive waste stream list down to a final medium list of waste streams. This was done by working with the top scoring waste streams only (i.e. those with the maximum score of 18) – a list of 73 waste streams across all product categories. The WP6 team worked with the peer reviewers to identify where wastes streams were very similar and could be amalgamated, where there was effective duplication with the same waste stream emerging in more than one product category and where there were grounds to evaluate similar waste streams from a process together as a single waste stream. Examples of this include spent grains, distillers' dark grain and draff from ales, lagers and spirits which could be considered to be sufficiently similar to be amalgamated for the purposes of this exercise. The resulting list of 37 priority waste streams is included at Annex C. The list includes well-known examples of spent grains and other organic waste streams from the production of alcoholic beverages (ales, lagers, cider, wines and spirits), press cakes from vegetable oil processing and meat & dairy side-streams such as slaughter by-products and whey protein. Fruits & vegetable waste streams which are often considered to have lower environmental impacts are represented by apple pomace, orange peel / juicing residues and tomato pomace.

3 Next steps

The 37 identified priority waste streams will be further assessed within the Project for high level business plan criteria, such as available quantities, locations, likely economies of scale and seasonality issues. The outcome of this will be a list of the top 20 waste streams for which the production systems will be researched, identified and modelled in subsequent tasks.

A wider list having a greater level of granularity has been used as the input to a Compositional Database which is currently under development in the Dissemination Work Package of the REFRESH Project. This will serve as an online resource, accessible by all stakeholders. The current list contains 75 waste streams and provides sufficient detail to allow the waste stream to be adequately described and its composition determined. An example of this is apple pomace from the pressing of apple juice and pectin production which appears as 'Apple, pomace' in the list of 37 priority waste streams. However, in the wider list of 75 priority waste streams, this is defined in greater detail as 'Apple, pomace (single-pressed)', 'Apple, pomace (double-pressed) and 'Apple, pectin-extracted fruit', all of which can originate from the same production system. Each of these could have different compositions although generically they all qualify as apple pomace.

The findings of this research are also of key importance for other workpackages within REFRESH, particularly the development of pilot projects under WP2 'Business Engagement – Frameworks for Action'. Understanding where the priorities are, and having the drive to push for innovative ideas in the area is something that will be picked up in forthcoming national piloting platform meetings, involving key industry members spanning retailers, manufacturers and suppliers.

4 Conclusions

This piece of work forms part of a two-step process to categorise and record the valorisation approaches and technologies currently used to exploit the top impacting waste streams. This first step has provided a systemic method to identify then prioritise the top waste streams across the EU, which has resulted in the 37 waste streams referenced above. The next step, which will be reported in a successive Project publication under WP6, is to use the waste hierarchy to identify and collate the types of methods and approaches currently applied to exploit these priority waste streams. Following further refinement, this will produce an output identifying the top 20 waste streams.

Key to this next step is interaction with industry, particularly through the route of the National Piloting Working Platforms in the REFRESH piloting countries (NL, DE, HU, ES), which will provide the team with guidance on business and consumer acceptance of these waste streams. A number of approaches are to be evaluated, and further literature reviews will be undertaken to identify new technologies and approaches that are not currently in use. This information will feed into the construction of a compositional database, which will be made available via a 'Centre of Excellence' – an online resource developed within the REFRESH Project.

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6 Annexes

6.1 Annex A: The top priority food product list

The top 80 food products identified with respect to environmental impact and consumption in the EU-28 are shown in the table below.

Table 2: The top priority food product list

Product name	
Liquid milk	Flavoured milk
Bread & rolls	Canned pasta & noodles
Carbonates / soft drinks	Crisps
Poultry, fresh & frozen	Sweet peppers
Juices	Lettuce
Bottled water	Cakes, pastries & morning goods
Pork, fresh	Chilled soup
Lager	Grapes
Beef, fresh & frozen	Other non-alcoholic drinks
Light wines	Cauliflowers
Fermented milk products	Ales
Cheese	Tomatoes
Deli food incl. cooked meats	Pineapples
Eggs	Frozen bakery products
Ready meals, chilled & frozen	Butter
Potatoes	Crackers (savoury biscuits)
Carrots	Cabbages
Other field veg (excl. dried)	Melons
Cream	Spirits
Sugar	Onions
Vegetable oil	Pickled products
Canned soup	Wet cooking sauces
Yogurt	Sugar confectionery

Concentrates	Pears
Oranges	Strawberries
Biscuits (sweet)	Ice cream (litres)
Wheat milling products	Lamb, fresh
Cucumbers	Frozen potato products
Fish/seafood, chilled & frozen	Cider/perry
Banana	Pizza, chilled & frozen
Breakfast cereals	Tea
Dried & chilled pasta/noodles	Functional drinks
Coffee	Margarine
Small oranges	Canned meat products
Canned ready meals	Jams & preserves
Apples	Lemons & limes
Prepared salads	Canned vegetables
Rice	Canned fish/seafood
Chilled desserts	Mushrooms
Chocolate	Infant Formula

6.2 Annex B: List of 291 identified waste streams

The complete list of 291 waste streams arising from the top priority food products are shown in the table below. They are displayed in product categories

Table 3: Complete list of identified waste streams

Food group	Food product	Waste stream	Food Supply Chain Sector
Fruit and vegetables	Apples	Field loss	Production
Fruit and vegetables	Apples	Grading loss	Processing
Fruit and vegetables	Apples	Storage loss	Distribution
Fruit and vegetables	Apples	Packaging loss	Distribution
Fruit and vegetables	Apples	Retail loss	Retail
Fruit and vegetables	Apples	Pomace (single-pressed)	Processing
Fruit and vegetables	Apples	Pomace (double-pressed)	Processing
Fruit and vegetables	Apples	Pectin-extracted fruit (outside UK)	Processing
Fruit and vegetables	Banana	Field loss	Production

Fruit and vegetables	Banana	Grading loss	Processing
Fruit and vegetables	Banana	Packaging loss	Distribution
Fruit and vegetables	Banana	Retail loss	Retail
Fruit and vegetables	Banana	Banana skin	Processing / Household
Fruit and vegetables	Banana	Over-ripe product	Household
Fruit and vegetables	Cabbages	Field loss	Production
Fruit and vegetables	Cabbages	Processing wastes	Processing
Fruit and vegetables	Carrots	Peelings	Processing / Household
Fruit and vegetables	Carrots	Tops & tails	Processing / Household
Fruit and vegetables	Carrots	Unused whole product	Household
Fruit and vegetables	Carrots	Rejected whole product	Processing
Fruit and vegetables	Cauliflowers	Field loss	Production
Fruit and vegetables	Cucumbers	Field loss	Production
Fruit and vegetables	Cucumbers	Grading loss	Processing

Fruit and vegetables	Grapes	Rejected grapes	Processing
Fruit and vegetables	Grapes	Shoots and woody material	Processing
Fruit and vegetables	Grapes	Grape stems	Processing
Fruit and vegetables	Grapes	Grapeseed	Processing
Fruit and vegetables	Juices	Rotten fruit, stem wastes, stems, stalks	Processing
Fruit and vegetables	Juices	Juice pressing (pits, seeds, pulp, grape lees, peel)	Processing
Fruit and vegetables	Juices	Organic residue, solid matter	Processing
Fruit and vegetables	Juices	Processing scraps	Processing
Fruit and vegetables	Juices	Bentonite, gelatine with organic debris	Processing
Fruit and vegetables	Juices	Spent earth filters	Processing
Fruit and vegetables	Juices	Unfinished product	Household
Fruit and vegetables	Lettuce	Field loss	Production
Fruit and vegetables	Lettuce	Storage loss	Distribution
Fruit and vegetables	Lettuce	Packing loss	Distribution

Fruit and vegetables	Lettuce	Retail loss	Retail
Fruit and vegetables	Lemons & limes	Field loss	Production
Fruit and vegetables	Lemons & limes	Grading loss	Processing
Fruit and vegetables	Lemons & limes	Storage loss	Distribution
Fruit and vegetables	Lemons & limes	Packaging loss	Distribution
Fruit and vegetables	Lemons & limes	Retail loss	Retail
Fruit and vegetables	Lemons & limes	Citrus zest and peel	Processing
Fruit and vegetables	Lemons & limes	Citrus pulp	Processing
Fruit and vegetables	Onions	Field loss	Production
Fruit and vegetables	Onions	Grading loss	Processing
Fruit and vegetables	Onions	Storage loss	Distribution
Fruit and vegetables	Onions	Packaging loss	Distribution
Fruit and vegetables	Onions	Retail loss	Retail
Fruit and vegetables	Onions	Processing wastes (tops/tails, brown skin & outer layers)	Processing

Fruit and vegetables	Oranges	Field loss	Production
Fruit and vegetables	Oranges	Grading loss	Processing
Fruit and vegetables	Oranges	Storage loss	Distribution
Fruit and vegetables	Oranges	Packaging loss	Distribution
Fruit and vegetables	Oranges	Retail loss	Retail
Fruit and vegetables	Oranges	Peel, seed, membrane residue after juice extraction	Processing
Fruit and vegetables	Oranges	Citrus zest and peel	Processing
Fruit and vegetables	Oranges	Citrus molasses	Processing
Fruit and vegetables	Pears	Pear waste	Processing
Fruit and vegetables	Pineapples	Pineapple leaf	Production
Fruit and vegetables	Pineapples	Peels, crowns, cores, trimmings, pomace	Processing
Fruit and vegetables	Prepared salads	Co-product fruit salad (peels & pips from preparation of prepared fruit salads)	Processing
Fruit and vegetables	Small oranges	Field loss	Production
Fruit and vegetables	Small oranges	Grading loss	Processing

Fruit and vegetables	Small oranges	Storage loss	Distribution
Fruit and vegetables	Small oranges	Packaging loss	Distribution
Fruit and vegetables	Small oranges	Retail loss	Retail
Fruit and vegetables	Small oranges	Citrus pulp	Processing
Fruit and vegetables	Strawberries	Field loss	Production
Fruit and vegetables	Strawberries	Grading loss	Processing
Fruit and vegetables	Strawberries	Packaging loss	Distribution
Fruit and vegetables	Strawberries	Retail loss	Retail
Fruit and vegetables	Strawberries	Fruit seeds	Processing
Fruit and vegetables	Tomatoes	Field loss	Production
Fruit and vegetables	Tomatoes	Grading loss	Processing
Fruit and vegetables	Tomatoes	Storage loss	Distribution
Fruit and vegetables	Tomatoes	Packaging loss	Distribution
Fruit and vegetables	Tomatoes	Retail loss	Retail

Fruit and vegetables	Tomatoes	Pomace (skin, pulp & seeds)	Processing
Bread, rice, potatoes, pasta and other starchy foods	Bread & rolls	Surplus product	Retail / Processing
Bread, rice, potatoes, pasta and other starchy foods	Bread & rolls	Bread crusts	Processing
Bread, rice, potatoes, pasta and other starchy foods	Bread & rolls	Under/overweight product	Processing
Bread, rice, potatoes, pasta and other starchy foods	Bread & rolls	Dough	Processing
Bread, rice, potatoes, pasta and other starchy foods	Breakfast cereals	Process (food) waste	Processing
Bread, rice, potatoes, pasta and other starchy foods	Breakfast cereals	Wastewater	Processing
Bread, rice, potatoes, pasta and other starchy foods	Canned pasta & noodles	Waste product	Processing
Bread, rice, potatoes, pasta and other starchy foods	Dried & chilled pasta/noodles	Waste product	Processing
Bread, rice, potatoes, pasta and other starchy foods	Potatoes	Field loss	Production
Bread, rice, potatoes, pasta and other starchy foods	Potatoes	Grading loss	Processing
Bread, rice, potatoes, pasta and other starchy foods	Potatoes	Storage loss	Distribution
Bread, rice, potatoes, pasta and other starchy foods	Potatoes	Grading loss (post-storage)	Distribution
Bread, rice, potatoes, pasta and other starchy foods	Potatoes	Packaging loss	Distribution

Bread, rice, potatoes, pasta and other starchy foods	Potatoes	Retail loss	Retail
Bread, rice, potatoes, pasta and other starchy foods	Potatoes	Fibre from potato starch production	Processing
Bread, rice, potatoes, pasta and other starchy foods	Potatoes	Protein from potato starch production	Processing
Bread, rice, potatoes, pasta and other starchy foods	Potatoes	Concentrated fruit juice from potato starch production	Processing
Bread, rice, potatoes, pasta and other starchy foods	Potatoes	Fruit water	Processing
Bread, rice, potatoes, pasta and other starchy foods	Potatoes	Peelings	Processing
Bread, rice, potatoes, pasta and other starchy foods	Potatoes	Prime potato puree from process water	Processing
Bread, rice, potatoes, pasta and other starchy foods	Frozen potato products	Broken & damaged potato chips	Processing
Bread, rice, potatoes, pasta and other starchy foods	Frozen potato products	Potato off-cuts (potato hopper)	Processing
Bread, rice, potatoes, pasta and other starchy foods	Frozen potato products	Potato off-cuts (cooked)	Processing
Bread, rice, potatoes, pasta and other starchy foods	Frozen potato products	Peelings (steam-peeling)	Processing
Bread, rice, potatoes, pasta and other starchy foods	Frozen potato products	Peelings (abrasion-peeling)	Processing
Bread, rice, potatoes, pasta and other starchy foods	Rice	Rice husks	Processing
Bread, rice, potatoes, pasta and other starchy foods	Wheat milling products	Wheat middlings	Processing

Bread, rice, potatoes, pasta and other starchy foods	Wheat milling products	Wheatfeed	Processing
Bread, rice, potatoes, pasta and other starchy foods	Wheat milling products	Bran	Processing
Milk and dairy foods	Cheese	Whey	Processing
Milk and dairy foods	Cheese	Whey concentrate	Processing
Milk and dairy foods	Cheese	Whey permeate	Processing
Milk and dairy foods	Cheese	Delactosed whey	Processing
Milk and dairy foods	Cheese	Curd waste/losses	Processing
Milk and dairy foods	Cheese	Salt whey	Processing
Milk and dairy foods	Cheese	Cheese smear/rind	Processing
Milk and dairy foods	Cheese	Discarded cheese cuts/pieces	Processing
Milk and dairy foods	Cheese	Brine sewage	Processing
Milk and dairy foods	Cheese	Waste water	Processing
Milk and dairy foods	Liquid milk	Sludge: microbial mass & protein mixture	Processing
Milk and dairy foods	Liquid milk	Washing water	Processing

Milk and dairy foods	Liquid milk	Salvage milk	Packaging
Milk and dairy foods	Liquid milk	Unfinished product	Household
Milk and dairy foods	Yogurt	Sludge	Processing
Milk and dairy foods	Yogurt	Sludge : microbial mass & protein mixture	Processing
Milk and dairy foods	Yogurt	Changeover losses	Processing
Milk and dairy foods	Yogurt	Washing water	Processing
Milk and dairy foods	Yogurt	Product past expiry date	Household
Meat, fish, eggs, beans and other non-dairy sources of protein	Beef, fresh & frozen	Blood	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Beef, fresh & frozen	Hides	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Beef, fresh & frozen	Heads and horns	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Beef, fresh & frozen	Hooves	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Beef, fresh & frozen	White offal	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Beef, fresh & frozen	Red offal	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Beef, fresh & frozen	Carcass fat	Processing

Meat, fish, eggs, beans and other non-dairy sources of protein	Beef, fresh & frozen	Meat trimming scraps	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Beef, fresh & frozen	Bones	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Beef, fresh & frozen	Fat	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Beef, fresh & frozen	Washing water	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Eggs	Manure	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Eggs	Egg shell waste (shell)	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Eggs	Egg shell waste (membrane)	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Eggs	Outgrades	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Fish/seafood, chilled, canned & frozen	Outgrades	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Fish/seafood, chilled, canned & frozen	Offal	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Fish/seafood, chilled, canned & frozen	Head	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Fish/seafood, chilled, canned & frozen	Bones	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Fish/seafood, chilled, canned & frozen	Frames and off-cuts	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Fish/seafood, chilled, canned & frozen	Fish skin	Processing

Meat, fish, eggs, beans and other non-dairy sources of protein	Fish/seafood, chilled, canned & frozen	Waste water	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Fish/seafood, chilled, canned & frozen	Crustacean body fluid	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Fish/seafood, chilled, canned & frozen	Crustacean heads	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Fish/seafood, chilled, canned & frozen	Crustacean shells	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Fish/seafood, chilled, canned & frozen	Crustacean intestines	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Fish/seafood, chilled, canned & frozen	Crustacean scraps	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Fish/seafood, chilled, canned & frozen	Mollusc exudate	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Fish/seafood, chilled, canned & frozen	Mollusc shell / shell particles	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Fish/seafood, chilled, canned & frozen	Mussel beard	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Lamb, fresh	Edible offal	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Lamb, fresh	Edible co-products	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Lamb, fresh	Main edible fats	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Lamb, fresh	Category 3 - slaughter	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Lamb, fresh	Category 3 - cutting	Processing

Meat, fish, eggs, beans and other non-dairy sources of protein	Lamb, fresh	Category 3 - imports	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Lamb, fresh	Specific Risk Material - slaughter & cutting	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Lamb, fresh	Stomach and intestinal contents	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Lamb, fresh	Hide & skins	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Lamb, fresh	Blood	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Lamb, fresh	Product waste	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Pork, fresh	Blood	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Pork, fresh	Hair/bristle	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Pork, fresh	Hide & rind remnants	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Pork, fresh	Head	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Pork, fresh	Hooves	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Pork, fresh	White offal	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Pork, fresh	Carcass fat	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Pork, fresh	Meat scraps	Processing

Meat, fish, eggs, beans and other non-dairy sources of protein	Pork, fresh	Bones	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Pork, fresh	Fat	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Pork, fresh	Washing water	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Poultry, fresh & frozen	Blood	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Poultry, fresh & frozen	Feather	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Poultry, fresh & frozen	Head	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Poultry, fresh & frozen	Feet	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Poultry, fresh & frozen	Guts	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Poultry, fresh & frozen	Giblets/offal	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Poultry, fresh & frozen	Bones	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Poultry, fresh & frozen	Poultry skin	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Poultry, fresh & frozen	Fats	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Poultry, fresh & frozen	Meat scraps	Processing
Meat, fish, eggs, beans and other non-dairy sources of protein	Poultry, fresh & frozen	Washing water	Processing

Food and drinks high in fat and/or sugar	Biscuits (sweet)	Damaged / rejected biscuits	Processing
Food and drinks high in fat and/or sugar	Biscuits (sweet)	Product past expiry date	Processing / Wholesale / Retail
Food and drinks high in fat and/or sugar	Butter	Sludge : microbial mass & protein mixture	Processing
Food and drinks high in fat and/or sugar	Butter	Washing water	Processing
Food and drinks high in fat and/or sugar	Butter	Unfinished product	Household
Food and drinks high in fat and/or sugar	Cakes, pastries & morning goods	Waste product	Processing
Food and drinks high in fat and/or sugar	Carbonates / soft drinks	Unconsumed product	Household
Food and drinks high in fat and/or sugar	Carbonates / soft drinks	Wastewater	Processing
Food and drinks high in fat and/or sugar	Chocolate	Rejected product	Processing
Food and drinks high in fat and/or sugar	Crackers (savoury biscuits)	Damaged / rejected biscuits	Processing
Food and drinks high in fat and/or sugar	Cream	Sludge : microbial mass & protein mixture	Processing
Food and drinks high in fat and/or sugar	Cream	Washing water	Processing
Food and drinks high in fat and/or sugar	Cream	Unfinished product	Household
Food and drinks high in fat and/or sugar	Crisps	Frying rejects	Processing

Food and drinks high in fat and/or sugar	Crisps	Surplus product	Processing
Food and drinks high in fat and/or sugar	Crisps	Floor waste	Processing
Food and drinks high in fat and/or sugar	Crisps	Vegetable peelings	Processing
Food and drinks high in fat and/or sugar	Crisps	Peel and trim	Processing
Food and drinks high in fat and/or sugar	Crisps	Waste starch	Processing
Food and drinks high in fat and/or sugar	Crisps	Primary sludge (uncooked) / feed-grade starch	Processing
Food and drinks high in fat and/or sugar	Crisps	Waste oil	Processing
Food and drinks high in fat and/or sugar	Ice cream (litres)	Wastes from ice cream production	Processing
Food and drinks high in fat and/or sugar	Ice cream (litres)	Changeover losses	Processing
Food and drinks high in fat and/or sugar	Jams & preserves	Rotten fruit, stem wastes, stems, stalks	Processing
Food and drinks high in fat and/or sugar	Jams & preserves	Fruit seeds	Processing
Food and drinks high in fat and/or sugar	Jams & preserves	Wastes from jam production	Processing
Food and drinks high in fat and/or sugar	Jams & preserves	Jam waste including plant washings	Processing
Food and drinks high in fat and/or sugar	Jams & preserves	Wastewater	Processing

Food and drinks high in fat and/or sugar	Margarine	Stalks, leaves, hulls	Processing
Food and drinks high in fat and/or sugar	Margarine	Crude press cake	Processing
Food and drinks high in fat and/or sugar	Margarine	Extracted press cake or spent meal	Processing
Food and drinks high in fat and/or sugar	Margarine	Gums	Processing
Food and drinks high in fat and/or sugar	Margarine	Soapstock	Processing
Food and drinks high in fat and/or sugar	Margarine	Spent bleaching earth	Processing
Food and drinks high in fat and/or sugar	Margarine	Distillate	Processing
Food and drinks high in fat and/or sugar	Margarine	Wastewater	Processing
Food and drinks high in fat and/or sugar	Margarine	Acid co-product / fatty-acid rich waste	Processing
Food and drinks high in fat and/or sugar	Sugar	Sugar beet leaves, weeds and beet tails	Processing
Food and drinks high in fat and/or sugar	Sugar	Sugar beet pulp	Processing
Food and drinks high in fat and/or sugar	Sugar	Molasses (from sugar beet)	Processing
Food and drinks high in fat and/or sugar	Sugar	Molasses (from raw cane sugar)	Processing
Food and drinks high in fat and/or sugar	Sugar confectionery	Waste product	Processing

Food and drinks high in fat and/or sugar	Vegetable oil	Stalks, leaves, hulls	Processing
Food and drinks high in fat and/or sugar	Vegetable oil	Crude press cake	Processing
Food and drinks high in fat and/or sugar	Vegetable oil	Olive stones	Processing
Food and drinks high in fat and/or sugar	Vegetable oil	Extracted press cake or spent meal	Processing
Food and drinks high in fat and/or sugar	Vegetable oil	Gums	Processing
Food and drinks high in fat and/or sugar	Vegetable oil	Soapstock	Processing
Food and drinks high in fat and/or sugar	Vegetable oil	Spent bleaching earth	Processing
Food and drinks high in fat and/or sugar	Vegetable oil	Distillate	Processing
Food and drinks high in fat and/or sugar	Vegetable oil	Wastewater	Processing
Other beverages	Ales	Malting by-products (malt powder, malt culms, malt residual pellets)	Processing
Other beverages	Ales	Barley screenings	Processing
Other beverages	Ales	Spent grains	Processing
Other beverages	Ales	Grains pressings	Processing
Other beverages	Ales	Spent hops	Processing

Other beverages	Ales	Surplus product / ullage	Processing
Other beverages	Ales	Hot trub	Processing
Other beverages	Ales	Yeast	Processing
Other beverages	Ales	Kieselguhr sludge / diatomaceous earth	Processing
Other beverages	Bottled water	Unfinished product	Household
Other beverages	Cider/perry	Pomace	Processing
Other beverages	Cider/perry	Unfinished product	Household
Other beverages	Cider/perry	Cider lees	Processing
Other beverages	Coffee	Coffee grounds	Processing
Other beverages	Coffee	Coffee husks	Processing
Other beverages	Coffee	Wastewater sludge	Processing
Other beverages	Coffee	Coffee grounds	Food service
Other beverages	Lager	Spent grains	Processing
Other beverages	Lager	Trub and yeast	Processing

Other beverages	Lager	Kieselguhr sludge / diatomaceous earth	Processing
Other beverages	Light wines	Rejected grapes	Processing
Other beverages	Light wines	Shoots and woody material	Processing
Other beverages	Light wines	Grape stems	Processing
Other beverages	Light wines	Pomace (skin and seeds)	Processing
Other beverages	Light wines	Grape skins	Processing
Other beverages	Light wines	Grape seed	Processing
Other beverages	Light wines	Bentonite and adsorbed organic matter	Processing
Other beverages	Light wines	Lies: yeast cells, crystallized matter (tartaric salts), precipitated tannins and pigments	Processing
Other beverages	Light wines	Precipitated salts of tartaric acid, some tannins and other phenolic materials	Processing
Other beverages	Light wines	Bentonite with adsorbed proteinaceous matter and colouring matter	Processing
Other beverages	Light wines	Sediment of fining material with adsorbed tannins and other phenolic materials	Processing
Other beverages	Light wines	Remaining yeast and bacteria cells, suspended organic matter, diatomaceous earths, cellulose pads and/or filtering cartridges	Processing
Other beverages	Light wines	Washing water	Processing

Other beverages	Spirits	Organic wastes, mash from grain, fruit or potato	Processing
Other beverages	Spirits	Spent grain (draff)	Processing
Other beverages	Spirits	Pot ale (still residue post-distillation)	Processing
Other beverages	Spirits	Spent lees	Processing
Other beverages	Spirits	Distillers dark grain	Processing
Other beverages	Spirits	Spent botanicals	Processing
Other beverages	Tea	Tea dust	Processing

6.3 Annex C: List of priority waste streams

The priority waste streams identified (organised by food group) along with their current management are shown in the table below.

Table 4: List of priority waste streams

Food product	Waste stream	Current management	Reference(s)
Apples	Pomace	Production of animal feed	Crawshaw 2001
Oranges	Peel, seed, membrane residue after juice extraction	Cattle feed	Wilkins et al 2007; Crawshaw 2001; KW Alternative Feeds 2016b
Oranges	Citrus zest and peel	Food ingredients (zest & peel)	Orchard House Foods 2016
Tomatoes	Pomace (skin, pulp & seeds)	Animal feed	Lazos and Kalathenos 1988
Potatoes	Fibre from potato starch production	Production of animal feed	AWARENET 2004

Potatoes	Concentrated fruit juice / protein from potato starch production	Protein extraction, production of animal feed	AWARENET 2004
Potatoes	Peelings	May be used directly as potato feed or combined with potato puree to give potato puree feed	Somsen 2004; Crawshaw 2001
Wheat milling products	Wheatfeed	Feed for use by cattle, sheep and pigs	Crawshaw 2001; KW Alternative Feeds 2016i
Wheat milling products	Wheat middlings	Feed for use by cattle, sheep and pigs	Crawshaw 2001
Cheese	Whey	Production of foodstuffs (whey powder, demineralised whey, WPC, WPI, WPT, WPP, lactose, Ricotta cheese, cream), production of animal feed (raw for pigs, whey powder, lactose), production of fertilizer, production of microbial culture medium (whey powder, lactose), fermentation and anaerobic digestion, transformation to peptides and glucose	AWARENET 2004; Green Feeds Ltd 2016; AC Shropshire Ltd 2015; Crawshaw 2001; WRAP 2015
Cheese	Whey concentrate	Liquid feed for pigs	Crawshaw 2001; KW Alternative Feeds 2016j
Cheese	Whey permeate	Animal feed	Crawshaw 2001; KW Alternative Feeds 2016k

Lamb, beef, pork & poultry	Blood	Production of foodstuffs (raw, plasma, albumin), production of pharmaceuticals, plants, production of animal feed (blood meal, raw, albumin), anaerobic digestion	WRAP 2011; AWARENET 2004; Leo Group Ltd 2016
Lamb, beef, pork & poultry	Proteinaceous matter incl. Category 3 material from slaughter plus carcass fat	Production of chemicals (glue, gelatin, collagen, glycerin, soap), production of pharmaceuticals (Ca, P, gelatin, collagen, fat, insulin, heparin, pepsin, steroids, cholesterol), production of animal feed (meat meal, fat), production of foodstuffs (sausage casing, catalase, additives), anaerobic digestion	WRAP 2011; AWARENET 2004; Leo Group Ltd 2016
Lamb, beef, pork & poultry	Bones	Production of animal feed (fat, bone meal), production of chemicals (glue, detergent), production of foodstuffs / pharmaceuticals (gelatin), composting, anaerobic digestion, production of low gel, low viscosity products	AWARENET 2004; Leo Group Ltd 2016
Lamb, beef, pork & poultry	Hair, feathers, hooves & feet	Production of chemicals (glue, gelatin, collagen, glycerin, soap), production of pharmaceuticals (Ca, P, gelatin, collagen, fat, insulin, heparin, pepsin, steroids, cholesterol), production of animal feed (meat meal, fat), production of foodstuffs (sausage casing, catalase, additives), anaerobic digestion, composting, production of feather meal (animal feed and fertilizer), production of pillows & eiderdown	AWARENET 2004; Leo Group Ltd 2016
Lamb, beef, pork & poultry	White and red offal incl guts & giblets	Production of chemicals (glue, gelatin, collagen,glycerin, soap), production of pharmaceuticals (Ca, P, gelatin, collagen, fat, insulin, heparin, pepsin, steroids, cholesterol), production of animal feed (meat meal, fat), production of foodstuffs (sausage casing, catalase, additives), anaerobic digestion	AWARENET 2004; Leo Group Ltd 2016

Eggs	Egg shell waste (shell)	Source of calcium for use in animal feed and pet food, landspreading, other potential uses under investigation	Galloway 2013; EGGNOVO 2016; Capriovus 2016
Fish & seafood	Mollusc shell / shell particles	Production of chemicals (plastics, paints), production of construction materials, production of fertilizer	AWARENET 2004
Margarine	Stalks, leaves, hulls	Production of animal feed, production of pharmaceuticals (terpenic acids, oleoropein)	AWARENET 2004
Margarine	Crude & extracted press cake or spent meal	Production of fuels, industrial uses (kernel oil, wood, activated carbon)	AWARENET 2004
Sugar	Sugar beet pulp	Marketed in fresh / ensiled form as pressed pulp or blended with molasses to give molassed sugar beet feed (MSBF)	AWARENET 2004; Crawshaw 2001; KW Alternative Feeds 2016g
Vegetable oil	Crude press cake	Production of fuels, industrial uses (kernel oil, wood, activated carbon)	AWARENET 2004; KW Alternative Feeds 2016f
Vegetable oil	Olive stones	Production of fuels, industrial uses (kernel oil, wood, activated carbon)	AWARENET 2004
Vegetable oil	Extracted press cake or spent meal	Production of fuels, industrial uses (kernel oil, wood, activated carbon)	AWARENET 2004
Vegetable oil	Gums	Production of animal feed, production of pharmaceuticals (lecithin, phosphatides)	AWARENET 2004

Vegetable oil	Distillate	Production of animal feed, production of pharmaceuticals (vitamin E, sterols)	AWARENET 2004
Ales	Malting by-products (malt powder, malt culms, malt residual pellets	Animal feed	Zero Waste Scotland 2014; Crawshaw 2001; KW Alternative Feeds 2016d,e
Ales	Barley screenings	Animal feed	Crawshaw 2001
Ales, lagers & spirits	Spent grains, distillers dark grain & draff	Animal feed, composting, anaerobic digestion	Fillaudeau et al 2005; Mathias et al 2015; Zero Waste Scotland 2014; Crawshaw 2001; KW Alternative Feeds 2016a,c,h
Ales	Spent hops	Soil conditioner, composting, anaerobic digestion; feed fraction	Zero Waste Scotland 2014; Crawshaw 2001
Ales	Surplus product / ullage	Feed for ruminant and monogastric animals	AC Shropshire Ltd 2015; Crawshaw 2001
Ales, lagers & spirits	Trub and yeast	Animal feed; marketed to the food and pharmaceutical industries; soil conditioner, sewer	Mathias et al 2015; Zero Waste Scotland 2014; Green Feeds Ltd 2016; AC Shropshire Ltd 2015; Crawshaw 2001; Talve 2001; Fillaudeau et al 2005
Cider/perry	Pomace	Animal feed, anaerobic digestion	WRAP 2012a; Crawshaw 2001

Light wines	Pomace (skin and seeds)	Production of ethanol, extraction of antioxidants & pigments, production of grapeseed oil (cooking oil & beauty ingredient) & grapeseed flour (food ingredient), production of resveratrol, production of bio-based packaging	AWARENET 2004; The Kerfoot Group 2016; McDougall 2014; Veuve Clicquot 2016; Anon 2016; A+S BioTec 2016
Spirits	Organic wastes, mash from grain, fruit or potato	Animal feed, composting	WRAP 2012b, WRAP 2013b
Spirits	Pot ale (still residue post-distillation)	Animal feed, anaerobic digestion	WRAP 2012c; Zero Waste Scotland 2014; Crawshaw 2001