REFRESH Policy Brief, June 2019
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Avoiding food waste through feeding surplus food to omnivorous non-ruminant livestock

Key Messages

- The EC's Circular Economy Action Plan and the European Parliament report on food waste set out to increase the use of surplus from the food chain in livestock feed without compromising feed and food safety.
- Building on advice from microbiologists, epidemiologists, veterinarians and pig nutritionists, the REFRESH technical guidelines on animal feed set out the key principles for producing safe feed from surplus food.
- To ensure safety, only omnivorous non-ruminant livestock should be allowed feed made from surplus food that may contain meat. Such feed should be sourced exclusively from specialist licensed treatment plants located off-farm and subject to stringent controls regarding heat treatment, acidification and biosecurity to ensure the feed is free from disease.
- 16% of the total amount of food that currently becomes waste, could become available to be processed into non-ruminant feed as a result of changing legislation to ensure the safe treatment of such surplus.
- Surplus food feeds could reduce farmer feed costs, land use for European livestock farming, carbon emissions, and deforestation from soy imports. From a food security perspective, surplus food feeds provide an opportunity to decouple some of Europe's feed supply from global agricultural commodity prices.

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1 Enacting policy to drive food waste reduction

Animal feed as a key REFRESH policy area for food waste reduction

Of the 88 million tonnes of food that currently leave the food supply chain as waste, a minimum of 14 million tonnes of surplus food could become available to be processed into non-ruminant feed as a result of changing legislation to ensure the safe treatment of such surplus (Luyckx et al. 2019). These 14 million tonnes are additional to the 5 million tonnes of permissible surplus such as bread already recycled into livestock feed by the former foodstuffs processing industry[1]. To achieve this potential, a European surplus-food-to-feed industry would need to reach similar food-to-feed recycling rates to those currently achieved in Japan. As a global pioneer of modern food-to-feed recycling, Japan turns 52% of surplus food from their catering, manufacturing and retail sectors into animal feed (FAO 2017).

This policy brief outlines the environmental, economic and safety considerations of reforming EU law to enable surplus food containing meat to be fed to omnivorous non-ruminant livestock like pigs, in order to drive food waste valorisation through animal feed.

Please note that the REFRESH "Technical Guidelines Animal Feed" (Luyckx et al. 2019a) **provide a more thorough discussion, detailed recommendations and scientific references underpinning the points raised in this brief.**

Reducing food waste in Europe through REFRESH research

The EU project REFRESH (Resource Efficient dRink for the Entire Supply cHain) is a four-year (2015-2019) Horizon 2020 EU research project taking action towards food waste reduction. The project goal is to support the Sustainable Development Goal 12.3[2] of halving per capita food waste at the retail and consumer level, reducing food losses along production and supply chains, reducing waste management costs, and maximizing the value from unavoidable food waste. Furthermore, the project promotes the consideration of the food use hierarchy which prioritises prevention, followed by redistribution for human, then animal consumption, before other forms of valorisation such as composting and bio-energy.

Through the policy relevant research carried out within REFRESH, three policy areas stood out as main focuses for policy conclusions: consumer behaviour, integrated supply chain policies (Voluntary Agreements & Unfair Trading Practices) and food surplus valorisation.

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[1] The five million tonnes of former foodstuffs currently processed into feed are not part of the 88 million tonnes referred to above, as they are not classified as food waste.

[2] "cutting in half per capita global food waste at the retail and consumer level, and reducing food losses along production and supply chains (including post-harvest losses) by 2030"

Scope of REFRESH policy brief on animal feed

This policy brief **focuses on surplus food that may contain meat or fish from catering, retail and manufacturing as feed for omnivorous non-ruminant livestock**, such as pigs and chickens[3]. It only focuses on such feed which has been **heat-treated and acidified in licenced, tightly controlled treatment facilities that are located off-farm.**

This brief **does NOT consider currently permissible former foodstuffs**, such as surplus cereal or confectionary goods, because these are already used in animal feed, and the European Commission has recently published a Commission Notice (European Commission 2018a) to enhance the use of former foodstuffs in feed. The Notice aims to clarify existing legislation and support national authorities in avoiding an unnecessarily strict application of the legislation[4].

This brief **does NOT cover ruminant feed, surplus food from households, surplus food from international catering or international transport, or surplus food treated on-farm,** because these options pose additional risks outside of the scope of this project. The findings set out in this brief do not change the need for measures to prevent the accidental or illegal feeding of untreated surplus food as this may cause the spread of African Swine Fever and other diseases of concern.

The focus on **animal feed must be considered in accordance with the REFRESH food use hierarchy**[5]. This means that food waste prevention at source and feeding edible surplus food to humans should be prioritised. After this, in most circumstances, the best use of unavoidable food surplus not fit for human consumption is livestock feed.

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[3] The REFRESH research mainly focussed on pigs. See the REFRESH Technical Guidelines on Animal Feed by Luyckx et al. (2019) for the rationale for this, but we also considered key poultry diseases in the chapter on safety in these guidelines.

[4] For more details, please see REFRESH Report D6.11 Identification of food waste conversion barriers (Broeze 2019)

[5] The REFRESH food use hierarchy is adapted from the European Waste Framework Directive's 2008/98/EC Waste Hierarchy and WRAP's Food and Drink Materials Hierarchy among others.

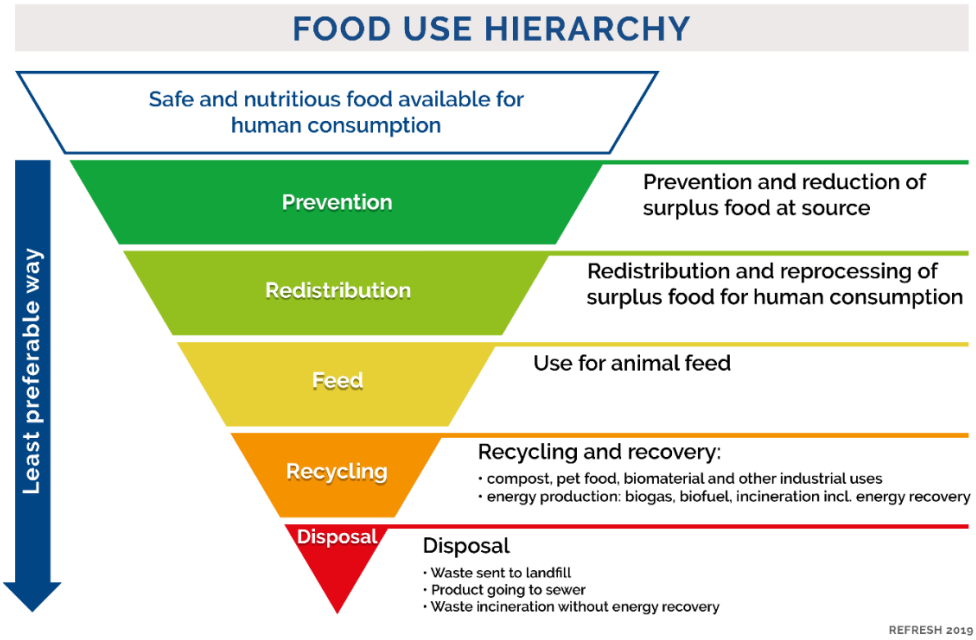

Figure 1: Food use hierarchy as adapted by REFRESH

2 Environmental benefits

Potential emissions savings – Life Cycle Assessment analysis

A consequential life cycle assessment carried out by REFRESH shows that **using 14 million tonnes of surplus food to replace feed for grower/finisher pigs could lead to an estimated annual reduction of greenhouse gas emissions of 5.8 million tonnes of CO_2 eq** (Luyckx et al. 2019). This is equal to the emissions from nearly 3 million UK passenger cars driven for one year[6]. The GHG emission saving is an estimate extrapolated from calculations based on current pig farming and waste handling market conditions in France and the UK. REFRESH considered the environmental cost of the heat treatment necessary to render the feed safe, as well as the need to turn to other sources of energy and fertilizer with reduced use of food waste in anaerobic digestion (De Menna et al. 2018).

Further research by REFRESH shows that it is possible to achieve better transport efficiencies from the surplus food supplier to treatment plants and from there to farms - compared to the transport costs originally calculated by de Menna et al. (2018). If such improved transport efficiencies are considered, GHG savings could be higher (Luyckx et al. 2019; Broeze 2019). The key reason that using unavoidable surplus in pigfeed results in GHG

[6] *Passenger car numbers calculated from UK government data on vehicle mileage and petrol use, and emissions/gallon of petrol use from US government data.*

emission savings is a reduced reliance on conventional feed crops such as soya which is connected with land use change and deforestation (e.g. in the Amazon) in feed producing countries. Findings by REFRESH on the environmental benefits echo those of peer-reviewed studies. For instance, zu Ermgassen et al. (2016) calculated that using 39.2%[7] of food waste from retail, catering, manufacturing and households at EU level, could reduce the land requirement for EU pork feed production by 1.8 million ha which represents a 21.5% reduction in the current global land use of industrial EU pork production.

Comparison with insects

In addition to the use of surplus food, the debate about reducing the resource and climate footprint of the livestock sector has also considered insects as future livestock feed. Insects have recently been approved to be used in livestock feed. However, further research is needed to determine the circumstances under which using insects as pig feed delivers environmental benefits. A Life Cycle Assessment (LCA) by van Zanten et al. (2015) shows that using larvae meal as animal feed results in "decreased land use" but "increased global warming potential and energy use", mostly because of the additional energy needed for growing and processing the larvae. Smetana et al. (2016) found that a higher quality insect-based livestock feed was achieved when the insects were fed with good nutritional quality feed such rye and soybean, but then the final product was associated with high environmental impacts. On the other hand, low quality feeds for the insects, based on manure, had low efficiency for insect yields. Furthermore, as dangerous diseases could survive in insects (EFSA Scientific Committee 2015), heat treatment is still necessary (see below).

3 Supporting the farming industry

Economic feasibility

Throughout Europe, "high volatility in feed prices resulting in high prices for both cereals and compound feeding stuffs… has created a difficult situation which has forced an important number of pig farmers to cease production." (EUROSTAT 2017). **Feed costs in 14 EU pig producing countries make up between 50% and 67% of total production costs** (AHDB 2017). **In Japan, however, industrial food-to-feed recycling plants deliver safe surplus food-based feed at half of the cost of conventional feed** (zu Ermgassen et al. 2016).

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[7] At the time of zu Ermgassen's research, Japan and South Korea recycled an average of 39.2% of surplus food into feed. More recent Japan government figures show a rate of 52% recycling of surplus food from the retail, manufacturing and catering sectors only. See Luyckx et al. (2019) for information as to why the use of household food waste in feed is being excluded at this stage for the EU proposal by REFRESH.

A life cycle costing (LCC) assessment by REFRESH shows that **when surplus food is generated in locations relatively close to pig farms, using surplus food in pigfeed can result in economic savings** (De Menna et al. 2019, Broeze 2019). Regionalising food and feed systems also has other positive effects in terms of closing resource and nutrient cycles and contributing to regional economic systems. LCC calculations were done for the UK and France as an example where detailed food waste data were available. REFRESH assumed a liquid feeding system because earlier research shows that liquid systems are more beneficial from an environmental perspective due to the additional energy needed to produce dry feed.

REFRESH results show **a net cost saving of €278 million per year in the UK, but an additional cost of €413 million per year in France**. Overall cost differences between the UK and France can partly be explained by longer distances between surplus food suppliers and pig farms in France (Luyckx et al. 2019, de Menna et al. 2019). **Efficient collection and feed transport systems, as well as cost-effective geographical locations for the treatment plants, will therefore be paramount** to the economic feasibility of a surplus-food-to-feed industry (Broeze 2019).

The LCC analysis was done for a plant with an assumed processing capacity of 260,000 tonnes of surplus food per year. A further techno-economic scaling evaluation at treatment plant level concluded that a processing capacity of 100,000 tonnes per year is more economically attractive (Luyckx et al. 2019). At the capacity of 100.000 tonnes per year, the scaling advantages for production at larger size are balanced against the transport costs which decrease with the availability of more plants at smaller capacity.

If conventional feed crop prices increase, using surplus food as feed will become even more viable. It will be important to consider the ownership and business models of treatment plants so that savings can be passed on to pig farmers and even the pigs themselves in the shape of improved animal welfare.

Animal welfare

Reducing feed costs may support farmers wishing to invest in animal welfare. In addition, feeding surplus food to pigs may improve animal welfare directly through providing nutritional variety which, if provided alongside conditions that allow rooting behaviour, could provide the additional food types required for higher welfare scores. From a welfare perspective, it may be important to complement a homogeneous liquid or dry feed with unprocessed low-risk surplus food such as bread, fruit or vegetables to provide variation, reduce boredom and encourage chewing.

Case study: The Japanese Eco-Feed Industry

Japan is the global pioneer of modern surplus food to feed recycling: a thriving Japanese industry collects surplus food from catering, supermarkets and manufacturing businesses for treatment in well-regulated treatment plants and feeds them to pigs as "eco-feed". 52% of surplus from the Japanese food industry is now used as livestock feed (FAO 2017). Japan's food-to-feed recycling plants deliver safe, surplus food-based feed at about half of the cost of conventional feed (Takahashi et al. 2012, Takahashi 2018) and Japanese consumers choose to pay a premium for meat products they see as healthier and more environmentally friendly (Kurishima, Hishinuma, and Genchi 2011).

The production of eco-feed in Japan has more than doubled from 0.48 million tonnes in 2003 to 1.19 million tonnes in 2016. there are currently 360 eco-feed producers, of which 47 process surplus food from retailers and 29 specialise in the processing of meat-containing surplus food (Japan Ministry of Agriculture, Forestry and Fisheries 2018).

Pig farming models using a 100% surplus food diet are viable in Japan. For example, **15 medium-sized pig farmers** (300 to 2,000 pigs each) **feed their pigs 100% eco-feed** because feed processor Japan Food Ecology Centre can guarantee a protein content of 15 to 17 % through computerised composition monitoring and the addition of a very small amount of soya (about 1% of total feed) as well as conventional compound feed ingredients such as synthetic lysine and calcium-vitamin premix.

4 Safety and treatment

In 2017, REFRESH hosted an expert panel with veterinary epidemiologists, microbiologists, veterinarians and pig nutritionists[8] to review existing evidence on feeding treated food surplus to pigs. These experts agreed that **from a technical point of view it is possible to produce safe pig feed from surplus food through a combination of heat treatment and acidification (fermentation or adding lactic acid for example) and biosecurity measures to prevent cross-contamination** (Luyckx 2018).

To ensure these treatment and biosecurity measures are implemented to the standard required and to allow for adequate monitoring and enforcement of safety requirements, **it will be necessary to limit the production of feed from surplus food to licensed treatment plants located separately from farm premises**. Given the European context – including the presence of African Swine Fever – treatment and biosecurity measures should be more stringent than those currently applied in Japan.

In Chapter 3 of the REFRESH Technical Guidelines on Animal Feed (Luyckx et al. 2019), the disease risks and proposed risk management strategies are explained. In food and feed safety risk management it is not realistic to aim

[8] *from the Universities of Wageningen, Leeds, Cambridge, the UK Animal and Plant Health Agency and the European Food Safety Authority Feedap Committee*

for the complete destruction of the micro-organisms considered a hazard. Zero risk does not exist, the risk of 'once in a million years' does. "The concept of Food Safety Objectives has been introduced to facilitate the application of meaningful food safety management practice to the interpretation of public health goals – often described as an Appropriate Level of Protection" (Bean et al. 2012)

REFRESH research shows that a well-developed disease risk management system consisting of heat treatment, acidification, biosecurity, traceability and official control measures can provide an appropriate Level of Protection that allows us to maximise the surplus food that is kept in the food supply chain as animal feed.

Heat treatment and acidification

REFRESH has identified Foot and Mouth Disease (FMD) and Highly Pathogenic Porcine Respiratory and Reproductive Syndrome (HP-PRRS) as the most heat-resistant of the pig diseases of concern. Inactivating FMD and PRRS will automatically achieve inactivation for the more heat-sensitive pathogens such as African Swine Fever. A full list of diseases and their heat sensitivity is available in the REFRESH Technical Guidelines Animal Feed (Luyckx et al. 2019).

Time – temperature combination options to achieve safe feed

Microbiologists use log reductions to quantify the extent to which a certain treatment or processing approach results in the destruction of micro-organisms. A 1-log reduction means that 90% of the dangerous organisms present initially have been destroyed, a 2-log reduction means 99% of organisms destroyed, a 3-log reduction 99.9% and so on.

A REFRESH model based on microbiological data from 24 studies provides information on the effectiveness of different combinations of time and temperature to inactivate Foot and Mouth Disease (FMD):

- 80°C for 30 minutes achieves a 17-log reduction. In other words, this heat treatment eliminates 99.99999999999999% of FMD virus present initially.
- 100°C for 10 minutes achieves a 60-log reduction.

As a reference, for food-borne pathogen *C. Botilinum* which produces the life-threatening botulinum toxin, a 12-log reduction is considered safe (EFSA, 2005). For other food-borne pathogens, a 6-log reduction is standard practice. The disease inactivation objectives for feed will need to be more stringent than those applied for food pathogens because of the severity of the impact and cost of a disease outbreak, such as African Swine Fever or Foot and Mouth Disease (FMD).

Source: designed by REFRESH using images from the Japan Food Ecology Centre, Inc. http://www.japan-fec.co.jp/english/index.html

Final legal criteria for the processing method, including time / temperature combinations will need to be presented in a format similar to animal by-product Processing Method 6 set out in EC Regulation 142/2011[9]. To arrive at these processing method criteria, the following additional research steps are needed[10]:

- Test heat-resistance of HP-PRRS in a laboratory because existing data are not sufficient to draw final conclusions. Inactivation objectives can be set bearing in mind that the risk of feed-borne transmission of HP-PRRS is theoretical, as there is no evidence that this has happened in reality.
- Microbiologists and veterinary epidemiologists need to set a final inactivation objective based on conservative assumptions regarding the volume of infected meat and viral load for FMD and HP-PRRS to be expected in the surplus food.
- Use the final inactivation objective to set different time / temperature options as described in the box above and then calculate which combination is the most energy- and cost-effective. Calculations should consider the maximum particle size to which the surplus food should be shredded prior to heat treatment.
- If higher temperatures for shorter times are preferable from a cost and energy perspective, test the impact of these temperatures on the digestibility and nutritional values of the treated surplus food.

Acidification is a useful complementary strategy for preventing germination and outgrowth of heat-resistant bacterial spores, and prolonging shelf life of the feed. Moreover, FMD is very sensitive to a low pH. Acidification can be achieved through fermentation which brings additional nutritional and probiotic benefits. There is evidence that fermented feeds can help **reduce antibiotic use** in pig farming (Missotten et al. 2015; McDonald et al. 2011).

Biosecurity and Hazard Analysis and Critical Control Points (HACCP)

Heat-treated feed needs to be kept safe and cross-contamination with raw surplus food should be prevented using adequate biosecurity measures. The technical requirements for biosecurity in the treatment of surplus food can be adapted from those applicable to the animal by-product processing industry. Commission Regulation 142/2011, Annex IV, Chapter 1 sets out the Requirements for Processing Plants and Certain Other Plants and Establishments, as applicable to Category 3 (low-risk) animal by-product materials. Some examples of these requirements are one directional process flows, zoning, measuring equipment to monitor temperature against time,

[9] EC Regulation 142/2011 is the implementing Regulation for EC Regulation No 1069/2009 of the European Parliament and of the Council laying down health rules as regards animal by-products and derived products not intended for human consumption.

[10] For those not familiar with food microbiology, it is recommended that these further research steps are read alongside the detailed explanations provided in Chapter 3 of the Technical Guidelines on Animal Feed (Luyckx et al. 2019).

etc. The know-how of the animal by-product processing (rendering) industry can be applied to achieve adequate biosecurity.

Traceability

The heat treatment, acidification and biosecurity measures should be designed to deliver safe feed even in the case that infected meat makes its way into the surplus food prior to treatment. Traceability measures can provide an additional safeguard and therefore a risk-based approach to traceability for surplus food that may contain or may have been in contact with meat is advisable:

- For pig feed treatment plants, any pig meat ingredients should be traceable to source. A similar principle should be applied to poultry feed.
- For all other ingredients, the "one-step-up, one-step-down[11]" traceability approach, which is standard in most of the food and feed sectors, should be applied by all operators in the supply chain (GS1 2017). This means that feed processing plants should be able to (a) trace surplus food inputs back to the immediate supplier (retailer, school kitchen, etc) and (b) identify the farms or feed compound producers to which the treated surplus food has been supplied.

Disease risk in the context of climate change

In legislating for the safe use of treated meat-containing surplus food in omnivore non-ruminant feed, decision-makers may wish to consider existing animal disease risks alongside emerging risks of food security, climate change, and unknown disease. For example, the **mycotoxin** load in staple food and feed crops is likely to increase due to a combination of climate change factors including increasing temperatures and CO2 levels as well as extreme wet and drought conditions. Preventing mycotoxin contamination of animal feed is an important part of overall food and feed safety strategies. Therefore, mitigating climate change contributes to animal feed safety.

5 Official controls

Preventing the accidental or deliberate breaking of the law is as important as effective pathogen inactivation and biosecurity.

Farm-level controls

Legislation for the prevention of Transmissible Spongiform Encephalopathies (TSE) and controls for ruminant feed should remain as they are. Controls also should remain the same for non-ruminant feed *on unlicensed farms*. For

[11] Food, feed and farm businesses must be able to identify the businesses to which their products have been supplied and to trace their food or feed chain inputs back to the immediate supplier.

controlling feed on farms licensed to use surplus-food-based feed, control tools will need to differentiate between surplus-food-based feed from licenced treatment plants and any untreated surplus food introduced illegally or accidentally. A mix of the following control approaches could be developed:

- Controls and record-keeping on animal production and feed volumes
- Testing for the presence of unprocessed surplus food. Options to be researched for this testing could include vibrational or infrared spectroscopy, immunoassay or chemical markers.

Treatment plant controls

To ensure safety, it is advisable that the same controls as currently apply to the animal by-product processing (rendering) and feed manufacturing sectors are also applied to surplus-food treatment plants. Processing businesses could pay for an initial application to obtain the permit, followed by annual subsistence charges to pay for ongoing inspections. Inspectors would monitor Hygiene and Processing Requirements such as one directional process flows, zoning, complaints and recall, labelling, traceability and HACCP procedures. The biosecurity and processing aspects of relevant regulations on Animal By-Products (EC Regulation 142/2011), Feed Hygiene, TSEs, Placing on the Market and Use of Feed and other relevant regulations, as well as monitoring of Mycotoxin, Dioxin and Nickel levels would all apply. It will be important to apply the learning from the former foodstuffs processing industry to prevent dioxin formation.

6 Meeting pig nutritional needs

The pig industry has very precise requirements for the nutritional content of feed. Although slower growth rates might theoretically be offset by lower feed costs, the requirements of modern fast-growing pig breeds mean that for the mainstream pig industry, little compromise on nutrition is possible.

Achieving nutritionally adequate feed for the modern pig

A range of strategies can be adapted from the Japanese eco-feed industry to achieve nutritionally balanced feed:

- Sourcing surplus food from a wide variety of food businesses to dilute variation
- Blending with conventional feed ingredients, co-products such as wheat middlings or spent brewers' grains, and conventional feed additives, such as synthetic lysine. Lysine is the most important amino acid in pig diets and synthetic lysine is already routinely used in feed.
- The Japanese eco-feed industry has developed computerised mixing technologies combined with specialised feed formulation tools. In the second REFRESH animal feed expert seminar, it was suggested that blends for the modern pig industry could contain 50% treated surplus

food ingredients (see Chapter 5 Nutrition and Supplementary Materials Part 1 in Luyckx et al. 2019).

- Separating surplus food into nutritional categories. In Japan this is often done at source (i.e. retailer). Whilst this may appear costly, European retailers such as Colruyt, Tesco and Sainsburys already manage strict segregation for their bakery surplus so that it meets existing legal requirements for former foodstuffs.
- The Japan Livestock Technology Association ecofeed manual notes that high carbohydrate foods can be used without problem from early stage to late stage of fattening. However, high protein, high fat surplus foods should only be used in the early stage of fattening. Therefore, the minimum requirement from a nutritional perspective would be to separate low-fat from high-fat foods.
- Selective sourcing of surplus food that is relatively consistent in composition is also an option though balance is needed with the aim to maximise the use of unavoidable surplus in feed.

REFRESH has also considered an "ecological leftover" scenario (Van Zanten et al. 2018) where the European population shifts to an environmentally sustainable diet, including some meat and dairy, but considerably less than is consumed currently. In this scenario, animal feed production must not compete directly for arable land with food crops[12]. Thus, we examined the nutritional aspect of feeding pigs with a diet near to 100% sourced from unavoidable by-products and surplus food.

Some modern pig breeds may not be suitable for 100% surplus food diets and it will be necessary to test such diets with more traditional breeds able to consume larger amounts of roughage and more tolerant of short-term nutritional variations. Supporting the farming of more traditional pig breeds has other benefits as there are growing concerns about the erosion of genetic resources in livestock because animal genetic diversity is critical for food security and rural development (Ajmone-Marsan 2010). Moreover, maintaining genetic diversity allows farmers to select stock or develop new breeds in response to changing conditions, including climate change and new or resurgent disease threats (Hoffmann 2010).

[12] In a vegan dietary scenario, crop residues stay on the field to feed the soil–food web; surplus from the food industry become a bio-energy source or are wasted. Because animals do not recycle these biomass streams back into the food system, additional crops have to be cultivated to meet the nutritional requirements of the vegan population. Therefore, the most effective dietary change mitigation scenario consists of limiting animal-source foods to non-ruminant meat and eggs from livestock produced solely from feed that does not compete directly for arable land with human edible crops: unavoidable food waste and by-products (Van Zanten et al. 2018). Further research is needed to determine the role of dairy production from marginal grasslands, and the trade-offs with regard to the methane emissions from ruminant livestock.

REFRESH calculated the availability of lysine (the most important amino-acid in pigfeed) and energy available in surplus food streams in the UK and France. The availability of lysine and energy are useful proxies for determining the nutritional suitability of surplus food for feed. REFRESH then calculated how much pork could be produced if only grower/finisher pigs (excluding piglet production) were fed with feed made from by-products and surplus food. In this scenario the production of grower/finisher pigfeed would not compete for arable land use with food crops. **If UK pork production were limited to that which does not compete with food crops for feed, there would still be enough pig production to allow 100g of pork per person every ten days. For France, there would be 100g of pork per person per week.**

7 Consumer acceptance

A review of 18 studies on the effect of surplus food feeds on the quality and nutrition of pork, including blinded taste trials, found that **increasing the proportion of surplus food in pig diets had no effect on overall palatability**, flavour, colour and fat composition, among other traits (zu Ermgassen et al. 2016).

Pork made from surplus food would primarily be of interest to consumers changing or reducing their meat consumption due to environmental considerations (Luyckx et al. 2019b). In Japan, pork from pigs fed on surplus food evolved from 'garbage pork' into a luxury 'eco-pork' product sold at a premium based on its environmental credentials. Potential cost savings from surplus food feeds could also support the availability of environmentally friendly and high-welfare meat products at more affordable prices and make "eco-pork" interesting for consumers that focus on animal welfare.

REFRESH research with consumers in Spain and the UK shows that information and awareness raising work will be important to build acceptance (Rahmani and Gil Roig 2018). However, the recent report by the European Commission (European Commission 2018b) on the development of plant proteins in the EU shows that there is already an important niche market with consumers whose choices are influenced by broader environmental concerns. A REFRESH survey with 3,500 UK consumers (Luyckx et al. 2019) confirms the **importance of certification for consumers to accept safety and environmental claims regarding pork from pigs fed on surplus food**. To ensure the credibility of certification, farms should be independently monitored and verified, possibly in conjunction with the official licencing and controls of treatment plants.

We acknowledge that there may be consumer concern regarding the presence of pork in pigfeed. However, in the survey carried out by REFRESH in the UK, **even with minimal public information assuring the public that feeding pork to pigs is safe, 31% of meat-eating respondents are already comfortable with this** (Luyckx et al. 2019)**.** On average the respondents were more indifferent/unsure than uncomfortable with the idea.

Intraspecies recycling in omnivorous animals such as pigs

It is possible that traces of pork may be present in feed made from surplus food, especially if the food is sourced from catering establishments. REFRESH therefore considered the issue of intraspecies recycling. **A 2007 EFSA scientific opinion states that "significant amounts of Bovine Spongiform Encephalopathy (BSE) infectivity have been fed to pigs in a research experiment in the UK and additionally that intra-species pig to pig recycling could have happened" in many farms, but that "no naturally occurring TSE, including BSE, have been detected so far in pigs".** In the UK study, pigs were fed with material with high BSE-levels in comparison to what they would be exposed to in normal farm situations. They were retained for 7 years after exposure, but no infectivity was found.

Similarly, a 1999 EC Scientific Steering Committee opinion issued prior to the introduction of the intraspecies recycling ban states that "no scientific evidence exists to demonstrate the natural occurrence of Transmissible Spongiform Encephalopathy ("TSE") in farmed pigs, poultry and fish, which may create a basis for an intra-species progression of a TSE infection due to intra-species recycling". **The EU is unique in having taken a precautionary approach to TSE in non-ruminants as there is no intraspecies recycling ban for non-ruminants in countries such as the United States, New Zealand, Japan and Australia where pigs may be fed protein of porcine origin either as part of heat-treated surplus food or as meat and bone meal of porcine origin**.

Whilst a precautionary ban on intraspecies recycling was necessary in the context of the BSE crisis, it may be of interest to review this ban for omnivorous non-ruminants considering global practice and a wider risk-benefit analysis that considers the climate mitigation and food security benefits of this proposal.

8 Conclusion

The EC's Circular Economy Action Plan (European Commission 2015) sets out to increase the use of surplus from the food chain in livestock feed without compromising feed and food safety. And **the European Parliament's Committee on the Environment, Public Health and Food Safety own-initiative report** (Borzan 2017) calls on the Commission "to analyse legal barriers to the use of former foodstuffs in feed production and to promote research in this area" while also bringing "food safety risk down to zero". It notes "the potential for optimisation of use of food unavoidably lost or discarded and by-products from the food chain, *in particular those of animal origin*, in feed production".

In response to these ambitions, REFRESH has researched the legal, safety, economic and environmental aspects of feeding surplus food to omnivorous non-ruminant livestock. REFRESH research shows that a well-developed disease risk management system consisting of heat treatment, acidification, biosecurity, traceability and official control measures can provide an appropriate Level of Protection that allows us to maximise the volume of surplus food kept in the food supply chain as animal feed. From a safety perspective, it is fundamental **that feed is only sourced from surplus food treated in specialist licenced treatment plants which comply with the same stringent biosecurity measures currently required of the rendering industry.**

The following are some of the relevant EU regulations that form the existing legal context relating to the use in non-ruminant feed of surplus food that is no longer fit for human consumption:

- **Regulation 999/2001** which bans using animal protein in animal feed (specifically amendments 1923/2006 and 56/2013 which extend this ban to non-ruminant omnivores).
- **Regulation 1069/2009** which bans using kitchen left-overs and catering waste for feed.
- **Amend Reg 142 / 2011**, specifically Annex IV where a processing method for meat-containing surplus food could be added to the existing list of approved processing methods for Animal By Products.

In modifying this legislation for the safe use of treated meat-containing surplus food in omnivore non-ruminant feed, **decision-makers may wish to consider existing animal disease risks alongside emerging risks of food security, climate change, and unknown disease.**

REFRESH findings demonstrate the emissions savings potential of using unavoidable surplus food as feed, even when we consider the energy needed to heat-treat such surplus food to ensure the feed is safe. Lifting the ban on feeding treated surplus food to omnivorous non-ruminant livestock may contribute substantially to EU sustainable diet targets and food waste reduction targets. Using surplus food as feed allows for small amounts of

meat in European citizen diets without contributing to competition over arable land between food and feed crops.

A new surplus-food-to-feed industry would also support regional circular economies with implications on Europe's **food security** and **farmer livelihoods** because a feed industry that increases its uptake of locally-sourced feed ingredients, can be both more secure and more predictable in terms of cost. The alleviation on land, water, fossil fuels and other resources created by resource efficiency, including food waste reduction, would lead to lower and less volatile food prices. What is important regarding price hikes and volatility in relation to this report is that, from a food security perspective, it makes sense to take any **opportunity** we can **to decouple feed supply from global agricultural commodity prices**.

Designing a prototype treatment and feed production system

In addition to the detailed recommendations outlined in the REFRESH Technical Guidelines on Animal Feed**, the next step to develop this proposal is to design and build a surplus-food-to-feed prototype sourcing, treatment and production system.** Designing such prototype system in a specific geographical location would allow the REFRESH technical guidelines to be finetuned in response to available surplus food streams. The system design could also aim to find the ideal trade-offs between environmental, economic and nutritional considerations. Geographical modelling would be an essential first step to deliver optimum location options in terms of transport efficiencies.

To maximize its usefulness, it is advisable that a prototype project involves the following experts and stakeholders:

- Japanese academic and eco-feed industry experts
- European former foodstuff processing industry
- European rendering industry
- European pig industry and pig nutritionists
- European porcine health academic and other experts
- Food and feed microbiologists

9 References

This is a selection of about 10% of the references that underpin the REFRESH research on animal feed. Please refer to REFRESH deliverable D6.7 Technical Guidelines Animal Feed (Luyckx et al. 2019) for further references and a more detailed discussion of the points raised above.

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