Safe and Sustainable Valorisation of Food Waste in the European Union

Reconciling Public Ambitions with Private Interests

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DISSERTATION

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General Introduction

Perishability is a quality inherent to anything that is edible, making wastage an intrinsic part of the food system. Without effective processing, handling, transporting, and storing, food products may be rendered inedible, leading to their removal from the food supply chain. Food may also be removed from the supply chain due to environmental factors beyond human control such as extreme temperatures and pest infestations. However, food waste stops being a natural and intrinsic aspect of the food system when it occurs in excess.

At the time of writing this dissertation, it is estimated that around one-third of all food produced on the planet ends up as waste (Gustavsson et al., 2011)[1]. In the face of a changing climate, dwindling natural resources, and an ever-growing population, this figure presents a serious problem. Over the last decade, the need to reduce food waste has come to be widely recognised by public actors such as government institutions and policymakers and to some extent, private entities like food business operators and non-governmental organisations (Smith, 2020). In response to this, a robust and multidisciplinary body of academic literature seeks to demarcate the boundaries of the problem, debate ways to address it, and create frameworks for measuring the impact of various interventions. However, in practice, the fuzzy and exceedingly convoluted nature of the food waste problem makes it difficult to set binding targets, divide responsibilities, and ensure accountability (Aschemann-Witzel et al., 2022; Bowman, 2020). Additionally, considering that the risk of consumer unsafety is an important driver of food waste, many actions to reduce its occurrence present the potential to harm consumer health.

The research presented in this dissertation seeks to expand our understanding of one particular facet of the wider food waste problem – the feasibility of safely and sustainably creating value out of food surpluses and waste while balancing the economic interests of private actors and the socio-environmental ambitions of public institutions. The need for such an inquiry is exemplified by the fact that the European Union has set ambitious targets to reduce food waste and promote a circular economy.

[1] The latest UNEP (2021) report on food waste acknowledges that there are still large gaps in national estimates of food loss and waste and therefore this estimate may not be entirely inaccurate. However, in the absence of an updates estimate, the 2011 figure continues to be the most widely accepted one in the academic community.

However, achieving these goals requires a comprehensive understanding of the complex dynamics between public policies, governance mechanisms, and legal frameworks that shape food waste management practices. Additionally, the increasing recognition of the economic, environmental, and social value embedded in food surpluses and waste streams presents an opportunity to develop innovative strategies that can benefit both private stakeholders and the broader society. By investigating the intricate interplay between public policy, governance, and law, this research aims to further the understanding of food waste valorisation phenomenon while providing valuable insights and recommendations for policymakers, businesses, and civil society organizations to foster a sustainable and efficient approach to food waste management in the European Union and beyond.

1. Food Waste Valorisation

1.1. What is food waste?

The Codex Alimentarius Commission (2019) defines food as "*any substance, whether processed, semi-processed or raw, which is intended for human consumption, and includes drinks, chewing gum and any substance which has been used in the manufacture, preparation or treatment of food but does not include cosmetics or tobacco or substances used only as drugs*". Since the European Union is the geographic focus of this dissertation, it is imperative that we consider the European definition of food alongside the internationally accepted one. The EU General Food Law regulation (Regulation (EC) No 178/2002, article 2), offers a more concise definition of food: "*any substance or product, whether processed, partially processed or unprocessed, intended to be, or reasonably expected to be ingested by humans*.

The relatively broader scope of the term 'waste' makes it trickier to define. The Global Waste Management Outlook published by the United Nations Environment Programme (2015) cautiously describes waste as "*unwanted or discarded materials, rejected as useless, unneeded or excess to requirements*". It further states that "*waste can be viewed as the combination of four wrongs - a wrong substance, in a wrong quality, in a wrong place at a wrong time*". The EU Waste Framework Directive

2008/98/EC defines waste in broader terms as "*any substance or object which the holder discards or intends or is required to discard*".

When ‘food’ and ‘waste’ are brought together though, the phrase takes on an ontological quality that is distinct from the one of food or waste considered separately. Edibility forms the core of both definitions of food discussed above. But what about inedible parts of food such as bones, peels, and pits? Growing and maintaining these parts demands the investment of as many resources as growing and maintaining the edible parts does. Therefore, is their wastage not a waste of these resources?

The definitions of waste discussed in this section cannot be directly applied to food either for they focus on the utilitarian quality of materials. Next to being a tradeable good like any other material, food is a source of sustenance; a requirement for the continuity of life itself. Therefore, is food ever truly unneeded? Or can it truly exist in excess when hunger continues to plague our societies? If food is a common good, who is the ‘holder’ described in the second definition? Food also bears cultural, social, and economic significance beyond its utilitarian value, distinguishing it from other types of waste.

As philosophically challenging as it is, defining food waste is a practical necessity because to identify the extent of wastage in our food system, defining food waste is the first step. To this end, there have been several efforts to define food waste as accurately and practically as possible in recent decades. The FAO, (2019) defines food waste as a “*decrease in the quantity or quality of food resulting from decisions and actions by retailers, food service providers and consumers*”. A decrease in the quantity and quality of food in earlier stages of the supply chain such as agriculture is termed as food loss. This distinction was born out of the necessity to identify the causes of waste or loss at different stages of the supply chain and develop practicable measurement methods (Gustavsson et al., 2011). However, since this dissertation focuses on valorising food after or while it is being wasted, this dichotomy was of little relevance. For examining the potential of creating value out of food waste or surplus, it was more important to work with a definition that encompasses parts of food that are traditionally considered inedible. The FAO definition also focuses on food security whereas this dissertation seeks to study food waste from a resource efficiency

perspective. Therefore, the definition of food waste proposed by the European Commission-funded FUSIONS project (2012 – 2016) was seen as the best match. When referring to food waste henceforward, unless specified otherwise, the following definition proposed by Gustavsson et al. (2014) for FUSIONS applies: "*Food waste is any food, and inedible parts of food, removed from the food supply chain to be recovered or disposed".*

1.2. Why and how should food waste be valorised?

Valorisation of food waste implies creating value out of food material that has been or is likely to be classified as waste. By doing so, this material gets a 'second chance' at fulfilling its potential while at the same time, reducing the negative impacts of food waste such as the expansion of landfills, rise in food insecurity, and financial losses to actors along the supply chain. Food can be valorised in a number of different ways depending on its physical state, location in the supply chain, quality, and nearness to consumers. By adapting the waste hierarchy proposed by the European Parliament Council in 2008, Papargyropoulou et al. (2014) developed a ranking system for the valorisation of food waste. While this version of the food waste hierarchy is the most popular in literature on food waste, the adaptation by Wunder, et al. (2018) is more suited for the purpose of the research undertaken as part of this dissertation. The hierarchy proposed by Wunder and colleagues is known as the food use hierarchy as opposed to the food waste hierarchy of Papargyropoulou et al. (2014) and offers a broader interpretation of the various valorisation pathways. The most effective way to tackle food waste, as per this system, is to prevent it from being generated at all. This is followed by three valorisation pathways i.e., redistribution, reuse, and recycling. The first valorisation pathway implies redistributing or reprocessing surplus food for human consumption. This includes donation to people affected by poverty and food insecurity, the discounted sale of food products that are nearing their expiry date, as well as the (re)processing of waste streams into new food products. The next pathway recommends re-using food waste for the production of animal feed whenever feasible. The last valorisation pathway involves recycling food waste biomass into compost, pet food, and biomaterial or recovering energy from it through anaerobic digestion or incineration. Only when none of these options are applicable, food waste must be

disposed of without nutrient or energy recovery. Figure 1, adapted from Wunder, al. (2018), illustrates this hierarchy.

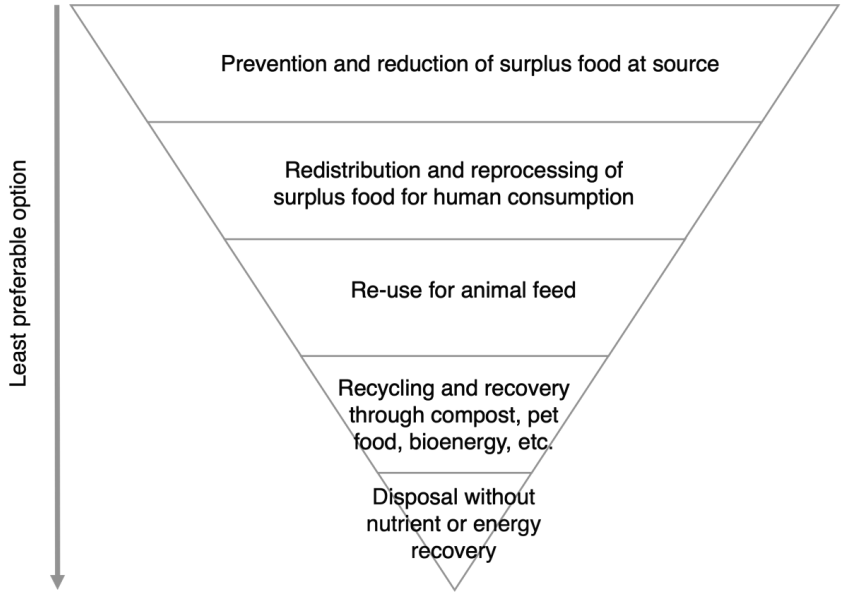

Figure 1 The Food Use Hierarchy as presented by Wunder et. al. (2018)

Like many recent works on food waste valorisation, this dissertation applies hierarchy discussed above when considering and comparing various food waste valorisation options. While this approach is not without shortcomings (see chapters 4 and 6), I would like to acknowledge that it has been fundamental to my understanding and analysis of the subject.

1.3. Who is responsible for valorising food waste?

Food gets wasted throughout the supply chain: crops get left unharvested on fields, grains get spoilt in granaries, processed foods get contaminated in factories, meat gets spoilt due to breakdown in the cold chain, supermarkets get left with bread past its expiry date, and forgotten vegetables get too wilted in our refrigerators to be appetising anymore. Therefore, reducing the amount of food that's wasted is the shared responsibility of everyone who interacts with it during its journey from the farm

to the plate (Göbel et al., 2015). Although not part of the food supply chain, actors such as policymakers, legislators, and competent authorities who do not interact with food directly are stakeholders in the food system and therefore also share this responsibility.

While consumers play an important role in realising the prevention pathway of the hierarchy, the heterogenous and scattered nature of food waste at the consumer stage makes it difficult to carry out valorisation activities. As a result, the work presented in this dissertation focuses on food waste from the pre-consumer stages of the food supply chain. It recognises that while food is a tradeable commodity with economic value for private actors, it is also a common good and a human right that must be preserved by public actors (Jackson et al., 2021). Therefore, I argue that both, public and private actors must separately and jointly ensure the efficient and sustainable valorisation of food waste. This shared responsibility creates a number of conflicts and uncertainties pertaining to the roles and responsibilities of various involved stakeholders, sharing of resources, and legal and economic feasibility of valorisation endeavours (Mourad, 2016). By addressing the underlying causes of such conflicts and understanding how relevant stakeholders experience uncertainties, I seek to identify ways for various parties to better fulfil their food waste valorisation responsibilities.

2. Safety, Sustainability, Security

2.1. Safety

Food surpluses and side streams or by-products such as peels and pulp of fruits and vegetables, spent grains, and oil seed cakes that are generated during various food processing and manufacturing activities being used for direct and indirect human consumption is a highly preferred valorisation strategy. This can be achieved by redistributing close-to-expiry or cosmetically imperfect foods to individuals affected by food insecurity and by processing by-products and waste streams such as peels and trimmings into new food products and ingredients (Morone et al., 2019). These valorisation strategies allow food materials to fulfil their original purpose of providing sustenance and ensuring the most efficient use of resources. However, food safety

may become a source of concern while undertaking such endeavours (Focker et al., 2022; Socas-Rodríguez et al., 2021). Microbiological spoilage, pesticide residues, incorrect labelling, and the presence of undeclared allergens are some examples of food safety concerns while valorising food waste. Even if food business operators are able to manage these hazards and ensure consumer safety, regulations protecting consumer health and safety may present challenges (Priefer et al., 2016).

Many valorisation activities defy the norms of the conventional food system (Zarbà et al., 2021). Food safety requirements designed for today's highly efficient and globalised food supply chains often do not account for the unique characteristics of by-products and surpluses. Therefore, discussions on food safety feature prominently in this dissertation. In many studies undertaken as part of this dissertation, I seek to understand whether private food safety standards could bridge the gap between public legislation on food safety and public policy ambitions to achieve sustainability goals.

2.2. Sustainability

Like many other works on food waste, 'sustainability' is discussed frequently in this doctoral thesis. My understanding of sustainability is shaped by Gro Harlem Brundtland's (1987) definition of sustainable development: "*meeting the needs and aspirations of the present generation without compromising the ability of future generations to meet their needs*". Brundtland's socialist ideals are clearly reflected in her work on this subject as she emphasises the importance of equitable wealth distribution among nations and the eradication of mass poverty as a means to achieving sustainability. I would therefore like to acknowledge that the idea of valorising food waste to achieve sustainability in the food system is not without political underpinning. In the context of food waste, developing valorisation pathways allows the prudent use of resources such as labour, water, soil-enhancing minerals, and fossil fuels which are intensively employed in the production and distribution of food. Therefore, when food is used to its maximum potential, it reduces the pressure on these resources and preserves them for future generations' use.

The related concept of the 'triple bottom line' (or the people-planet-profit approach to sustainability) also finds a mention in some of the chapters that follow this one. With

its roots in the field of management studies, the triple bottom line approach seeks to operationalise sustainability as a function of corporate social responsibility (Elkington, 1994). Several stakeholders involved in food waste valorisation, especially food business operators, take on this approach when rationalising their decision to create value out of food waste.

'Circularity' or the 'circular economy' are discussed often as well. Although not identical to sustainability, circularity is an adjacent concept that focuses on closing or slowing down material loops. Geissdoerfer et al. (2017) define the circular economy as "*a regenerative system in which resource input and waste, emission, and energy leakage are minimised by slowing, closing, and narrowing material and energy loops*". Such a system promises a sustainable alternative to the current 'take-make-waste' approach to using resources and emphasises the economic and environmental benefits of using raw materials to their full potential before they are discarded.

2.3. Security

The FAO (1996) defines food security as a state that exists when "*all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life".* The severity of the food waste problem is often emphasised by juxtaposing food waste numbers against statistics for food insecurity. The fact that one-third of all food produced globally is wasted while one in three individuals experiences hunger indeed represents a profound paradox.

Although food security is not a key focus in this dissertation, it is inextricably linked to the argument for reusing surplus food to meet the needs of individuals affected by poverty and hunger. In chapters 4 and 5 where food banks and surplus redistribution are important themes, food security forms the scaffolding for the study design. In chapter 8, I adopt a broader perspective on the issue of food waste leading to food insecurity by examining the concept of the human right to food. In these chapters, I also examine the ethics of using 'leftover' food to feed those in need. The works of critical scholars such as Dowler & O'Connor (2012), Lambie-Mumford & Dowler (2015), Poppendieck (1999), and Riches & Silvasti (2014) on private actors using

surplus food to provide aid to food insecure citizens in a Welfare State have informed the discussions on food security in this thesis as well.

3. Law, Policy, Governance

3.1. Law

Many legal areas such as food information and safety, labelling, tort, tax, competition, and waste law exert influence on food waste prevention and valorisation activities (Bradshaw, 2018). Despite this, literature on food waste rarely pays attention to how various legislations and their interactions impact food waste reduction goals (Eriksson et al., 2020). Similarly, legal scholars seldom take a 'law in action' approach to food waste to examine how regulatory requirements pan out in a pragmatic setting.

Occupying the liminal space between legal studies and social sciences, much of my work seeks to understand whether legislations that impact food waste are congruent with the practicalities of valorisation activities. While I do not undertake legal analysis (except in chapter 6), my empirical work delves into stakeholders' understanding of and interaction with matters pertaining to legislative requirements. Where qualitative research methods were employed, participants were encouraged to share their experiences with interpreting and applying pertinent regulations.

Given that this thesis focuses on valorising food waste for human consumption, regulations concerning the safety and marketing of food products are particularly important. However, some other adjacent legal areas are of relevance to the subject of this dissertation as well. As a result, regulations relating to animal feed safety (chapter 2), fisheries (chapter 3), waste management and renewable energy (chapter 6), and human rights (chapter 8) are also discussed.

3.2. Policy

The European Union lacks a comprehensive legal framework specifically addressing sustainability concerns in the agri-food system (Banterle et al., 2018). While sustainability is referred to in various treaty articles and regulations, it is only discussed

in broad terms. Therefore, public policies on the subject are pivotal in assessing the Union's and its Member States' ambitions regarding issues of environmental relevance such as food waste.

Literature analysing policy documents such as the Farm-to-Fork strategy, Common Fisheries Policy, Circular Economy Action Plan, and reports from EU-funded projects like FUSIONS and REFRESH have informed the direction of this thesis to a significant extent. In particular, the deployment of policy instruments to achieve sustainability goals in the food system was of interest to me while designing the studies undertaken as part of this dissertation. My research probes how market-based, regulatory, and voluntary instruments are perceived by relevant stakeholders and whether their implementation creates tensions concerning food safety and the economic aspects of the food system.

Chapters 2, 6, and 8 discuss the impact of pertinent public policies on food waste valorisation at the EU level whereas chapters 3, 4, 5, and 7 examine the same in the Dutch context. The Netherlands, being a part of the European Union, aims to achieve the United Nations' Sustainable Development Goal 12.3, which involves reducing per capita food waste by 50% by 2030. Serving as a roadmap to achieving resource efficiency, the 'Circular Economy in the Netherlands by 2050' agenda has been influential in the creation of various domestic policy instruments. By presenting conceptual and empirical insights regarding the impact of these instruments, the research presented in this thesis provides policymakers with evidence-based recommendations to enhance their decision-making processes and improve the effectiveness of policy implementation.

3.3. Governance

Due to the co-existence of several official definitions and measurement methods, the involvement of multiple stakeholders, and the lack of an all-encompassing solution, food waste is recognised as a 'wicked problem' (Närvänen et al., 2020; Weber & Khademian, 2008). In policy and management sciences, wicked problems are defined as "*a class of social system problems which are ill-formulated, where the information is confusing, where there are many clients and decision makers with conflicting values,*

and where the ramifications in the whole system are thoroughly confusing" (Churchman, 1967). From climate change to the refugee crisis, the number of issues being categorised as wicked is on the rise; increasing the risk of the term turning into a buzzword (Termeer et al., 2019). However, adopting a wicked problem framework in my work was pertinent because it allowed me to explore non-traditional and collaborative forms of governance to manage food waste at the systemic level.

Although I explicitly refer to food waste as a wicked problem only in chapter 4, governance approaches specific to wicked problems guided many aspects of study design. Specifically, I examined the role of private actors next to public ones because multi-stakeholder, public-private partnerships have shown promising results in the governance of other wicked problems (Dentoni et al., 2018). This informed the scope of my studies, the sampling strategy, and in the case of empirical works, the data collection. Next to multi-stakeholder partnerships, I also investigate the relevance of transition brokers (Cramer, 2020), small wins (Weick, 1984), and private standards (Rao et al., 2021; van der Meulen, 2011) in better governing the transition to a climate resilient, low-waste food system in Europe.

4. This Dissertation

4.1. Aim

This thesis aims to explore how food waste can be valorised in a safe and sustainable manner in the European Union while reaching a compromise with regard to the economic interests of private actors and the socio-environmental ambitions of public institutions. My secondary aim was to identify conflicting policy goals and tensions amongst stakeholders and the ways in which they impede food waste valorisation. By applying theoretical knowledge on food safety legislation, public policies on sustainability in the food system, and the governance of the food waste problem in real-life contexts, this dissertation seeks to expand our current understanding of how the transition to a resource-efficient food system can be optimised.

4.2. Overview

The seven research chapters of this dissertation present results and discussions from studies undertaken to achieve the aim described above. Chapter 2 lays the foundation of the thesis by mapping out the most relevant food processing by-products in the EU and the various ways in which they can be valorised. This chapter underscores the importance of balancing safety, nutrition, and environmental sustainability considerations when developing strategies to valorise food waste as human food and animal feed. It discusses how dissonance between different policy goals, consumer perception, and legislative hurdles can pose barriers to achieving improved utilisation of food waste. Based on these insights, Chapter 3 takes on an empirical approach to studying food waste valorisation in a real-life context. Focusing on fishing by-catch resulting from a sustainability-focused reform in the Common Fisheries Policy, it examines the possibility of using a 'reuse' valorisation strategy to connect safe-to-consume by-catch with Dutch food bank parcels which often lack fish.

Chapter 4 shifts the focus from by-products and waste streams to actors involved in valorising them. Using a phenomenological approach, it explores the ambitions and apprehensions of relevant stakeholders to better understand the current state of food waste valorisation in the Netherlands. Having conducted this study when the impacts of the Covid-19 crisis reverberated throughout the food redistribution sector, several participants shared the tribulations they faced during the pandemic. A separate analysis of this data resulted in Chapter 5 which examines how food charity operations relying on surplus food were impacted by the supply chain disruptions caused by the Covid-19 crisis.

Chapter 6 considers the conversion of food waste biomass to biofuel and biogas. By analysing the legislation and policies surrounding the subject, it seeks to identify whether this valorisation pathway competes with higher-priority valorisation strategies. The chapter discusses the possible causes for food business operators preferring the energy conversion route over the food or animal feed routes. However, some food businesses are able to overcome these barriers and successfully valorise food waste streams into products that can be used for human consumption. Chapter 7 studies the case of one such circular company based in the Netherlands.

Finally, Chapter 8 reflects on the actions of retail corporations in the context of food waste valorisation. One of the most powerful actors in today's globalised food supply chains, the retail sector impacts the state of food waste in more ways than evident. The chapter applies a business and human rights framework to this issue to identify ways in which retail corporations can be held accountable for their role in systemic food waste reduction. Chapter 9 summarises the key findings of all research chapters and charts out the main considerations for safely and sustainably valorising food waste while addressing the needs of all involved stakeholders.

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2

Valorized Food Processing By-Products in the EU: Finding the Balance between Safety, Nutrition, and Sustainability

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Abstract

Food businesses in the European Union are preparing for a carbon-neutral future by gradually transitioning to a circular way of operating. Building upon results from the EU REFRESH project, we consider the most valuable food processing by-streams in Europe and discuss potential food safety risks that must be considered while valorising them for human consumption. These risks are weighed against the nutritional benefits offered by these products and their potential applications in food supply chains. Broadly, we examine whether it is possible for spent grains, cheese whey, fruit and vegetable scraps, meat processing waste, and oilseed cakes and meals to be safe, sustainable, and nutritionally valuable at the same time. The discussion highlights that valorising by-products obtained from food processing operations is feasible on a large scale only if consumers deem it to be a safe and acceptable practice. Extracting valuable compounds from by-products and using them in the preparation of functional foods could be a way to gain consumer acceptance. Furthermore, we find that current EU food safety legislation does not sufficiently accommodate food processing by-products. A way to bridge this regulatory gap could be through the adoption of private food safety standards that have shown proclivity for sustainability-related issues in food supply chains. Finally, by proposing a decision tree, we show that it is indeed feasible for some food processing by-products to be valorised while ensuring sustainability, food safety, and nutritional relevance.

1. Introduction

The European Commission's aspiration to move toward a circular economy is no secret. With the recent unveiling of the Green Deal, an ambitious plan to make Europe carbon neutral by 2050, it is clear that in the future, businesses will be expected to work with closed loops of resources to minimize waste and reduce the impact of their actions on the environment. The Farm to Fork strategy, a subset of the Green Deal, focuses on the food system and aims to employ the circular economy model to make food production more sustainable (European Commission, 2019).

In the context of food supply chains, closing the loop would mean making better use of food waste, surplus, and by-products. It is estimated that around 88 million tons of food is wasted in Europe every year (Stenmarck et al., 2016). While saving at least a part of this amount might seem like an irreproachable goal, some of the most attractive solutions may make food less safe for consumers. As the innovative use of side streams and by-products becomes the new norm in a sustainable food system, changing food safety needs must be a core part of the development. The EU General Food Law does not define the concept of "safe food." Rather, it focuses on the negative concept of "unsafety" by stating in Article 14 (2) that food shall be deemed as unsafe if it is considered to be injurious to health or unfit for human consumption. Furthermore, it does not make a distinction between products that are inherently unsafe and those that have been rendered unsafe by their specific condition (Meulen & Szajkowska, 2014). This puts the burden of proof on food businesses and makes it a challenge for new or novel foods to be established as not unsafe.

Given the pervasive nature of food waste and the existence of different methods to measure it, there is no conclusive evidence on how much food is wasted at each stage of the food supply chain. Most studies focusing on measuring food waste in the EU agree that the largest share of food is wasted at the consumption stage. The processing stage is considered to be a close second. A report published by the European Commission compared six studies measuring food waste at different stages of the supply chain and found that the estimate for the processing stage (referred to as the manufacturing stage in the report) is between 12% and 41% (Caldeira et al.,

2017). While the amount of waste from households is higher than that from the processing stage, processing waste is less scattered and is more homogeneous in nature. This makes it a more attractive option for valorisation.

In food waste management practices, the food waste hierarchy framework developed by Papargyropoulou et al. (2014) is widely applied (Papargyropoulou et al., 2014). This hierarchy makes preventing food waste a top priority, followed by reusing surplus food for human consumption. After this, the next priority is to convert food surplus to feed for animals that are part of the food chain. Up until this stage, food safety remains a central concern. The two last stages of the hierarchy include energy recovery and disposal. Once the waste has reached these stages, it is no longer part of the food supply chain and, therefore, food safety is no longer a concern. However, keeping food waste and surplus within the food supply chain is seen as the more sustainable option, considering environmental, economic, and social implications (Papargyropoulou et al., 2014).

Known drivers of food waste at the processing stage include inadequate control systems, inefficient operations, poor use of equipment, spoilage caused by suboptimal handling and storing conditions, damage incurred during transportation, and cold chain inefficiencies (Canali et al., 2017). REFRESH (2015–2019), a project funded by the European Commission mapped current knowledge on food waste valorisation and developed tools to support decision-making regarding valorisation pathways. Its predecessor, FUSIONS, was active between 2012 and 2016 and lay the groundwork for REFRESH by creating definitions and developing methodologies for measuring the extent of the problem. The two projects together have advanced the current understanding of Europe's food waste problem and set the course for future action. Topics such as legal and policy perspectives, life cycle analyses, economic aspects, business practices, and innovation have been covered by the projects. One of the outcomes of the REFRESH project was the creation of the FoodWasteExplorer— An open access database that provides information about biochemical composition of agri-food chain waste streams (available via www.foodwasteexplorer.eu. accessed on 13 April 2021). The database sources a majority of its information from other databases focused on animal feed. Therefore, in its current form, it is questionable

whether data from FoodWasteExplorer can be used for valorising food processing by-products for human consumption.

Next to these two EU projects, various review and meta-review articles have further improved current knowledge on the use of by-streams (Djagny et al., 2001; Gebrechristos & Chen, 2018; Gómez-Guillén et al., 2011; Mirabella et al., 2014; Sagar et al., 2018). While food safety, sustainability, and nutrition are discussed to varying extents in literature, a critical reflection focusing on all three has never been published. Through this article, we hope to fill this gap. In line with Gilson & Goldberg's (2015) guidelines for conceptual papers, rather than collecting new data, we propose new, untested relationships among existing constructs found in literature. In this paper, the untested relationship is the one shared by food safety, nutrition, and sustainability in the context of valorising food processing by-products. Next to this, we employ Toulmin's "claims, grounds, and warrants" framework for constructing a sound argument (Jaakkola, 2020; Toulmin, 2003). The claim we make is that it is possible for valorised food processing by-products to be safe, sustainable, and nutritionally valuable at the same time. We then use arguments found in existing literature as grounds to support our claim.

As for warrants, which are underlying assumptions that link grounds to claims, we work with the presupposition that food safety, nutrition, and sustainability are equally important to the food industry in its pursuit to find ways to valorise food processing by-products.

For individual by-streams, the various articles cited in this paper as well as the FoodWasteExplorer database have already created comprehensive lists of hazards that could occur during the valorisation process. Our aim, therefore, is not to repeat this exercise but to create new knowledge on the topic by weighing food safety risks against nutritional benefits and potential uses of these by-products.

2. Important By-Products in the EU

Similar to the estimates regarding waste at different stages of the supply chain, there is no conclusive evidence on the amount of waste generated by the various sub-sectors of the processing stage. However, recent work published by Caldeira et al. (2019) offers a well-founded estimate, calculated using the mass flow analysis concept. The total food waste at the processing stage was found to be 30.6 million tons annually (Caldeira et al., 2019). Figure 1 shows the estimated contribution of the top five sub-sectors at the processing stage.

Considering that food is wasted at the processing stage in significant quantities, it became important to identify which by-products should be given priority for valorisation. This is a crucial step so as to enable the food industry, policymakers, and legislators to set up infrastructure and resources focusing on valorising specific by-products into new, valuable products. In 2016, REFRESH composed a list of 20 priority food waste streams. These were selected on the basis of their environmental impact and the volume generated (Moates et al., 2016). All categories in Figure 1 find a place in the list, thus indicating that the sub-sectors with the highest volumes of waste are given priority in facilitating valorisation. Below, some of the top contributors are discussed in the context of potential valorisation pathways, food safety bottlenecks, and nutritional benefits.

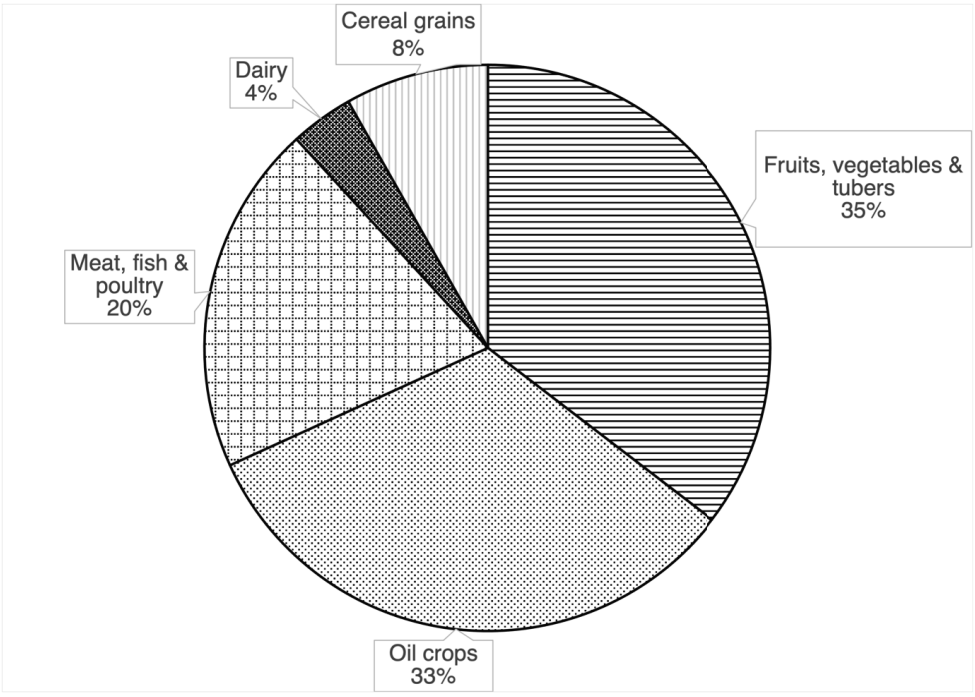

Figure 1 Food waste estimates per sub-sector at the processing stage (Caldeira et al. 2019)

2.1 Spent Grain

Spent grains, a by-product of ale, lager, and spirit production, is listed as one of the twenty priority streams due to the annual volume generated in the EU (Moates et al., 2016). On average, 20 kg of spent grains remain behind for every hectolitre of these beverages produced (Moates et al., 2016). It is estimated that 3.4 million tons of spent grains are produced within the EU every year (Lynch et al., 2016). This by-product consists mostly of barley peel, pericarp, seeds, residual endosperm, and aleurone (Chetrariu & Dabija, 2020). It is often referred to as brewer's spent grains or BSG.

BSG has a complex chemical composition, which makes it suitable for many valorisation endeavours. However, the most prominent bottleneck in valorisation is the high moisture content of BSG. At 80% moisture content, the average shelf life of this product is 7–10 days (Chetrariu & Dabija, 2020). Together with its fermentable sugar contents, the high moisture makes BSG liable to rapid deterioration (Lynch et al., 2016). A study by Sodhi et al. (1985) found eight isolates of Aspergillus, Fusarium,

Mucor, Penicillium, and Rhizopus in BSG stored in a gunnysack for 30 days (Sodhi et al., 1985).

To preserve BSG, various techniques can be used. Adding lactic acid, acetic acid, formic acid, or benzoic acid to moisture-rich BSG mixtures is known to effectively preserve quality and nutritional value (Lynch et al., 2016). Kuentzel and Sonnenberg (1997) found potassium sorbate to be effective as well. Spent grains can also be dried prior to storage (Kuentzel & Sonnenberg, 1997). This not only makes it less susceptible to microbial spoilage but also reduces the product volume, and as a result, decreases transport and storage costs (Santos et al., 2003). Traditionally, BSG is dried using direct rotary-drum driers. However, this process is energy-intensive and is being replaced by more energy-efficient methods such as freeze-drying, oven drying, and freezing (Bartolomé et al., 2002; Mussatto, 2014).

Next to microbiological risks, chemical risks must also be considered while valorising BSG. A study published by Ekielski and colleagues (2018) shows that chlormequat and mepiquat, two compounds commonly used as pesticides, can be formed while roasting grains during the brewing process (Ekielski et al., 2018). Based on their work, it is possible that the spent grains obtained from darker malts may contain these toxic compounds in trace amounts.

Currently, BSG is used in food as well as feed applications. Incorporating BSG in the human diet can contribute to positive health effects (Chetrariu & Dabija, 2020). Spent grains can be added to food products to increase their fibre and protein content (Stojceska & Ainsworth, 2008). The glutamine, non-cellulosic polysaccharides, and soluble dietary fibres present in BSG have been linked with accelerated intestinal transit, alleviation of both, diarrhoea and constipation, decreased incidence of gallstones, as well as reduced cholesterol and postprandial glucose levels (Mussatto, 2014). Due to the presence of biologically active compounds in BSG, food fortified with it is considered to be functional food (McCarthy et al., 2013). Several studies involving pasta, bread, infant formula, and meat and fish products have shown that BSG can add significant nutritional value to foods (Lynch et al., 2016; McCarthy et al., 2013; Nazzaro et al., 2018; Nocente et al., 2019; Spinelli et al., 2016; Stojceska & Ainsworth, 2008). For instance, Stojceska (2019) shows that by replacing 30% of regular flour

with BSG during bread making, the level of dietary fibre can increase up to five-fold (Stojceska & Ainsworth, 2008). This contributes toward consumers' recommended daily dietary fibre intake (Stojceska, 2019). BSG can be used for technical applications related to food production such as the production of xylitol, lactic acid, and prebiotics (Chetrariu & Dabija, 2020). It is also a source of phenolic compounds and can be used as a substrate for the growth of various microorganisms (Chetrariu & Dabija, 2020).

BSG is a low cost, nutritionally attractive material that is readily available in large quantities throughout the year (Lynch et al., 2016). Results from Lynch et al. (2016) indicate that developing efficient methods for its preservation and formulating legislation to govern the production and utilization process would substantially improve the safe use of BSG in various food application. After focusing on ways to minimize waste, the beer brewing industry must work toward developing methods for complete recovery of by-products on a large scale (Kao, 2018). Next to this, specific analytical methods for the characterization of functional compounds need should be developed (Kao, 2018). This would aid in the valorisation of not only BSG but also other valuable by-products such as hops and yeast. Lastly, the bioactivity, bioavailability, and toxicology of the functional components derived from BSG need to be assessed via in vitro and in vivo studies (Kao, 2018). If this is achieved, we might see BSG being better utilized and kept within the food supply chain in the years to come.

2.2 Fruits, Vegetables, and Tubers

Pomace and peels of apples, oranges, tomatoes, potatoes, grapes, olives, and sugar beet find a prominent place in the REFRESH priority list (Moates et al., 2016). The disposal of these by-products is of lower consequence to the environment in comparison to some other waste streams, but their leachate and methane emissions still present a risk (Misi & Forster, 2002; Sweet et al., 2016). Recovery solutions for fruit and vegetable waste streams are negatively impacted by the fact that they often contain large amounts of suspended solids and present high biochemical and chemical oxygen demand. As a result, recovery solutions and waste treatment become more expensive (Mirabella et al., 2014).

Pomace from apple processing and cider production is an important by-product for several European countries including the United Kingdom, France, Spain, Ireland, and Germany. Currently, the most widespread way to valorise this pomace is by converting it to animal feed. Given that apple pomace is a rich source of dietary fibre and antioxidants, various studies have considered ways to use it in food applications (Henríquez et al., 2010; Huber & Rupasinghe, 2009; Wolfe & Liu, 2003). However, the safety of apple pomace for human consumption has not been comprehensively reviewed (Skinner et al., 2018). The incidence of the natural toxin amygdalin in apple seeds as well as the presence of plant protection products such as neonicotinoids and arsenic-based pesticides on apple skins is a source of concern while valorising apple pomace for human consumption (Bolarinwa et al., 2014; Lozowicka, 2015; Opyd et al., 2017; Skinner et al., 2018). Patulin, a mycotoxin, also presents a food safety risk while valorising apple pomace and skins (Beretta et al., 2000). However, the presence of this hazard does not render apple by-products unusable. Patulin can be controlled by employing a combination of control measures throughout the production process (Moake et al., 2005).

Similar to apple pomace, the safety of consuming tomato pomace has not been extensively studied. However, current literature mentions the possibility of adverse effects because of the mildly toxic glycoalkaloid, tomatine (Salehi et al., 2019). Next to this, allergic reactions to the various proteins present in the tomato and irritable bowel syndrome from consuming high amounts of seeds and skins have been reported in literature (Laza, 2014; Żukiewicz-Sobczak et al., 2013).

For South European countries like Spain, Italy, Greece, and Portugal, orange by-products such as peels, seeds, and membranes are an important waste stream. Several compounds like soluble sugars, fibre, lipids, organic acids, flavonoids, vitamins, and minerals found in these waste products can be of much value in food applications (Fernández-López et al., 2004). While conversion to animal feed remains the most popular valorisation option for orange processing waste streams, several food applications have been successfully piloted in recent years (Mirabella et al., 2014). However, utilizing orange peels in food applications without taking appropriate measures to remove pesticides might pose a food safety risk (Li et al., 2012).

A number of studies have shown that food processing steps such as washing, boiling, and juicing can reduce the level of pesticide residues in food to a large extent (Burchat et al., 1998; Li et al., 2012; Randhawa et al., 2007). However, some processing steps that involve dehydration lead to a concentration of pesticides (Hossain et al., 2014; Joshi et al., 2020; Li et al., 2012). Factors such as temperature and microbial activities can also cause pesticide residues to undergo transformation, leading to the contamination of food processing by-products with other chemicals (Al-Muhtaseb et al., 2010; Li et al., 2012; Sánchez Maldonado et al., 2014).

Plant protection products are not the only food safety concern while valorising fruit and vegetable processing by-streams. As in the case of apple pomace, other by-products can present risks in the form of toxins that are unique to them. When valorising potato peels, for instance, glycoalkaloids found in the Solanum genera are a potential hazard (Gebrechristos & Chen, 2018; Joshi et al., 2020). While glycoalkaloids are present in various parts of the potato, they are more concentrated in peels. Therefore, while using peels in food products, this risk must be considered (Hossain et al., 2014; Sánchez Maldonado et al., 2014).

Another concern when utilizing fruit and vegetable processing by-products is microbial spoilage due to high moisture content. The food processing sector struggles with valorising pomace and skins from tomato and grape processing operations because these by-products contain significant amounts of moisture (Al-Muhtaseb et al., 2010; García-Lomillo & González-SanJosé, 2017). Drying prior to storage can assure higher stability but it can also result in the concentration of pesticides. Furthermore, moulds are also capable of producing mycotoxins at low levels of water activity (Romagnoli et al., 2007).

Despite food safety concerns, fruit and vegetable by-products are an attractive resource for the food and nutraceutical industries. Epidemiological research indicates that regular consumption of fruits and vegetables is linked to a decreased risk for developing various diseases including cancer, cardiovascular disease, high blood pressure, diabetes, and Alzheimer's disease (He et al., 2007; Kromhout et al., 2016; McCall et al., 2009). These health effects have been linked to the bioactive phytochemicals in fruits and vegetables (Liu, 2003). The increasing consumer demand

for such compounds is often met through dietary supplements, functional foods, and nutraceuticals (Liu, 2003; Timbo et al., 2006). Fruit and vegetable by-products are rich sources of phytochemicals. As a result, the extraction of phenolic compounds, dietary fibbers, and other bioactive compounds from these by-streams has been widely studied (Galanakis, 2020). Compounds such as lycopene from tomato pomace (Allison & Simmons, 2017; van Steenwijk et al., 2020) and various phenolic compounds from grape seed extract, apple peels, and orange peels (Babbar et al., 2015; Chen et al., 2020; Weseler & Bast, 2017; Wolfe & Liu, 2003) are examples of compounds that can be valuable for the food industry for their health effects.

Next to being a source of bioactive compounds, fruit pomace can also enhance the dietary fibre content of various food products. It can be included in cereal-based foods while retaining consumer acceptance, improving health benefits of the products, and also offering a way to upcycle valuable by-products that would have otherwise ended up as waste (Quiles et al., 2018). Quiles et al. (2018) showed that fruit pomace in its dried form can be used to enrich the dietary fibre content of various baked products like bread, cakes, muffins, cookies, biscuits, and extruded products.

Although this paper considers by-products from fruit, vegetable, and tuber processing as a single category, each by-stream presents unique challenges for valorisation. Different parts such as stems, leaves, and skins of the same product can also present great diversity in the risks that must be considered prior to valorisation. Much of the current knowledge on the topic focuses on the utilization of these by-streams for animal feed. If they are to be used for food applications, data regarding safety must be documented and current legislation on food safety must expand its scope to include these by-products. If this is accomplished, the amount of fruit, vegetable, and tuber by-products that leave the food supply chain could be substantially minimized.

2.3 Dairy

The dairy industry is a commercially important subsector of the European food industry. It is also the second largest contributor to food waste at the processing stage and generates large volumes of liquid waste. It is estimated that 9 million tons of cheese is produced within the EU per annum. This generates around 50 million m3 of

whey. Dairy processing by-products can contain proteins, fatty substances, salts, lactose, and cleaning chemicals (Kosseva, 2009). The REFRESH list mentions whey, the protein-rich by-product of the cheesemaking process, as a priority waste stream.

Smithers (2008) points out that whey and its disposal have always been a source of nuisance for cheesemakers and casein manufacturers. Throughout the sector's history, dairy companies have been on the lookout for the most economically attractive way to dispose of their whey. Some previously used disposal techniques include spraying the whey onto fields or discharging it into bodies of water or municipal sewage systems. These methods, however, have had severe environmental repercussions. The study notes that the biochemical oxygen demand of whey is estimated to be nearly 175 times higher than standard sewage effluent. This has led regulatory authorities to restrict the disposal of untreated whey. As a result, dairy companies are left with the obligation to find innovative ways either to dispose of or use their whey.

The contamination concerns regarding whey are closely related to those of milk and other milk products. Microbiological hazards are the biggest cause of concern for the dairy industry, followed by chemical and physical hazards (van Asselt et al., 2017). Listeria monocytogenes, Staphylococcus aureus, Salmonella, and human pathogenic Escherichia coli have been identified as the most important microbiological hazards in dairy products (van Asselt et al., 2017). Next to this, chemical hazards are known to end up in milk mainly due to ingestion or production of unwanted compounds by the cow (van Asselt et al., 2016). Contaminated feed, grazing on contaminated soil, administration of veterinary medicines, and fraud are some key causes for concern (van Asselt et al., 2016). Aflatoxin M1, environmental contaminants like dioxin and dioxin-like compounds, and veterinary drugs are the most concerning chemical hazards for the dairy industry. Metal and plastic particles are considered to be important physical hazards (van Asselt et al., 2016). Literature on the safety of dairy products focuses mainly on milk or other commercially important products like cheese and butter. Literature about safety concerns specific to whey is not widely available.

As with other by-products of food processing, conversion to animal feed remains an important valorisation option for whey. However, the increasing interest in finding

sustainable ways to meet the protein needs of a growing population has led researchers to take a keen interest in valorising whey for direct human consumption (Prazeres et al., 2012). Some long-standing valorisation options include the production of beverages such as the Swiss drink Rivella and the Italian soft cheese ricotta. In the United States, cheese whey falls under the category of “generally recognized as safe.” FDA regulations state, “GRAS is the self-determination of safety and regulatory compliance in an otherwise stringently regulated venue” (Burdock & Carabin, 2004).

With the overall trend to replace animal-source foods with plant-source ones, it is debatable whether investing resources to develop new ways to utilize dairy by-products aligns with the agenda to make food production more sustainable. Nevertheless, dairy is currently an important source of dietary protein which is a vital component of the human diet (de Boer et al., 2006; Pedersen et al., 2013). Given the commercially important position held by the dairy industry, the wide-spread consumption of dairy products, and the demand for protein-rich foods to feed the growing population, it is unlikely that dairy production will cease to exist in the near future.

It has been established that exercising individuals and athletes need more dietary protein than their sedentary counterparts (Campbell et al., 2007). This demand is often met through high quality supplemental protein sources like whey and casein protein (Campbell et al., 2007). Developing products from valorized whey with athletes as target consumers may therefore be beneficial. A meta-analysis focusing on the efficacy and safety of whey protein found that no relevant data on the safety of the product was reported in any of the included studies (Lam et al., 2019). However, the same paper found that no side effects were reported either (Lam et al., 2019).

A recent study by Yadav et al. (2015) suggests that using whey as a substrate to create bioprotein might be an interesting way to keep whey within the food supply chain. Bioprotein is a heat-inactivated bacterial single-cell protein that can be used in both food and feed applications. However, the study also warns that contamination with carcinogenic components, metallic components, and mycotoxins is a possibility (Yadav et al., 2015). In 2018, “whey basic protein isolates” was approved as a novel food product in the EU for use in infant formula, meal replacement beverages, dietary foods for special medical purposes, and food supplements (Yadav et al., 2015).

Identifying ways to valorise whey can help improve food security, keep valuable dietary proteins within the food supply chain, prevent environmental damage caused by whey disposal, and help the dairy industry become more circular. As per Smithers (2008), advancement in novel separation methods such as vibratory shear enhanced processing, chromatographic technology, high power ultrasound, ion exclusion, and molecular recognition-based isolation techniques will offer the dairy industry new opportunities to safely valorise whey for human consumption.

2.4 Meat and Other Animal Products

Globally, the demand for meat has been rising directly in proportion to consumers' increasing purchasing power. At the same time, interest in organ meats and non-prime cuts has been falling dramatically. As a result, the meat industry is left with large quantities of slaughterhouse by-products (Mirabella et al., 2014). Stuck with 20% of the waste generated at the processing stage, the meat processing and allied sectors seem to be faced with a difficult conundrum as the food industry inches toward a more sustainable future. The REFRESH list mentions hair, feathers, hooves, feet, organ meat, proteinaceous matter, and eggshells as priority by-products (Moates et al., 2016).

Keeping meat processing by-products within the food supply chain is more challenging than valorizing by-products from other sectors of the food industry. Following the bovine spongiform encephalopathy (BSE) crisis, the handling of slaughterhouse waste is very strictly regulated in the European Union. Organ meats such as brain, nerves attached to the brain, spinal cord, and bone marrow are classified as high risk because they may contain prions that can spread BSE and other neurodegenerative disorders (Glatzel & Aguzzi, 2000). Additionally, heavy metals like lead and cadmium are more likely to be found in higher concentrations in organ meat (Alao et al., 2017; Colles et al., 2020). A study by Colles et al. (2020) indicated that the Flemish population's consumption of organ meat is likely to play a role in the increased perfluorinated compounds in their blood levels. Perfluorinated compounds are degradation-resistant molecules that are made up of carbon chains bound by fluorine atoms. Exposure to them has been associated with adverse health effects.

Under the stringent requirements of Regulations (EC) No 999/2001 and No 853/2004, the meat industry is left with fewer options to utilize waste products. Council Directive 75/442/EEC classifies animal by-products in categories 1, 2, and 3 depending on the risk they pose. Only by-products classified as “Category 3” are considered safe for valorization for food and feed purposes. While staying in line with regulations, some valorization pathways to keep meat processing by-products in the food supply chain include production of processed foods such as sausages, use in specific animal feeds, and export of organ meats to countries that traditionally consume them.

Some functional ingredients can be derived from meat processing by-products as well. Bioactive peptides from these by-products offer various health-promoting properties. Hypocholesterolemic, antioxidant and antithrombotic peptides have been found to modulate the cardiovascular system (Toldrá et al., 2016). Mineral binding peptides are known to act in gastrointestinal systems and immunomodulatory peptides in immune systems (Toldrá et al., 2016). Results from Ryder et al. (2016) have shown that bioactive peptides extracted from blood and collagen could play a role in the production of health-promoting products (Ryder et al., 2016).
Next to this, meat processing by-products can also offer compounds that have technological applications in the food industry (Toldrá et al., 2016). For instance, immunoglobulins, serum albumin, and fibrinogen are used for their gelation and emulsification properties. Plasma proteins can be used for protein enrichment (Yousif et al., 2003) and foaming (Del Hoyo et al., 2008). White blood cells from sheep have been found to aid antimicrobial activity against S. aureus, E. coli, and P. aeruginosa (Bah et al., 2016). The combination of enzymes thrombin and fibrinogen, registered under the trademark Fibrimex®, is used for binding meat pieces and for increasing the hardness and springiness of meat products (Toldrá et al., 2016). Gelatin, obtained from the hydrolysis of collagen, is widely used in the food industry for its gel-forming ability. It is also used as a clarifying agent, stabilizer, and protective coating material (Djagny et al., 2001; Gómez-Guillén et al., 2011). Protein hydrolysates are used as flavoring agents as well (Toldrá et al., 2016).

Considering that meat processing by-products have shown great nutritional and economic potential, discarding them is no longer practical (Toldrá et al., 2016).

Valorizing them for direct use in human food may be riddled with food safety challenges but they can add value in the form of functional ingredients. Next to human and animal food applications, animal processing by-products can be safely valorized through use in the production of cosmetics, chemicals, leather, biodiesel, among others (Toldrá et al., 2016).

2.5 Oil Seed Cakes and Meals

Soybean, rapeseed, and sunflower are the three most widely processed oil seeds in the EU (*FEDIOL Statistics*, 2019). After oil is extracted from seeds, the main by-products left behind are oil cake and meal. It is estimated that 32 million tons of these by-products are produced in the EU on an annual basis (*FEDIOL Statistics*, 2019). Given these large volumes, both by-products find a place in the REFRESH list.

Edible oil cakes are nutritionally valuable and can be used to supplement human diets through addition in bakery products, infant foods, and multipurpose supplements (Ancuța & Sonia, 2020). Depending on the raw material and processing conditions, they can contain between 45 and 65% protein (Arntfield, 2018; Gupta et al., 2019; Kowalski et al., 2020; Schweiggert-Weisz et al., 2020). As per the studies published by Arrutia (2020) and Arntfield (2018), using them as functional protein flours is relatively straightforward and highly sustainable (Arntfield, 2018; Arrutia et al., 2020). However, they are not widely used in food applications because they contain antinutritive compounds like phytic acid and polyphenols. Being a large and diverse group of compounds, polyphenols can be both, nutritionally valuable and detrimental. In the case of oilseed by-products, they form insoluble complexes with proteins and reduce bioavailability (Roos et al., 2013; Rozan et al., 1996). However, the polyphenol content in oil cakes and meals can be reduced by aqueous ethanol extraction which increases protein availability and improves flavors (Schweiggert-Weisz et al., 2020).

Next to direct use in food products, oilseed cakes and meals can be retained in the food supply chain by using them as substrates for the production of bioactive compounds, enzymes, vitamins, pigments, flavors, and amino acids (Ancuța & Sonia, 2020; Gupta et al., 2019). Oil cakes and meals contain phenolic acids, flavonoids and lignans in free, esterified or condensed forms (Ancuța & Sonia, 2020). These

compounds help in reducing oxidative stress and can therefore help in the prevention of various types of cancers (Ancuța & Sonia, 2020). They can be extracted by using solvents, high pressure, microwave, and supercritical fluid (Ancuța & Sonia, 2020). Cakes and meals also act as excellent substrates for growing mushrooms (Krupodorova & Barshteyn, 2015; Rozan et al., 1996; Schweiggert-Weisz et al., 2020). Soybean oil cake was found to be especially suitable for this purpose in a study conducted by Krupodorova, et al. (2015).

The safety of consuming oilseed cakes and meals has not been extensively studied yet. Oilseeds contain chemical compounds that aid in their growth and defense against insects and microorganisms. These compounds often end up in the by-products and can result in bottlenecks during valorization (Arntfield, 2018). While most of them present antinutritional properties, allergenicity remains a cause for concern for soybean and rapeseed by-products (Arntfield, 2018).

Although not extensive, there has been some research on the safety of using oilseed by-products as animal feed. Mycotoxins have been known to enter the human food chain through the use of contaminated oil cakes and meals in animal feed (Bhat & Reddy, 2017). Oil cakes and meals can get contaminated by toxigenic fungi during storage. Some pathogenic fungal strains that have been found belong to Aspergillus, Fusarium, Monascus, and Penicillium (Bhat & Reddy, 2017). These strains are all capable of producing mycotoxins such as aflatoxin B1, alternariol, fumonisin B1, ochratoxin A, T-toxin, and zearalenone (Bhat & Reddy, 2017; Garon et al., 2006). Next to contamination during storage, presence of fungi in the raw material can also lead to the formation of mycotoxins (Bhat & Reddy, 2017; Garon et al., 2006). Threat from mycotoxins in oilseeds and processing by-products are often not taken into consideration in food safety because the refining process which takes place at a high temperature (240 C for 6 h.) often destroys the fungal spores. Therefore, the oil obtained at the end of the process is free from fungi (Bhat & Reddy, 2017).

Like spent grains, oil cakes and meals are low-cost and nutritionally rich materials that are available in large quantities throughout the year. However, their antinutritional properties and tendency to get contaminated by fungi prevents these by-products from being directly utilized in food production. If oilseed cakes and meals are to be used

widely for human consumption, their mycotoxin contamination needs to be further investigated. Methods to efficiently remove antinutritional properties without damaging the flavor profile and desirable physico-chemical properties must also be developed. In the meanwhile, these products can be used in food application indirectly through use as a substrate and through the extraction of beneficial compounds.

3. Discussion

3.1 Valorisation for Animal Feed Versus Human Consumption

According to the food waste hierarchy, utilizing food and its by-products for human consumption takes precedence over conversion to animal feed (Papargyropoulou et al., 2014). In reality, this is not always feasible. Converting by-streams to animal feed is an attractive option because the safety and quality requirements for animal feed are often lower than those for human food. However, using the animal feed chain as a route to dispose of degraded or contaminated foodstuffs can have far-reaching consequences (Thieme & Makkar, 2017). For instance, Riet-Correa et al. (2013) highlight how feeding visibly mouldy potatoes and maize that have been declared unfit for human consumption to ruminants can lead to mycotoxicosis outbreaks. Mycotoxins are hard to eradicate and once they enter the food chain via meat and dairy products, they linger in it. Additionally, climate change is likely to present new challenges to controlling the proliferation of mycotoxin-producing fungi in Europe in the near future (Paterson & Lima, 2010).

Other chemical, biological, and physical hazards are also a source of concern while valorising food waste as feed. Most of these hazards are present in the food chain as well but proximity to consumers ensures higher accountability. Avenues to pivot by-streams that are currently used for animal feed to human consumption exist but must go through rigorous risk assessment before such products are made available to consumers. However, until then, conversion to animal feed will continue to be an important means to keep food processing by-streams within the food chain. The role of EU feed hygiene legislation, specifically Regulation (EC) No 183/2005, is crucial in ensuring that feed placed on the market is of an appropriate quality, is traceable, and is safe for animals and, by extension, humans.

3.2 Consumer Perspective

Despite the food industry's continued effort to move from a linear way of operating to a circular one, valorising by-products from waste streams on a large scale is possible only if consumers deem it a safe and acceptable practice. While European consumers are increasingly inclined toward more sustainable diets, food safety remains an important concern in the post-BSE era. Although the food supply is likely to be safer than ever before, food safety is the main concern for one in five European consumers when purchasing food (EFSA, 2019).

In recent years, consumer willingness to move toward a more sustainable food system has been studied quite extensively (Azzurra et al., 2019; Hartmann, 2011; von Meyer-Höfer et al., 2015; Yang et al., 2020). However, comprehensive studies focusing on willingness to consume products that include components derived from valorised food by-streams have been few. One study conducted as part of REFRESH looked into consumer perception of valorised food by-products and presented some preliminary findings on the topic (Djamel & Jose Maria, 2018). Results from the study show that while consumers are comfortable with the idea of reducing food waste via familiar methods such as gleaning, valorisation of processing by-products is perceived as less safe and trustworthy.

The same study indicated that consumers who feel a lack of connection with food producers, policymakers, and legislators also tend to have a lack of trust in the safety of food products made from valorised surplus and by-products. Additionally, results from the study indicate that sociodemographic characteristics may impact consumer willingness to purchase valorised foods. Women were found to be less likely to purchase food made using valorised by-products than men because women were more risk averse regarding food safety. Furthermore, older participants were found to be more accepting of valorised food, possibly because of richer life experiences in the context of food production and processing. The authors consider this an indication that time will play an important role in the adoption of novel valorisation methods.

Another study that examined the willingness of consumers to buy biscuits containing upcycled defatted sunflower oilcake flour concluded that information about nutritional and environmental benefits of these new foods play an important role in shaping consumer attitude (Asioli & Grasso, 2021). Indicating the health and environmental benefits of such products through labels could improve their chances of succeeding in the market (Coderoni & Perito, 2020).

Using ingredients derived from by-products of food processing in functional foods and nutraceuticals could be another path to successful valorisation. Several factors including higher consumer interest in the relationship between diet and health, increasing life expectancy, and the surge in healthcare cost drive the health food industry today (Siró et al., 2008). The European nutraceutical market was valued at $6.4 billion in 2013 and was set to grow at an annual rate of 7.2% between 2013 and 2018 (Siró et al., 2008).

However, it is also known that European consumers are more critical of new products and technologies compared to their counterparts in other developed countries such as the United States (Siró et al., 2008). Siró et al. (2008) hypothesize that Europeans' acceptance of functional foods is less unconditional and better thought-out as compared to consumers in the US. Van Trijp (2009). Van Trijp highlights that the European market for functional food is characterized by large regional differences when it comes to the use and acceptance of these foods; with Central and Northern European countries showing higher interest than Mediterranean countries. Bigliardi & Galati, (2013) indicate that several researchers in the field agree that functional foods have a generally positive image among consumers in Europe (Bigliardi & Galati, 2013). Therefore, it can be expected that European consumers that have previously shown interest in sustainably produced foods and foods that offer health benefits might be accepting of functional foods derived from food processing by-streams.

3.3 Legal Perspective

When by-products are used for food applications, businesses are required to follow the same safety standards that are applicable to regular foodstuffs. However, current food safety legislation does not sufficiently accommodate food processing by-

products. For in-stance, Commission Regulation (EC) No 1881/2006 setting maximum levels for certain contaminants in foodstuffs, does not cover by-products like pomace, peels, skins, spent grains, whey, or oilseed cakes, and meals. As a result, contaminants unique to these by-products are overlooked. When considering Commission Regulation (EC) No. 2073/2005 on microbiological criteria for foodstuffs, a similar observation can be made, with the exception of whey and certain animal by-products. Commission Regulation (EU) 2018/62 that lists foodstuffs to which maximum residue levels for pesticides apply does not mention by-products either. As such, food processing by-products currently do not find a place in any lists or annexes of the EU legislation defining safety criteria.

A way to bridge this gap could be through the adoption of private food safety standards that accommodate the specific requirements of food processing by-products. It is known that actors in the food supply chain often work with private food safety standards as a way to cope with regulatory uncertainty (Charlier & Valceschini, 2010; Rao et al., 2021). Other characteristics of these standards such as their proclivity for sustainability-related issues and their tendency to pre-empt the future adoption of public regulations might prove them to be a useful tool for food businesses that wish to valorize their by-products (Rao et al., 2021). This falls in line with REFRESH's recommendation to use voluntary agreements between actors in the food supply chain to tackle food waste. The advantage that private standards might have over voluntary agreements is that private standards are already widely used by the industry. Private food safety standards stand the chance to attract several businesses looking to make their operations more circular if they include risk assessments and safety criteria for by-products. If such standards become widely accepted among food businesses, it could impel legislators to expand the scope of current food safety legislation to include food processing by-products. This in turn would offer a safety net to food businesses looking to move towards a more circular way of operating.

4. Research Implications

All by-products discussed in this paper are unique in their composition and therefore present a diverse range of challenges for food businesses that wish to valorize them.

While there is no universal formula to determine whether safety, sustainability, and nutritional relevance can be ensured when valorizing a by-product, it is possible to consider each by-product on a case-by-case basis. Based on the findings and deliberations discussed in this paper, we propose a decision tree. As shown in Figure 2, this decision tree can assist practitioners and businesses in deciding whether a food processing by-product should be valorised and retained in the food supply chain. The decision tree assumes that sustainability, safety, and nutritional quality are equally important in the valorisation endeavour.

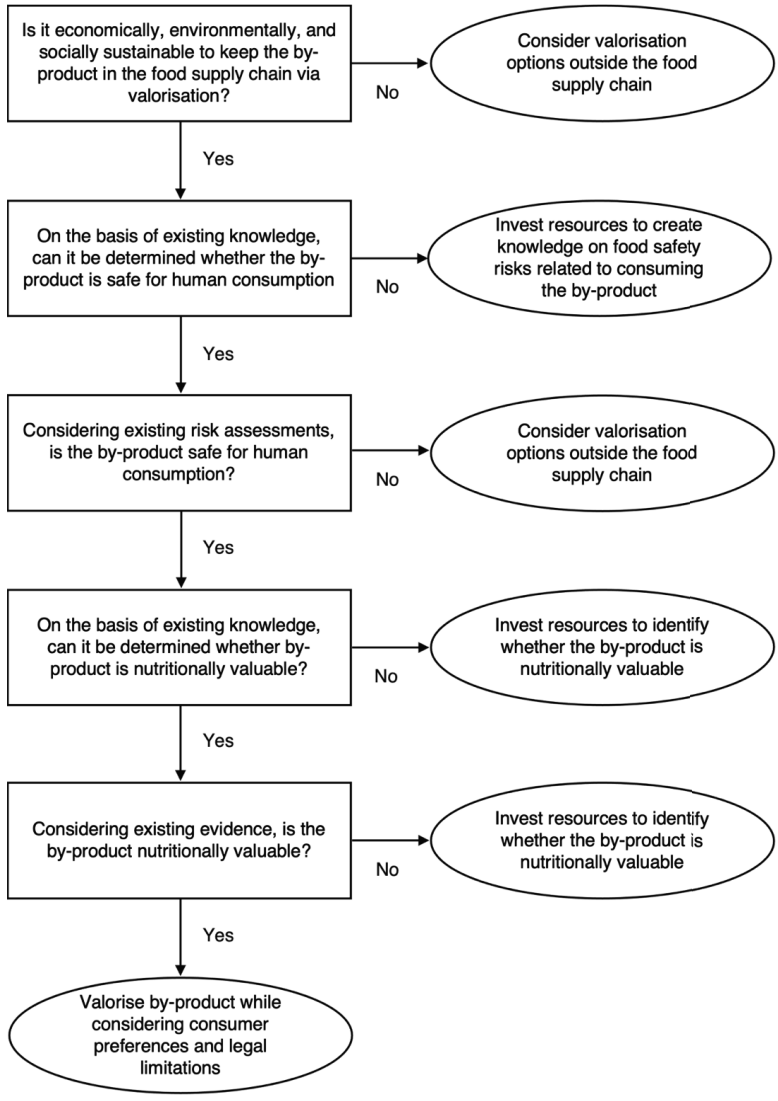

Figure 2 Decision tree supporting sustainable, safe, and nutritionally relevant valorisation of food processing by-products

The first step of the process requires businesses to identify whether it is sustainable to valorise the by-product. In line with the definition proposed by the United Nations Brundtland Commission in 1987, we consider sustainability as “meeting the needs of

the present without compromising the ability of future generations to meet their own needs" (United Nations, 2021).

Before considering next steps, businesses must identify whether valorising the by-product in question is an operation that can be carried out in the long term and whether its environmental, economic, and social outcomes are favourable. Depending on the context, various impact assessment models can be employed to identify whether valorising the product is sustainable or not.

Next, it is critical to examine whether the by-product, after further processing, is safe for human consumption. If this information is not existent, businesses must invest resources to create new knowledge on the topic. Lastly, valorising by-products and turning them into new food is justifiable only if they can add value to the human diet and do not negatively impact consumer health. It is important to note that decisions informed by this diagram must be considered in the context of several external variables specific to the by-product in question.

5. Conclusions

By analysing the existing knowledge on the topic through a conceptual lens, we suggest that it is possible to valorise food processing by-products while ensuring safety, high nutritional quality, and sustainability. Although well embedded in literature, it is important to further build upon the ideas discussed in this paper through empirical research. One way to do this could be by examining how food businesses practically experience the various bottlenecks mentioned in this paper and whether proposed solutions are practically feasible.

Despite this paper viewing food waste valorisation through a European lens, its results and discussion can be extrapolated to the global context. The EAT–Lancet Commission's report on food in the Anthropocene indicates that significant reduction in the amount of food lost and wasted throughout the food supply chain is essential if the global food system is to stay within its safe operating space (Willett et al., 2019). Innovative technological solutions and supporting public policies have a critical role to

play in achieving a reduction in food loss and waste (Willett et al., 2019). This philosophy is in line with the United Nations' Sustainable Development Goals, especially goal 12 focusing on responsible consumption and production.

In aspiring to decrease food waste while meeting stringent food safety requirements, the food industry must tread a tightrope. Achieving food production operations that are both sustainable and safe will require constant work to educate both consumers and food entrepreneurs (Kasza et al., 2019). It is also of vital importance for regulatory authorities, policymakers, and legislators to be open to new ideas and to react quickly to new developments. While working with closed loops of resources in the food industry may present several obstacles, valorising food processing by-products can offer improved food security, new sources of sustainable dietary proteins, and health-improving bioactive compounds.

In the EU, a fundamental requirement for putting food on the market is that it should be fit for human consumption and compliant with all food safety requirements. While the end goals of by-product valorisation and ensuring food safety might not seem congruent, finding a middle ground is key to the success of any valorisation endeavour. Private food safety standards willing to accommodate the special needs of such products could be key to achieving this middle ground. Keeping the food supply safe is an ongoing and dynamic undertaking. Being prepared to adapt to the demands of the changing times is the only way to make sure that the future of the food system is both safe and sustainable.

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Conflicts of Interest

The authors declare no conflict of interest.

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3

Let Them Eat Fish! – Exploring the Possibility of Utilising Unwanted Catch in Food Bank Parcels in The Netherlands

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Abstract

The Common Fisheries Policy of the European Union was reformed in 2013 with the aim of improving the sustainability of the fishing sector. The Landing Obligation, a cornerstone of this reform, requires fishers to land their unwanted catch instead of discarding it at sea. Existing literature pays little attention to what becomes of this unwanted catch once it is landed. To further the discourse on the sustainable valorisation of unwanted catch, this study explores whether unwanted catch that is safe for human consumption could be used for improving food security. The paper focuses on Dutch food banks, which deliver critical food aid to over 160,000 individuals yearly but struggle to provide all dependant recipients with nutritionally balanced food parcels. The research question is addressed in two ways. The food bank recipients' willingness to consume unwanted catch (UWC) is evaluated quantitatively through a survey. Next to this, data from interviews with relevant stakeholders are analysed qualitatively. Results indicate that the Food Bank Foundation and its recipients are willing to receive this fish if it is safe to consume and accessible. However, various factors such as existing infrastructure, lack of economic incentive to donate, competition from non-food and black markets, and the fishing industry's conflict with the landing obligation might pose barriers to this kind of valorisation. The dissonance between fisheries, food, and sustainability policies is discussed and identified as a key limiting factor. To bridge the differences between these policy areas, we propose public-private partnerships and voluntary agreements among involved stakeholders.

1. Introduction

As part of the 2013 Common Fisheries Policy (CFP) reform, the European Commission introduced a Landing Obligation (LO) which requires all catches of species subject to catch quotas and minimum conservation reference size to be landed and counted against quota (Regulation (EU) No 1380/2013). The objective of this requirement is to promote selective fishing and significantly reduce the incidence of unwanted catches (UWC). Despite implementing selective fishing strategies such as the use of specialised gear and locating species-specific hotspots, some untargeted fish are still likely to end up being caught and landed (Reid et al., 2019). Considering that fishers have traditionally discarded such fish at sea, routes to fully utilise the landed UWC are currently underdeveloped. The 2015–2019 implementation period for the LO saw the sector focus on negotiating requirements and engineering ways to fish more selectively. However, little attention was paid to developing sustainable ways to utilise UWC that would be landed as a consequence of the LO.

Next to conserving marine biological resources, reducing waste was a key incentive in bringing about this reform (Karp et al., 2019). When UWC with low survival rate is discarded at sea, it contributes neither to the health of the fish stock nor towards meeting the dietary needs of the growing population. Therefore, the practice of discarding UWC at sea can be seen as wasteful and undesirable (Karp et al., 2019). However, not utilising this UWC once it is landed is as wasteful and undesirable, if not more. Given that meeting current and future protein needs of the population is a significant challenge for the food system (Henchion et al., 2017), not making appropriate use of the landed UWC to supplement the human diet when feasible is a missed opportunity. This is true also for developed countries like the Netherlands, where over 1 million people out of the 17.4 million population are known to be part of low-income households (Centraal Bureau voor de Statistiek, 2020). Of these, several individuals require social assistance to procure sufficient food (Centraal Bureau voor de Statistiek, 2020). The national Food Bank Foundation, Voedselbanken Nederland, aids these individuals by providing weekly food parcels through its network of 171 food banks (Voedselbanken Nederland, 2020). Based on existing literature, it is known that Dutch food banks, like their counterparts around the world, struggle to provide recipients with nutritionally balanced parcels (Bazerghi et al., 2016; Neter et al., 2018).

In the Netherlands, fish and fruit are particularly scarce in food bank parcels (Neter et al., 2018). Neter et al. (2018) found that 99% of the food bank recipients did not consume fish in amounts considered sufficient by the national dietary guidelines. This issue cannot be ignored, as the number of food bank recipients continues to grow (Voedselbanken Nederland, 2020). Although it is known that there is a lack of fish in food bank parcels, no previous studies have enquired as to whether food bank recipients are keen on consuming more fish if it is made available to them. Our study provides a first foray into this topic.

Together, the issues of UWC underutilisation and fish deficiency in food bank parcels concern several of the United Nations Sustainable Development Goals (UN SDGs), such as goal 2-zero hunger, goal 3-good health and well-being, goal 12-responsible consumption and production, and goal 14-life below water. The goals stand for eliminating hunger and food insecurity, ensuring a healthy life, making consumption and production more sustainable, and ensuring the sustainable use of marine resources. The SDGs give UN Member States, including the Netherlands, a blueprint for a more sustainable future. Although many actions have already been taken, most Member States are not on track to reach the goals by 2030 (Eurostat, 2021). By sustainably utilising UWC and increasing the protein content of food bank parcels, the Netherlands would come closer to realising the SDGs. However, with existing EU policies, market conditions, and stakeholder relations, addressing the issue is not straightforward, and may require several large-scale changes.

Currently under the LO, UWC that is under the minimum conservation reference size (MRCS) cannot be sold for direct human consumption in the EU. Instead, it ends up as pet food, fish meal, or other products. According to Cashion et al. (2017), on a global scale, as much as 90% of fish which are safe for human consumption end up being used for fishmeal, fish oil, and other non-food applications. This does not align with the food waste hierarchy developed by (Papargyropoulou et al. (2014), which states that before recycling food into animal feed, redistribution for human consumption must be considered, if feasible. Iñarra et al. (2019) have adapted the hierarchy specifically for fish waste management, starting again with (1) prevention and reduction, and continuing to (2) human consumption, (3) bio-products, (4) animal feed, (5) industrial uses, (6) production of energy, (7) agronomic purposes and finally,

(8) disposal. In line with this, the LO promotes prevention and reduction of fish waste as a top priority. However, it forfeits the second step in the hierarchy to avoid creating a market for <MRCS fish. In the case of UWC > MRCS, the LO allows for the fish to be utilised for human consumption. Since substantial efforts to create a market for these fish have not been undertaken, any landed UWC that does not have a high market value as a food product is likely to be used for animal feed production, non-food applications, or even disposed of.

At the time of writing this paper, literature on the successful utilisation of UWC in Europe was found to be scarce. This is not surprising considering that the LO was implemented only recently and the issue of UWC valorisation is rather new. DiscardLess, an EU Horizon2020 project with a focus on reducing fishing discards in the region, collated information about some ongoing initiatives. A 2019 report from the project indicated that unavoidable UWC in parts of Denmark is either discarded after landing or sold to fish meal or fish oil producers (Larsen et al., 2019). In the Netherlands and Germany, the pet food industry is the largest buyer of UWC. In Boulogne-Sur-Mer, the biggest harbour in France, UWC was largely found to be sold to a local company that specialises in the production of cosmetics, health products, and fish meal. Pescanova, the biggest fishing company in Spain, was reported to be selling UWC outside of the EU (Larsen et al., 2019). Some pilot projects focusing on valorising UWC for human consumption were found in the literature as well. Two studies from Spain showed the successful valorisation of UWC into fish mince products such as fish finger and burger patties (Blanco et al., 2018; Iñarra et al., 2019). A project based in northern Finland was also reported to be able to set up a fish mincing facility to utilise UWC for human consumption ("*Minced Fish from Unwanted By-Catch"*, 2019). No literature focusing on utilising UWC for food charities in Europe could be found.

The idea of donating UWC to food banks, however, is not entirely novel. SeaShare is a US-based organisation that enables the donation of similar type of UWC to hunger relief organisations. SeaShare, as described by Watson et al. (2020), partly relies on what the US legislation calls a prohibited species donation (PSD) programme (Watson et al., 2020). During its pilot run in 1993, the PSD program authorised the donation of salmon that was classified as prohibited species in order to prevent valuable fish

protein from leaving the food supply chain (Watson et al., 2020). Later in 1996, Amendments 26 and 29 to the Fishery Management Plans for Groundfish in the North Pacific (61 FR 38358) allowed a full-fledged programme to be established (Watson et al., 2020). SeaShare, which is a non-profit organisation, supported the PSD programme by taking on the logistical and financial burden of processing and distributing this fish (Watson et al., 2020). While this Prohibited Species Donation Program serves as inspiration for what could be done in the Netherlands, due to the differences in intra-industrial relationships, as well as in fishing-related laws and regulations in the US and EU, the possibilities within the Netherlands warrant a separate evaluation.

Therefore, this study explores the possibility of including more fish in Dutch food bank parcels by utilising UWC. It does this by assessing whether food bank recipients would be interested in such fish. This is followed by an analysis of relevant stakeholders' views on valorising UWC in this manner.

2. Methods

2.1 Study Design

This mixed methods study was designed to investigate the possibility of utilising unwanted catch in Dutch food bank parcels from two perspectives. The first perspective focuses on whether food bank recipients are interested in receiving more fish in their parcels and if they are keen on consuming UWC. It was important to ascertain this because without an interest from the food bank recipients, further investigations would not be justified. Therefore, to understand whether food bank recipients want more fish in their parcels and whether they are willing to eat UWC, a quantitative approach was deemed appropriate. The goal with this approach was to survey the terrain before proceeding with further data collection. A detailed description of the method employed is provided in Section 2.2.

The second perspective looks at the fisheries supply chain and seeks to identify whether it is economically, logistically, and legally possible to utilise UWC in this manner. To answer this question, it was necessary to gather insights from stakeholders and experts working directly with this supply chain. A qualitative

approach using semi-structured interviews was seen as the best fit for collecting and analysing such data since it seeks to contribute to an improved understanding of social realities (Flick et al., 2004). It does this by drawing attention to processes, meanings, patterns, and structural features (Flick et al., 2004). The purpose this perspective serves is to mine the surveyed terrain. A detailed description of the method employed is provided in Section 2.3.

2.2 Questionnaires – Statistical Analysis

Questionnaires were used to determine whether there was a demand for more fish in the food banks and if food bank recipients were willing to consume UWC. Printed questionnaires were distributed to the recipients of Food Bank Venlo during May and June 2021. Two hundred and ninety-eight paper questionnaires were packed in individual envelopes and were transported to the food bank for distribution. In the food bank, volunteers placed the envelopes in the recipients' food parcels.

Food bank recipients had two weeks to participate in the research and involvement was entirely voluntary. The self-administered questionnaires were in Dutch and consisted of six questions, five of which were multiple-choice. The questions were asked in the following order: (1) age, (2) gender, (3) food bank visits per month, (4) frequency of receiving fish from the food bank, (5) willingness to receive more fish, and (6) willingness to eat UWC. The term UWC was explained to the participants in the introduction and repeated in question 6. The first two questions were asked to determine whether the demographic of the sample matched with that of food bank recipients from across the country. This data was also collected to examine whether age and gender were associated with desire for more fish and willingness to consume UWC. The third and fourth questions were asked for the purpose of determining whether the frequency of visiting the food bank was associated with the quantity of fish received. Finally, respondents were asked if they would be willing to eat UWC. The definition of UWC was provided along with this question but description of the fish (species, size, state) was not included. This was done in order to understand whether respondents' interest in fish was associated with the fish's status as UWC solely. The number of questions were limited so as to require as little of the respondents' time as possible. The food bank recipients could either return the filled-in questionnaires

during their next visit to the food bank or scan a QR-code for the online version created with Qualtrics. Returned paper questionnaires were collected from the food bank and online responses were retrieved from Qualtrics. The relationship between gender and willingness to consume UWC and age and willingness to consume UWC were tested using a chi-square test of independence.

2.3 Interviews

Qualitative data were collected through in-depth semi-structured interviews with experts working with the Dutch Food Bank Foundation and the fisheries sector. The theoretical sampling strategy of Glaser & Strauss (1967) was used to create a suitable sample (Glaser & Strauss, 1967). This strategy entails collecting, coding, and analysing data simultaneously to inform decisions regarding what data to collect next and where to find them. In this approach, data collection, analysis and theory emergence take place in a parallel manner (Glaser & Strauss, 1967). All participants were contacted via email with a brief explanation about the purpose of the study and the relevance of their participation. Ten participants were interviewed, following which recruitment was stopped because data from the interviews were no longer contributing to the further development of existing codes. This phenomenon is described by Glaser & Strauss (1967) as theoretical saturation and marks the end of data collection (Glaser & Strauss, 1967). Table 1 provides an overview of the participants' profiles and expertise. The interviews were conducted in English and lasted for 45 to 75 min. With the participants' consent, interviews were recorded and transcribed verbatim. All participants were invited to review their interview transcripts for any inaccuracies.

As described above, the process of analysing the transcripts to identify recurring themes and ideas took place continually alongside data collection. Relevant phrases, sentences, or even entire sections were coded inductively using the in vivo technique described by Saldana (2021). At the end of the first coding cycle, 30 codes were identified. In the next round, codes that were related to each other were grouped together into 11 categories. Subsequently, the 11 categories were further grouped together into four themes informed by the analysed data as well as previously read literature on the topic.

Table 1 Overview of participants and their expertise

Participant	Expertise	Description
P1	Supply chain	Procurement and supply chain specialist connected with the Netherlands Foodbank Association.
P2	Market research	Market researcher connected with the Netherlands Foodbank Association.
P3	Food safety	Food safety specialist connected with the Netherlands Foodbank Association.
P4	Marine ecology	Research scientist based in the US, specialising in quantitative marine ecology.
P5	Marine ecology	Research scientist based in the US, specialising in marine conservation ecology.
P6	Fisheries governance	Independent consultant having extensive experience with NGOs focused on sustainable fishing.
P7	Fisheries governance	Project manager for sustainable fisheries governance programmes in the Netherlands.
P8	Fish trading and processing	Commercial head for a fish trading and processing business in the Netherlands.
P9	Fish trading and management	Director for a national fish auction in the Netherlands.
P10	Fisheries political affairs	Director for various association advocating for the interests of fishers in the Netherlands.

ATLAS.ti version 8.4 was used for all rounds of coding. The first and third authors undertook data analysis independently following the method described above and later compared and consolidated their findings. As an additional validation strategy, the last author oversaw the comparison and merging of the two independent analyses. Wherever necessary, excerpts, quoted verbatim unless modified to improve readability or to ensure anonymity, have been used in Section 3 to underpin the findings.

2.4 Ethical Considerations

Food bank recipients received the questionnaires as part of their regular food parcels. They were informed in writing about the aim of the study and that filling out and returning the questionnaires was voluntary. This approach was chosen over the researchers personally handing out questionnaires to ensure complete anonymity and so that the food bank recipients would experience no discomfort or pressure. Each envelope contained a piece of candy as acknowledgment for participation.

All participants who were interviewed were informed about the aim of the study, data storage, and privacy. Participants were given the opportunity to ask questions about these topics. They were informed that they could choose not to answer any questions asked by the researchers and to stop the interview at any given point. All participants gave their written informed consent.

3. Results

3.1. Demand and Supply

3.1.1 Demand for More Fish in Food Bank Parcels

Out of the 298 distributed questionnaires, 46% were returned, and the total number of responses was 138. Gender representation was evenly split with 69 female and 68 male participants. One participant did not report their gender. The age distribution ranged from 21 to 76 years old, and the respondents' mean age was found to be 45

years, with a standard deviation of 12 years. Thirteen individuals did not report their age. It was found that the study sample's demographic closely matches that of food bank recipients throughout the country (Voedselbanken Nederland, 2020).

Out of the 138 respondents, 61 reported never receiving fish in their food parcels and 52 reported receiving fish once a month. The rest of the respondents reported receiving fish more often. However, visiting the food bank more frequently did not increase the quantity of fish received. Of the 72.5% of respondents who visited the food bank once per week, 38% reported that they received fish once per month. Of those who reported visiting more frequently, 37% reported receiving fish once per month.

Regarding food bank recipients' willingness to eat more fish, 106 (72.5%) respondents indicated that they wanted more fish in their diet. Of these, 98% were willing to eat UWC. Results indicate that 81% of the female respondents wanted more fish in their diet, while 72% of the male respondents reported the same. This difference between genders with regard to desire for more fish is in line with the larger Dutch population, where women were observed to consume fish more frequently than men (van Rossum et al., 2016). However, with regard to UWC, results from the chi-square test indicated that the relationship between gender and willingness to consume UWC was not significant at baseline ($X2$ (2, N = 136) = 4.28, $p = 0.117$). Thus, female participants were not less or more likely than male participants to not be willing to eat UWC. Similarly, age did not show a significant association with willingness to consume UWC ($X2$ (4, N = 124) = 1.22, $p = 0.881$). None of the age groups in the sample were therefore more willing to consume UWC than others. This contradicts previous studies which indicate older consumers to be more accepting of food that is traditionally seen as surplus or waste (Djamel & Jose Maria, 2018; Henchion et al., 2017). However, the oldest age group (50–76) is underrepresented in our sample as compared to the national food bank recipient population, and different results are possible if more individuals in the age group were to be included in the study. Tables 2 and 3 provide an overview of gender in relation to willingness to consume UWC and age in relation to willingness to consume UWC. Missing data were not included while computing the chi-square test.

Table 2 Gender in relation to the willingness to consume UWC

	Total number of participants (% by gender)	Willing* (% m/f)	Not willing* (% m/f)	Unsure* (%m/f)	Missing values	p-value
Gender						.117
Male	68 (49.3%)	52 (47.7%)	10 (76.9%)	6 (42.9%)		
Female	69 (50.0%)	57 (52.3%)	3 (23.1%)	8 (57.1%)	1	
Missing	1	1	0	0		

Table 3 Age groups in relation to the willingness to consume UWC

	Total number of participants (% by age group)	Willing* (% by age groups)	Not willing* (% by age groups)	Unsure* (% by age groups)	Missing values	p-value
Age group						.882
18 - 29	15 (10.9%)	12 (12.1%)	2 (16.7%)	1 (7.1%)		
30 - 49	67 (48.5%)	53 (53.5%)	7 (58.3%)	7 (50.0%)		
50 - 76	43 (31.2%)	34 (34.3%)	3 (25.0%)	6 (42.9%)		
Missing	13	11	1	0	1	

** = Reported willingness to consume UWC*

The board of the Food Bank Foundation seems to be aware of the lack of fish in the parcels. During the interviews, relevant participants acknowledged that food parcels rarely contained fish. It was mentioned that several food bank recipients could not consume various meats for religious reasons. Therefore, as per interviewees, adding more fish to the parcels would be seen as favourable by the recipients because it would improve the nutritional content of the parcels and religious or social restrictions would not apply. It was mentioned that the Food Bank Foundation was already working to identify actors in the fish supply chain who were willing to donate their surplus fish.

3..1.2 Availability of Edible UWC in The Netherlands

From the results presented above, it is evident that the Food Bank Foundation and its recipients are interested in UWC. However, our inquiry regarding the availability of edible UWC did not yield as concordant a response. Neither the interviewed study participants nor existing literature could provide definitive information regarding how much edible UWC was available or discarded in the Netherlands. One of the interviewees was reliably informed that up to half of the demersal (groundfish) catch was unwanted. Other interviewees working with the fishing industry were also aware that a large quantity of fish was caught unintentionally by demersal fleets but did not provide an estimate regarding the numbers. In 2018, Stichting De Noordzee, a Dutch non-profit organisation focused on sustainability in the North Sea, reported that the Dutch demersal fisheries discarded more than 70,000 tons of fish at sea every year (Stichting De Noordzee, 2018). The Common Dab and the European Plaice were reported to be the most discarded fish (Stichting De Noordzee, 2018). The same article mentions that the LO could help reduce these numbers by stimulating the fishing industry to engineer creative ways to avoid UWC instead of landing it (Stichting De Noordzee, 2018). The article, however, does not mention what happens to this UWC when it is landed.

Based on the data collected from our interviews, it appears that UWC which is landed has three possible destinations. UWC that has demand as food for human consumption enters the food supply chain through mainstream fish auctions. UWC that does not have market value as food, including <MCRS catch that cannot be used for human consumption as per Regulation (EU) No 1380/2013, is sold for other applications such as animal feed, pet food, fish oil, food additives, pharmaceuticals, and cosmetics. Lastly, unwanted catch that has no demand at all or cannot be used due to reasons such as spoilage or damage is discarded. Finding uses for all of the landed UWC is anticipated to be one of the most challenging impacts of the landing obligation (Hedley et al., 2015). There are some existing market opportunities for these fish, but as reported by Hedley et al. (2015), it is clear that new markets will need to be developed if the incoming stream of UWC is to be fully utilised

If the food waste hierarchy is to be applied in this context, safe to consume UWC should stay in the human food supply chain to ensure sustainable utilisation (Papargyropoulou et al., 2014). Donating part of the UWC to the food banks could be a way to do this without creating a market for these fish. However, there are several economic barriers to this, as further discussed in Section 3.2. When asked whether it would be feasible to use UWC < MCRS in food bank parcels, none of the interviewees working with the fisheries responded enthusiastically. Some interviewees believed that if the <MCRS fish were to be utilised for human consumption, it would take away the fishing industry's incentive to fish more selectively. Most interviewees did not think that the situation in the Netherlands was unfavourable. P10 described it as: "The fishermen sell all their fish at the auction—target species as well as non-target species. All the fish which is marketable is being sold. There is no fish which is not being sold". This excludes under MCRS catch, but interviewees did not seem to view this fish as food. This can be extended to UWC without a market value in general.

Those working on the ground might have a different perspective on the issue. In a paper published by de Vos et al. (2016), all Dutch fishers interviewed for the study expressed their aversion of being obliged to land < MCRS catch due to reasons related to principle, profitability, and environmental protection. An episode of the Dutch television show Keuringsdienst van Waarde that documented this issue also indicated that fishers saw this legislative requirement as unreasonable, wasteful, and unsustainable (*Keuringsdienst van Waarde*, 2018). However, this does not imply that the fishers would be willing to donate this fish. As per results from Maynou et al., (2018), European fishers saw donating UWC as the least favourable valorisation route. In comparison, other stakeholders like NGOs, researchers, and industry representatives expressed moderate interest. The same study compared the opinions of stakeholders by fishing regions. Stakeholders involved in North Sea fisheries considered charity to be the least favourable option (Maynou et al., 2018).

In the US, a programme that facilitates the donation of UWC that cannot be used for any other purposes has been successfully established. P4, who studied the impact of this programme, emphasized the importance of stakeholder cooperation, community support, and goodwill in establishing it. Based on the responses of participants working with the Dutch fisheries, the fishing sector in the Netherlands does not seem to have

any prior experience with working with food banks. As a result, cooperation or goodwill cannot be expected from stakeholders yet. NGOs or civil society organisations could play a role in brokering such an understanding between the food banks and the fishing sector. However, based on interviewees' responses, the fisheries in the Netherlands do not currently share a cordial relationship with such organisations.

Several interviewees working with the fishing industry believed that the Food Bank Foundation should try to procure fish from a later stage of the supply chain as opposed to the pre-auction and auction stages. Frozen fish close to its expiration date, procured from various stages of the supply chain was suggested as a possible option. However, given that this study focuses on UWC, this option will not be explored further.

3.2 Economic Feasibility

3.2.1. Paying for Unwanted Catch

Bringing UWC that is currently used for non-food applications back into the food supply chain is a sustainable way of utilising such fish. Donating it to the food bank is an attractive way to do this from the perspectives of food security and public health, but it raises concerns regarding economic viability. The food banks in the Netherlands do not pay for procuring food. Next to providing food aid, the Food Bank Foundation aims to reduce food waste by utilising surplus food that would have ended up as waste otherwise (Voedselbank Nederland, n.d.). Therefore, it relies on food businesses seeing the merit of donating their surplus. In this case, however, fishers may not see the need to donate their UWC because it can be sold to other destinations and used for other purposes, such as animal feed or pet food. Income from such sale itself is unlikely to offset the costs incurred from keeping UWC on board (Buisman et al., 2013). However, donating UWC instead would further reduce profits. Interviewees working with the fishing industry expressed their understanding regarding donation being the more sustainable option but also regarded it as an unlikely scenario due to its impact on profits. Considering that implementing the LO is likely to cost demersal cutter fleets between EUR 5.6 and 12.3 million in transition costs (Buisman et al., 2013), the sector's worries regarding profits and economic viability are well founded.

Additionally, the market value of UWC is dynamic. One of the interviewees described the example of the octopus to demonstrate this: “Five years ago, octopus was a low-value side catch. It was sold at 2 euros per kilogram. But these days, it has a value of around 18 euros per kilogram. Nowadays, we see that the demand for fish is healthy and even the side-catch is expensive”. In hopes of receiving a higher price for their UWC in the future, fishers may not want to donate their UWC to the food bank and classify it as low value fish.

When asked whether paying a small amount of money for procuring UWC was something the Food Bank Foundation would consider, interviewees working with the food banks conveyed that this would not be feasible. Interviewees indicated that over the last years, the food banks’ supply has decreased while the number of people signing up to receive food aid has increased. Additionally, they believed that if the foundation started paying for one category of products, all their procurement partners would expect to be paid.

3.2.2. Processing Costs

Economic barriers to donating UWC do not end at the procurement stage. If we were to consider the hypothetical scenario of fishers being willing to donate their low value UWC to the food banks, processing costs would still be a concern. Processing the fish would be necessary because providing whole, unprocessed fish to the food bank recipients might lead to them wasting it as a result of not knowing how to handle it. A cross-cultural study by Olsen et al. (2007) found the Dutch population to have the least positive outlook towards preparing fish at home compared to the other four European countries considered in the sample. Given that the food bank recipients are known to consume particularly low quantities of fish (Neter et al., 2018), interviewees working with the food bank agreed that it would be important to introduce UWC in an accessible manner. Therefore, processing costs must be taken into consideration. This challenge might be easier to overcome than paying for procuring fish. Although the Food Bank Foundation does not spend on procuring food, interviewees stated that it is willing to do so for setting up infrastructure to process the food that it procures. Currently, food banks source most of their products from the retail stage of the supply chain. However,

P1 mentioned that the board was looking to procure at least a part of its supply from earlier stages of the supply chain because the retail sector was becoming increasingly efficient at managing its surplus. Procuring from earlier stages of the supply chain would entail some degree of processing and as per the information provided by relevant participants, the board of the Food Bank Foundation is looking into the possibility of creating a separate foundation that handles the procurement and processing of such food. However, processes such as filleting fish are highly specialised and relatively expensive. It is therefore important to undertake a thorough cost-benefit analysis before investing in such facilities. It is important to note, however, that utilising fishing by-products is not completely new to the fishing industry. Operations to valorise fish by-products including cutting, boiling, drying, and ensiling exist across European harbours but limited attempts to introduce UWC in existing manufacturing operations have been made (Iñarra et al., 2019; Maynou et al., 2018).

If UWC < MCRS is to be utilised in food bank parcels, processing costs might be an important factor to consider given the small size and bony structure of such fish. However, interviewees working with the Dutch fishing industry were far less willing to discuss the possibility of donating under MCRS catch to the food banks. Some interviewees mentioned that utilising < MCRS catch in other sustainable ways was not economically viable either. Regarding such trials, they elaborated: “Fishers are not allowed to sell certain unwanted catch for human consumption, so it must go for products like pet food, fish meal, and fish oil. For demersal species, this is just not economically viable. We did look at whether you could extract high level proteins or turn it into fish oil instead of using it for pet food for instance. But the problem is that they would have to treat the unwanted catch in accordance with the same quality standards they use for their commercial fish. That is impossible”.

Upon enquiring if they considered this fish to be safe for consumption, all answered favourably. However, they stated the LO requirement to not use this fish for human consumption as the restricting factor. When we enquired about the same issue but in a hypothetical situation where the LO allowed the donation of UWC < MCRS to the food bank, interviewees began to propose other profitable ways of utilising this fish. Another hypothetical scenario suggested by the researchers focused on the government providing monetary compensation to fishers for donating UWC or UWC <

MCRS to the food banks. This option was not seen as favourable due to the possibility of it turning into a perverse incentive. However, targeted benefits such as tax deductions or subsidies related to sustainability were viewed more favourably. In the US context, P4 described similar incentives to have worked positively for the fish donation programme.

3.2.3. Competition from Non-Food and Black Markets

UWC that does not have a high market value as food is redirected to animal feed, pet food, or other technical uses. These supply chains are well established in the Netherlands and would therefore pose as a barrier to entry for the food bank. Some interviewee responses indicated that selling UWC for non-food applications is not favoured by the fishers but given that they are able to recover a part of their costs through these transactions, they cannot refuse them. Despite not bringing in as much value as the food supply chain, non-food chains are important to the fishing industry. For instance, several participants mentioned that the recent shutting down of Dutch mink farms had negatively impacted the fishing industry because mink farmers no longer purchased fish as food for their minks. One participant expressed the situation as follows: “Feed producers pay maybe seven to eight cents per kilo of this fish and that is not the best way to bring these proteins back into the chain. Seven cents do not make the fishers happy anyway. One cent more than the feed producers and they would rather give it to the food bank”. However, as discussed above, the Food Bank Foundation is unwilling to pay for procuring this fish. Selling UWC to fish meal and oil producers is also seen as more advantageous than donating it to charity because these well-established supply chains are known to be able to cope with uncertainties like fluctuations in composition and quality (Maynou et al., 2018). Fish meal is also likely to be seen as an economically advantageous choice because Europe is a net importer of fish for non-food use (EUMOFA, 2020).

Some interviewees mentioned that the existence of black markets for under MCRS catch might pose as a barrier for donating it to the food banks. It was suggested that legalising the use of UWC < MCRS in food banks may help these shadow markets proliferate and make it more challenging for national authorities to implement the LO. One of the participants stated, “if a fishing vessel is found with undersized fish being

stored in a frozen state for sale as food, the fisherman could simply say that it is all for the food bank and then sell it illegally". Bellido et al. (2017) discuss this in the context of the Mediterranean region wherein they note that implementing the LO may lead to the expansion of illegal markets for fish below the minimum size. However, this is discussed in the context of simply keeping the fish onboard to land it and not donating it to food banks.

3.3 Logistics and Infrastructure

3.3.1. Fishing Industry's Perspective

Prior to the LO being implemented, fishers were able to select what fish to keep on board and what to discard or release at sea. As a result, fishing vessels have been designed to accommodate catch that can be brought ashore and sold at an attractive price (Viðarsson et al., 2019). Interviewees mentioned that vessel infrastructure and labour costs would be a cause for concern if fishers were expected to treat UWC in the same way they did regular catch. If UWC is to be used by the food banks, a high level of food safety will have to be ensured by applying standard bleeding, cleaning, sorting, and cold storage procedures. This, in turn, will require labour, space, and machine capacity on board. Without any monetary returns, fishers are unlikely to be willing to undertake these tasks. Even in the current situation where UWC can be sold at a low price for non-food purposes, fishers are not in favour of processing and accommodating this fish onboard (Viðarsson et al., 2019).

When it comes to infrastructure related investments, interviewees working with the fishing industry in the Netherlands stated that the sector is heavily focused on developing fishing gear that will enable more selective fishing, thereby eliminating UWC. Based on interviewee responses, developing vessel capacity to handle UWC can be seen as a contradiction to improving fishing gear and, as a result, fishers might be unwilling to invest in it. The work of Viðarsson et al. (2019) confirms that vessel owners are reluctant to invest in technology to process and preserve UWC onboard. The same paper suggests silage production from <MCRS catches onboard the vessels. This silage could be used for producing fish meal for animal feed and other uses but render it unusable for food bank use.

It was not possible to access information regarding how UWC is currently handled aboard Dutch vessels. Generally, the main challenges for onboard management are associated with catches under MCRS. (Viðarsson et al., 2019). UWC > MCRS is often destined for human consumption and can therefore be managed as per the traditional onboard handling processes.

3.3.2. Food Donation Logistics

If we were to assume that the fishing industry is willing to cooperate with the food banks for the donation of UWC < MCRS, the Food Bank Foundation would need to invest in suitable logistics and infrastructure to be able to use this fish. Although fish is rarely provided in food bank parcels, the cold chain for frozen meat products is already established. As per relevant interviewees, the Food Bank Foundation would need to expand its current cold storage and transportation facilities if it was to receive more fish. This investment was seen as viable if a regular flow of processed, ready-to-cook fish could be ensured. However, given that the fishing industry's objective is to fish more selectively and reduce UWC, ensuring a steady flow of fish for the food bank could be challenging. Considering these uncertainties, it would be seen as risky for the Food Bank Foundation to invest in expanding its cold chain specifically for fish. A possible solution to this could be renting such logistics facilities. As per the information provided by interviewees, the Food Bank Foundation already rents such a warehouse to manage its current flow of frozen products.

Regarding food safety, relevant interviewees were confident about the volunteers being able to handle fish if the food banks were to receive it processed and then frozen. The food banks work with an in-house private standard for food safety which already includes provisions for handling fish. Therefore, it can be expected that ensuring the safety of UWC in food bank parcels is feasible if it is handed over to the food banks in good condition.

Dutch food banks are likely to be able to incorporate more fish in its inventory more easily compared to the US fish donation programme described by P4 and P5. The programme described by them is based in Alaska and required significant

infrastructural investment to make it operational. The Dutch food banks, in comparison, have a well-established system for procuring, transporting, storing, and redistributing surplus food, including products that need cold storge facilities. However, based on interviewee responses, the fishing industry may not feel confident about food banks' capacity to handle UWC. One of the interviewees described that the industry itself engages in charitable acts but the food banks may not be able to replicate this: "Sometimes fishers donate fish for social causes. One or two times a year, they participate in a project for homeless people in Rotterdam where they donate fish, fry it, and give it to the homeless people. But if you want to incorporate fresh fish into the parcels of the food banks, that's going to cause a bit of a logistical problem because the food banks are absolutely not equipped to handle whole fish that is not processed".

3.4. Fisheries Policy and Legislation

The Common Fisheries Policy and the Landing Obligation and their impact on UWC valorisation came up as a prominent theme in our analysis. The LO, and by extension the CFP, share a rather paradoxical relationship with the research question this study seeks to answer. The possibility of donating UWC to the food banks arises largely because fishers are now obliged to land fish that they unintentionally catch. Prior to the implementation of Regulation (EU) No 1380/2013, fishers could simply discard UWC at sea. It is only due to the Landing Obligation that this fish will need to be brought ashore, thus giving rise to surplus fish that needs to be utilised. At the same time, the LO also creates barriers for donating this fish to the food banks.

Firstly, the fishing industry's discontentment towards the LO may negatively impact its willingness to donate UWC. One of the interviewees working in close cooperation with the fishers described the LO as following: "This landing obligation is not workable. It's not doable. It's not enforceable. We need to turn away from this non-workable regulation and move towards a workable regulation. But everyone is so politicised. And everybody is so concerned with the issue of discarding at sea. Nobody on the policy side wants to give in". This sentiment of the fishing industry towards the LO has been discussed in existing literature as well (de Vos et al., 2016; Kraan & Verweij, 2020; Pastoors et al., 2014; van Hoof et al., 2019). To prepare for the implementation of the LO, the Dutch government launched a working group (werkgroep Aanlandplicht)

in autumn 2012 (van Hoof et al., 2019). Scientists, NGOs, industry representatives, and civil servants from the ministry and the control agency were invited to be part of this working group (Pastoors et al., 2014). However, the Dutch fishing industry reacted negatively to the possibility of having to land UWC and refused to participate in the working group (Pastoors et al., 2014). Based on interviewee responses, it is evident that the fishing industry continues to hope that legislators will take the fishers' dissatisfaction into consideration and repeal the requirement to land UWC. Establishing a system where UWC is donated to the food banks might create dependency on landing UWC and therefore make it difficult to reverse LO. Regarding the push to make amends to the LO, an interviewee working on fisheries governance in the Netherlands elaborated: "There is a strong call to re-evaluate the landing obligation. Everybody in the industry says it's not working. They say it's actually contributing more to illegal fisheries. The fishers are so worried about fisheries being closed and therefore, about their survival. We are very lucky to still be allowed to go on board and see the actual catch composition for research. But we also know from colleagues in other countries that fishermen tell them: 'Sorry, we cannot take you anymore, because you would see that we are actually discarding unwanted fish at sea'".

Secondly, the restriction on using UWC < MCRS for human consumption impedes the possibility to donate this fish. Interviewees frequently stated that donating < MCRS fish to the food banks would not be possible because (Article 15(11) of) Regulation (EU) No 1380/2013 does not permit the use of such fish for human consumption. They viewed this requirement as non-negotiable and central to the LO. However, during the formative stages of this legislation, the sale of UWC < MCRS for direct human consumption was hotly debated (Borges, 2021). Some Member States, especially those from the Baltic basin, proposed that once the undersized fish are caught and counted against quota, they should be given appropriate value (Borges, 2021). They expected that this value would be low enough to deter fishers from catching too many undersized fish (Borges, 2021). However, other Member States, particularly from the Mediterranean basin, were of the opinion that this could encourage fishers to catch undersized fish because, unlike the Baltic, consumer demand for small fish is high in the Mediterranean region (Borges, 2021). As a compromise, legislators concluded that UWC < MCRS should be landed, counted against quota, and then sold only for non-

human consumption (Borges, 2021). These diverging views on the use of <MCRS coupled with the fact that consumer demand for small fish varies significantly across the continent may indicate that one policy may not fit all Member States. It is important to note that the decision to not allow the direct human consumption of <MCRS was based on general knowledge and is not supported by empirical evidence (Borges, 2021).

This reluctance to consider that undersized fish could be used for human consumption can be seen in other pieces of European legislation too. For instance, the 2013 proposal to regulate fishing in the Skagerrak reflects this (European Parliament, 2013). In the draft version, Article 5 initially stipulated the following: '(…) the sale of catches of that stock below the minimum conservation reference size shall be restricted to reduction to fish meal, pet food or other non-human consumption products only, or for charitable purposes.' The final version of the proposal omitted 'or for charitable purposes'. A report recording the decision-making process explained that this was done because 'it is not appropriate that juveniles be sold for charitable purposes' (European Committee on Fisheries, 2013). Further, it stated 'it would have been possible to amend the provision so that juvenile fish may be given to charitable purposes, but as there is no such tradition in the Member States surrounding the Skagerrak, such a provision would have no place in the Regulation' (European Committee on Fisheries, 2013). This goes on to show that the aversion to donate UWC for use as food or for charity is based on arbitrary factors rather than scientific evidence.

4. Discussion

The aim of this research was to explore the possibility of including more fish in Dutch food bank parcels by utilising unwanted catch. This study is socially and environmentally relevant because donating UWC to the food banks could not only improve the nutritional quality of the food parcels but also reduce food waste from the fishing industry. Based on the results discussed above, economic, and legislative barriers, stakeholder relations, and the state of logistics and infrastructure would

currently make the donation of UWC to food banks challenging. In this section, we discuss the possibility of overcoming these barriers.

The push to ban discards at sea came from a place of concern regarding food waste. Discussions about high volumes of discards in European fisheries were ongoing at the Commission when British celebrity chef Hugh Fearnley-Whittingstall's 2010 public campaign gained popularity across the Member States. Celebrities, influential retailers, environmental NGOs, and the general public expressed solidarity with Fearnley-Whittingstall's demand to end the wasteful practice of discarding UWC at sea (van Hoof et al., 2019). The campaign, backed by over 650,000 petitioners, played an important role in influencing legislators to pass a law requiring fishers to land their unwanted catch instead of discarding it at sea (de Vos et al., 2016; Kraan & Verweij, 2020; van Hoof et al., 2019). The Commission hoped that the LO would encourage the fishing industry to focus its attention on developing selective fishing practices and eventually, significantly reducing the existence of UWC. However, developing selective fishing techniques that reduce discard rates to the 5% benchmark set by the CFP cannot be realised instantaneously. This is especially true for fisheries such as the demersal fleets that fish in the North Sea where the discard rate has historically been as high as 40% (IMARES Wageningen UR, 2014). Until such tools and technologies are developed and successfully implemented, UWC will continue to be landed. The initial emphasis on food waste that led to the realisation of LO was eventually replaced by concerns regarding the health of fish stocks and marine ecology. Neither the CFP nor connected policy areas provide Member States with guidelines regarding how surplus fish that would be landed as a consequence of the LO should be sustainably utilised. The policy formulation process can be considered top-down due to the fishing industry's minimal involvement in it. The fishing sector's aversion to this approach is evident in the results. De Vos et al. (2016) indicate that fishers feel that their professional knowledge was disregarded by policymakers and scientists who lack a pragmatic understanding of how the industry is organised. In their paper on the US-based seafood donation programme SeaShare, Watson et al. (2020) describe that a flexible, bottom-up approach coupled with regulatory changes enabled the programme's success.

In the European context, literature recognising the food waste problem associated with the Landing Obligation is scant. The European Court of Auditors' 2016 report on food waste is one of the few public documents that acknowledges that UWC landed as a result of the LO could end up as food waste (European Court of Auditors, 2016). The report describes the lack of legal provision to donate UWC in the new CFP as a missed opportunity. Furthermore, it encourages the Commission to assess the possibility of including legal provisions in the CFP to donate surplus fish (European Court of Auditors, 2016). The paper published by Vaqué (2017) makes an identical appeal (Vaqué, 2017). The EU FUSIONS research project (2012–2016) also identified the risk of the LO turning fish waste at the sea into food waste on land (Vittuari et al., 2015). This paper adds to the limited body of literature focusing on this issue and recommends better cohesion between the CFP and the EU's food waste reduction ambitions. Including a legal provision to donate surplus UWC would be a first step in facilitating this. It is unlikely that such provisions would discourage selective fishing. Landing unwanted catch would still be seen as unfavourable by fishers due to limited onboard storage and low value fish getting counted against quota. The incentive to fish selectively would considerably outweigh the incentive to land UWC and donate it to charity.

If donations are to be operationalised in the EU, legal provisions will have to be supported by suitable infrastructure. One way to facilitate this could be through the European Maritime Fisheries and Aquaculture Fund (EMFAF) which entered into force in July 2021. Part of its EUR 6,108,000,000 budget is allocated to projects focused on ensuring food security through the supply of seafood products in the Member States (Regulation (EU) 2021/1139). Additionally, the fund was set up to help fulfil the objectives of the EU Green Deal, which explicitly states reducing food waste as one of its goals (European Commission, 2019, 2021). Donating UWC to food banks not only improves food security through seafood products but also reduces food waste and ensures that UWC is utilised sustainably. To safeguard fishers' economic interests, such projects could be supported by public-private partnerships. Iñarra et al. (2020) show that turning UWC > MRCS into fish burgers or other minced fish derived products is an economically viable way to utilise UWC while also increasing fish consumption. If the fish is delivered to consumers, including food bank recipients, in an affordable and easy to cook format, it is likely to be well received. The paper

published by Iñarra et al. (2020) describes results from one of the few case studies that explore the possibility of utilising UWC for human consumption and will need to be replicated in different contexts. However, it considers UWC < MRCS to be ineligible for such operations largely due to the legal restriction on using such fish for direct consumption. If the EMFAF is utilised to set up operations to produce new fish products from UWC and if direct human consumption of UWC < MRCS is permitted for charitable purposes, part of the fish products can be donated to the food banks. This could help ease the fishing industry's concerns regarding the economic consequences of donating UWC. At the same time, such funding and state support could help the food banks set up infrastructure and logistics to safely handle the fish.

Voluntary agreements as a form of private governance could also help advance the sustainable utilisation of unwanted catch. EU REFRESH (2015–2019), a project focused on reducing food waste across the EU, recommended voluntary agreements (VAs) as a tool for private actors to fill legislative gaps with regard to food waste valorisation (Piras et al., 2018). VAs can be used as an alternative course of action to traditional legislation and can be directed by government officials, businesses, or other actors (Piras et al., 2018). In the context of UWC utilisation, the VA could focus on developing new markets, setting up infrastructure, and discouraging the illegal trade of UWC. Donating a share of the UWC to improve food security could be a part of the agreement. Relevant actors who could collaborate include fishing industry associations, fish processors, NGOs, and the Food Bank Foundation. The EMFAF or other national funds set up for the purpose of improving food security could help finance such programmes.

Some limitations faced by existing food waste-focussed VAs in the Netherlands are already known. It is important to take these into account while developing any new agreements on UWC valorisation. For instance, Piras et al. (2018) point out that besides SDG 12.3, the Netherlands does not have a specific national food waste reduction target. Due to the lack of dedicated policy measures, government support for voluntary actions is limited. The same report also indicated that a paucity of food waste data makes it challenging to arrive at objective targets. Current food waste VAs in the Netherlands also lack built-in sanctions for non-compliance. This makes it possible for free riders to take undue advantage of such agreements by joining them

only to improve their public image without taking concrete action to reduce food waste (Piras et al., 2018). Next to this, prior to setting up any programmes, taking demand-side barriers into consideration is critical. To address such barriers, van Putten et al. (2019) recommend selling unwanted catch at an affordable price and educating consumers about preparing such fish. Efforts to increase consumer acceptance should be directed towards the general public and not only food bank recipients because several types of UWC can be used for direct human consumption.

Strengths and Limitations

This paper makes a first attempt to analyse whether unwanted catch that is landed as a consequence of the new EU Common Fisheries Policy can be utilised to improve food security. It adds valuable insight to a limited body of literature that discusses the issue of unwanted catch through the lens of food waste valorisation. It is, however, not without limitations. Not all relevant stakeholders could be interviewed for this research. Some stakeholders (n = 7) invited to take part in this study did not agree to participate. Additionally, fishers, who would be the ultimate decision makers regarding the donation of UWC, were not included in the sample. This is due to the scope of our enquiry being limited to understanding this previously unexplored issue from a bird's eye view as opposed to mapping the reality on the ground. Future research on this topic could highlight the viewpoint of legislators, policymakers, and fishers, thereby filling the gap in the literature. Next to this, despite employing validation strategies such as peer reviews and multi-author coding while analysing data from the interviews, a certain degree of bias could be present in this study due to its qualitative nature.
Lastly, quantitative data was collected by recruiting participants from only one out of the 171 food banks in the Netherlands. Whether food bank recipients across the country share the same inclination towards eating UWC remains unknown. The respondents were only provided with the definition of unwanted catch. Additional information such as fish species and condition (processed, unprocessed), and taste tests might yield different results. However, prior to this research, it was not known whether the food banks and their recipients were inclined to receive more fish. Their attitude concerning unwanted catch had never been studied either. Results presented in this study open the doors to further enquiry on this issue.

5. Conclusions

This study explored the possibility of including more fish in Dutch food bank parcels by utilising unwanted catch. It did this, firstly, by gauging whether food bank recipients would be interested in such fish. This was followed by an analysis of relevant stakeholders' opinions on such an initiative. By considering unwanted catch utilisation, fish shortage in Dutch food bank parcels, and food waste valorisation together, this paper paves the way for a better understanding of all three issues and their possible interconnectedness.

Currently, several economic, legislative, social, and logistical barriers stand in the way of donating unwanted catch to food banks. However, given the European Commission's, and in turn the Dutch government's, strong focus on achieving the SDGs, change is possible. As highlighted in this paper, sustainably utilising unwanted catch and reducing food waste are often not viewed by policymakers as interconnected issues. Through this study, we aim to challenge this narrative. Legislative change, sufficient funding, and industry-led initiatives such as voluntary agreements can make donating safe-to-consume surplus fish to food banks a reality in the near future. Such an initiative could potentially improve health, accommodate the increasing demand for sustainable protein, and prevent wastage of valuable marine resources.

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Informed Consent Statement

Participants involved in this study consented to their involvement by signing a declaration of informed consent. The questionnaires, both digital and physical, asked for survey participants' consent.

Data Availability Statement

The first author can be contacted to request a copy of the code book.

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Conflicts of Interest

The authors declare that there are no conflicts of interest.

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4

It takes a village to valorise waste: Understanding the phenomenon of food waste valorisation from the perspective of supply chain actors engaged in it

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Abstract

The repurposing of surplus food and food processing by-products is a key aspect of the shift towards a circular bioeconomy. In the Netherlands, food supply chain actors are already working towards making better use of agri-food surpluses in order to improve food security and resource efficiency. By analysing the experiences of these actors, this study aims to identify the current state of the sector and highlight barriers and enablers of successful food waste valorisation.

Based on a phenomenological analysis of 16 in-depth unstructured interviews with participants from the Netherlands, we empirically demonstrate that supply chain actors involved in food waste valorisation consider local embedding, societal perception, and food safety to be important aspects of their work. They often grapple with legislative and logistical uncertainties and face various ethical dilemmas such as having to pay for products that were once considered waste. Building on these findings, we propose that experienced professionals with a penchant for sustainability can play the role of 'transition brokers' as the food system moves towards a circular way of operating. We also posit that private standards and voluntary agreements could be a way for the sector to better manage the various bottlenecks that are characteristic of food waste valorisation endeavours.

1. Introduction

A sizeable portion of food produced for human consumption ends up in landfills every year. Through technological and policy innovation, it is possible to upcycle at least a part of this waste by developing new pathways for its use or transforming it into new raw materials and products. The most environmentally and socially beneficial way to do this is to utilise food surplus and by-products to meet the nutritional and food security needs of the growing population (Papargyropoulou et al., 2014; Wunder et al., 2018). This is already happening in several parts of the world through a broad range of practices such as donating surplus food to charities (Bilska et al., 2016; Caplan, 2017; Lambie-Mumford, 2017; Midgley, 2014; Schneider, 2013), connecting consumers with surpluses through digital platforms (Bernardi et al., 2021; de Almeida Oroski, 2020; Mullick et al., 2021; Sedlmeier et al., 2019), creating a market for mishappen produce (Cooremans & Geuens, 2019; Makhal et al., 2021; Mookerjee et al., 2021; Qi et al., 2022; Tu et al., 2018), and extracting valuable biological compounds through processing (Cecilia et al., 2019; Dimou et al., 2019; Galanakis, 2020; Jiménez-Moreno et al., 2020; Rao et al., 2021b). Several sustainability focussed entrepreneurs have created products from surplus foods and ingredients that would have otherwise ended up as waste. Following the example of Bhatt et al., (2018), we refer to these food products as value-added surplus products (VASP). All endeavours to retain food that would have otherwise ended up as waste in the food supply chain are considered to be food waste valorisation in this study.

Given that food waste is a complex problem involving several stakeholders, valorisation endeavours are frequently met with legislative, logistical, and economic challenges. The fields of public policy and management recognise food waste as a wicked problem. It can be characterised as such because of its unstructured, cross-cutting, and relentless nature (Närvänen et al., 2020; Weber & Khademian, 2008). Food waste is an unstructured problem because of the co-existence of several official definitions and measurement methods (Närvänen et al., 2020). The involvement of multiple stakeholders dotting the expanse of the food system makes it cross-cutting (Närvänen et al., 2020; Parfitt et al., 2010). Given the lack of an all-encompassing solution that can end the problem once and for all, the issue of food waste is also

relentless (Närvänen et al., 2020). As is the case with all wicked problems, there is no straightforward or unilateral way to address this problem. Instead, a collaborative and multidimensional approach involving various stakeholders must be undertaken (Roberts, 2000; Weber & Khademian, 2008). To accelerate this kind of collaboration among stakeholders, understanding the problem through their perspectives is critical.

In recent years, researchers and policy makers have been working towards gathering empirical evidence that can help further our understanding of stakeholders' experiences of dealing with food waste and its prevention. Currently, much of this knowledge comes from research that is focused on consumer behaviour and food waste at the household level (Xue et al., 2017). Results from such studies have helped in designing interventions that aim to reduce the amount of food that is wasted in the household setting (Hebrok & Boks, 2017; Kim et al., 2019; Reynolds et al., 2019; Zamri et al., 2020). While more than half of all food waste is estimated to occur at the household level, several million tonnes of food is wasted before it reaches the consumer (Parfitt et al., 2010; Xue et al., 2017). Actors in the food supply chain, including producers, manufacturers, distributors, and retailers, can play a role in reducing and better utilising food surplus and waste. Current literature focusing on pre-consumer food waste largely concerns establishing food waste quantities (Bellemare et al., 2017; Corrado et al., 2019; Parfitt et al., 2010; Spang et al., 2019; Xue et al., 2017), underscoring technological innovation (Arancon et al., 2013; Lin et al., 2013; Nayak & Bhushan, 2019), mapping business and supply chain issues (Aschemann-Witzel et al., 2017; Diaz-Ruiz et al., 2019; Göbel et al., 2015; Huang et al., 2021; Yetkin Özbük & Coşkun, 2020), and identifying legislative and policy barriers (Broeze & Luyckx, 2019; Eriksson et al., 2020; Garske et al., 2020; Vittuari et al., 2015). Similar to the broader scholarship on the circular economy (Närvänen et al., 2021), material flows and technological aspects of food waste valorisation are better understood in comparison to the social, institutional, and organisational aspects. We address this gap in literature by presenting a qualitative investigation into the experiences of supply chain actors engaged in food waste valorisation in the Netherlands. Our study focuses on non-consumer actors such as farmers, entrepreneurs, retail executives, and food aid workers who are involved in food waste valorisation in different capacities. By analysing their experiences of participating in, organising, and leading these

operations, we aim to shed light on the current state of the food waste valorisation sector from the perspective of those engaged in it.

2. Food Waste Valorisation in the Netherlands

As a Member State of the European Union, the Netherlands aspires to realise the United Nations' Sustainable Development Goal (SDG) 12.3 by halving per capita food waste by 2030 (United Nations, 2023). This ambition is reflected in the government's 'A Circular Economy in the Netherlands by 2050' agenda. In 2016, the cabinet outlined steps to ensure that raw materials, products, and services are used in a sustainable manner in the years to come. The report 'Execution Programme Circular Economy 2019-2023' (Ministerie van Infrastructuur en Waterstaat, 2019) indicates that sustainable and circular biomass is a priority for the Netherlands and reducing food waste is an important means to achieve this. The Samen Tegen Voedselverspilling (Together Against Food Waste) foundation is at the forefront of the food waste reduction movement in the country. Together with over 100 stakeholders from the public and private sectors, the foundation manages consumer campaigns, voluntary agreements among food supply chain actors, and liaises with industry stakeholders and government bodies. Between 2018 and 2021, the Dutch government made resources worth EUR 8 million available to small and medium sized enterprises focused on sustainable food (Rijksoverheid, 2019).

Publicly available information on food waste reduction in the Netherlands focuses largely on preventing food from turning into waste at the household level. Efforts to redistribute surplus or valorise unavoidable food waste are not widely reported. However, some non-consumer focussed initiatives have gained popularity in the country. Voedselbank Nederland is a network of over 170 charities that procure surplus food products from retailers and distributors to redistribute them among food insecure individuals (Voedselbanken Nederland, 2020). Several other independent charities are also engaged in similar activities. Digital platforms such as Too Good To Go and OLIO connect consumers with discounted surplus food products in their neighbourhoods. Either through such platforms or independently, supermarkets such as Lidl offer close-to-expiration products at reduced costs. Businesses like

Kromkommer, Krush, VeggiHap, and Verspillingsfabriek transform surpluses or by-products into VASP such as soups, breakfast cereal, and pasta. Nijsen, an animal feed producer, specialises in converting former foodstuff into sustainable pig feed.

Overall, the Netherlands offers a conducive ecosystem for supply chain actors who seek to incorporate food waste prevention and valorisation into their operations. Sharing knowledge, resources, and technical know-how are promoted as ways of achieving the goal of 'Circular Netherlands 2050'. However, most food waste reduction efforts remain voluntary in nature and in the absence of non-compliance sanctions, businesses are not held accountable for lack of effort towards the cause (Piras et al., 2018). Against this background of the Dutch laissez-faire approach to food waste valorisation, we examine the motivation and experiences of actors who choose to engage in it.

3. Methods

Considering that the lived experiences of food waste valorisation professionals were central to our research, the phenomenological approach was found to be suitable for conducting this study. Phenomenology, as a qualitative research method, seeks to distil the common meaning of several individuals' lived experiences of a certain phenomenon (Creswell & Poth, 2016). The purpose of this approach is to further the understanding of the phenomenon in question by studying a richly detailed and contextual account of study participants' lived experiences (Sorrell & Redmond, 1995). In his pioneering work on the subject, Van Manen (1997) posits that the point of phenomenological research is to 'borrow' other people's experiences and their reflections of it so as to come to a better understanding of a certain aspect of human experience. Although phenomenology is not a widely employed research method in the field of food (social) sciences, we chose to work with it because both, food waste valorisation as a phenomenon as well as participants' experiences of it were crucial to our research.

Tesch (1984) suggests allowing the nature of the phenomenon to decide the number of participants to be recruited for the study. While 10 to 15 participants are

recommended, sample sizes often vary between six and 25 (Tesch, 1984). In this study, 16 participants involved in food waste valorisation in various capacities were interviewed. Participants were recruited through a purposive sampling strategy wherein they were chosen on the basis of the specific qualities, knowledge, and experience they possessed (Etikan et al., 2016). The sample was designed to have equal number of participants working for for- and non-profit organisations in order to allow a comparison of their experiences. Table 1 presents an overview of participants and a brief description of their professional or volunteer experience.

Conducting interviews is the most practiced data collection method for phenomenological studies (Creswell & Poth, 2016). Although other methods such as observations or written accounts can be used as well, interviewing is preferred because it is less intrusive and is sensitive to the nature of the enquiry (Creswell & Poth, 2016). Participants may be provided with an introductory text detailing the aim and the scope of the study so they can come prepared with meaningful narratives (Sorrell & Redmond, 1995). For this study, participants were contacted by the first author via email with information about the study and the nature of the interview. They were informed about the purpose of the study a second time by the researchers prior to the interviews. Interviews were conducted between September 2020 and November 2021 and lasted between 60 and 75 minutes each. As suggested by Sorrell & Redmond (1995), interviews were not only ‘conducted’ but were also shaped and participated in by the interviewers to enable the participants to provide a detailed and focused account of their experiences. All interviews were conducted in English and transcribed *verbatim*. Participants were requested to review interview transcripts for inaccuracies.

Table 1 Description of participants' professional backgrounds

Participant	Description
P1	Founder and director of a logistics organisation transporting surplus food to charities across the country.
P2	Food safety expert advising food charities about food safety and quality on a *pro bono* basis.

P3	Independent food packaging professional offering *pro bono* consultancy services to charitable organisations that redistribute surplus food.
P4	Quality management and regulatory affairs professional offering *pro bono* consultancy services to charitable organisations that redistribute surplus food.
P5	Founder of a social start-up that connects retail surplus with charities that run soup kitchens and social restaurants.
P6	Hospitality professional volunteering with a charity that prepares meals from retail surplus and offers them to those in need, free of cost.
P7	Procurement professional offering *pro bono* consultancy services to charitable organisations that redistribute surplus food.
P8	Employee of a charitable shop that runs a community refrigerator.
P9	Fresh produce grower and the founder of a start-up valorising fresh produce waste and surplus into VASP.
P10	Co-founder of a catering company that connects the hospitality industry with surplus produce.
P11	Head of business development for a start-up that valorises fruit peels into VASP such as food additives and functional ingredients.
P12	Research and development manager for a start-up that valorises fruit peels into VASP such as food additives and functional ingredients.
P13	Quality manager for a business that creates VASP such as soups and sauces from catering leftovers.
P14	Sustainability manager for a retail chain that donates a portion of its surplus food products to charities.
P15	Co-founder of a start-up that valorises vegetable processing by-products into VASP such as pasta.
P16	Sales executive for a digital platform connecting consumers with close to expiration food products in supermarket and other food retail outlets.

Transcripts were analysed using the three steps described by Streubert & Carpenter (2011), supplemented by the explanation by Creswell & Poth (2016). In the first step, known as naïve reading, we read all the interview transcripts to become familiar with

the text as a whole and the underlying meanings. Next, we performed structural analysis wherein the text was read once again but this time with the intention to identify patterns and make connections. At this stage, all authors met frequently to discuss and compare their understanding of the text. Sections of the text that were perceived as significant were highlighted and were assigned codes to indicate their relevance. This was followed by coded pieces of text being grouped into broader units of description to create clusters. Interconnected clusters were grouped together into themes. Finally, in the third round of interpretation, all authors collectively reflected on the data analysis process to ensure a comprehensive understanding of the findings. Atlas.ti was used to manage and code the data. Wherever necessary, excerpts, quoted *verbatim*, unless modified to improve readability or ensure anonymity, have been used to underpin the findings. The study was conducted in line with the requirements of the Helsinki protocol and received ethical approval from the Ethics Review Committee Inner City Faculties of Maastricht University under reference number ERCIC_196_10_06_2020.

4. Findings

Our analysis resulted in the construction of five overarching themes that collate the experiences shared by the study participants. Figure 1 illustrates the themes and sub-themes in a schematic format. The subsections that follow illustrate the themes in further detail

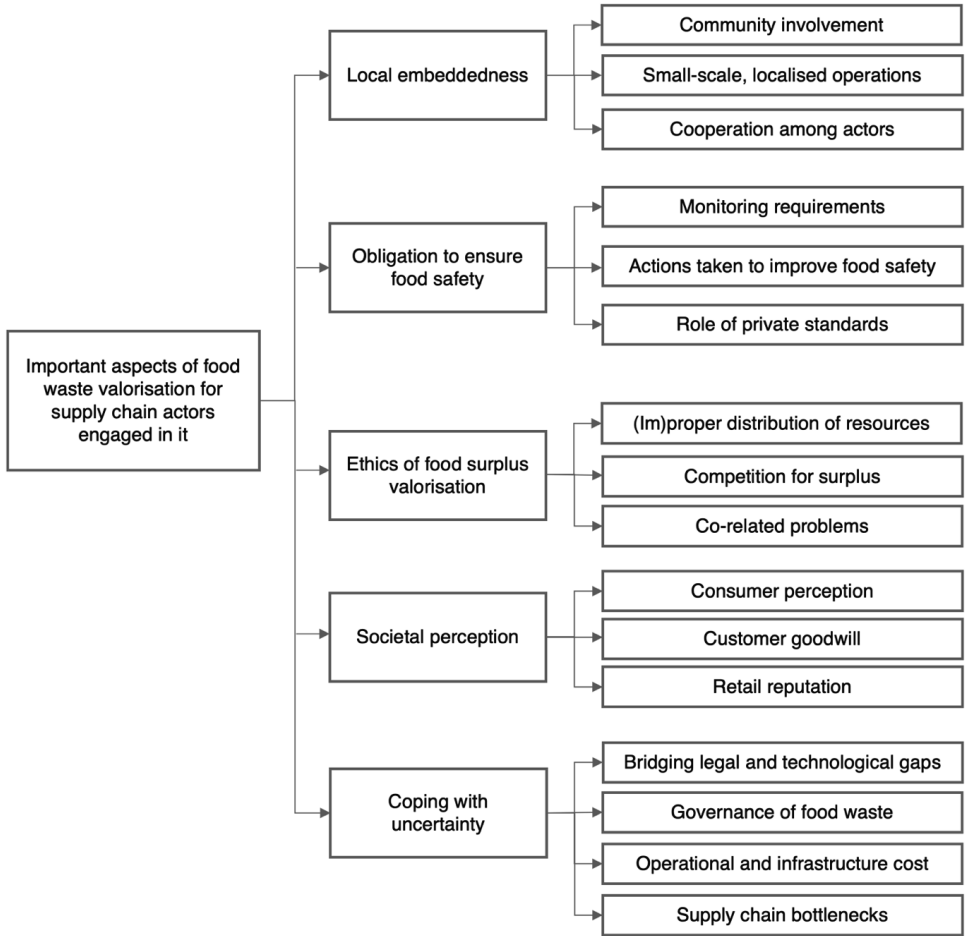

Figure 1 Themes and sub-themes

4.1 Local embeddedness

Improving food access for underserved communities, reducing the amount of food wasted by local businesses, and establishing sustainable, localised, and short supply chains were important motivating factors for participants when choosing to work in the field of food waste valorisation. Altruistic motivations were higher among participants working with food charities or non-profit organisations. Most of these participants were strongly driven by the wish to ‘give back to the community’. They spoke at length on topics such as food insecurity, access to nutritious food, and desire to help fellow

community members. In comparison, participants working with for-profit organisations focused on the issues of inefficient resource use and environmental damage at local and regional levels.

Several participants exhibited a strong preference for working with businesses that were local to the area or were managed by residents of the area. For instance, P1 narrated their observation regarding franchise owners of supermarkets being more willing to donate surplus food products to their own communities as opposed to managers of retail chains who did not have any connections with the residents of the area. P1 explained this through the example of the Dutch co-operative supermarket chain Plus: *"With companies like Plus, where they work with the franchise model, we see that owners are really keen on sending surplus to the local community. But with non-franchise supermarkets, that is often not the case."*

Preference for localised and short supply chains was also a prominent theme when discussing the possibilities of expanding a profitable valorisation business. When asked about the possibility of scaling up operations, participants expressed concerns regarding environmental and logistical barriers. For instance, P11 believed that procuring fruit peel from farther away than they currently do would diminish the sustainable aspect of the business: *"I don't think scaling up this kind of an operation is valuable. What we do is, we make a radius of around 250 kilometres around this city and collect peels from supermarkets within that radius. If you go further, then the pollution caused by getting the peels here will be too big. And if there is a region with a lot of peel waste, then they could set up a similar concept there."* Furthermore, P11 expressed willingness to share their knowledge and technology with other entrepreneurs with a similar vision. P15 shared that the vegetable waste they worked with varied in volume and composition on a daily basis. This would make it logistically challenging to set up a single factory that supplies several markets. Instead, they supported the idea of 'clustered' production wherein small-scale factories, tailored to the surplus available in the region, could be set up in different parts of the world.

Lack of social cohesion came up as a barrier to successful valorisation endeavours. Several participants shared that reducing food waste through redistribution or creating new products was feasible only if various actors in the supply chain cooperated with

one another. P9, when asked about what kind of relationship they envision among food chain actors to allow food waste to be valorised, narrated their experience as follows: *"Nowadays there is no trust in the food chain. Everybody is there for their own selves. I want to be able to look inside the factory of the processor. I am happy to allow other processors to look in my factory as well. We need to be able to trust each other and learn from each other's mistakes."* Similarly, other participants hoped that the years to come would see improved commitment towards the cause from their communities and relevant stakeholders.

The small scale of food waste valorisation activities often means that organisations engaged in them cannot access resources at the national level. This is especially true for smaller, independent charities. P14 explained that stores from their retail chain only worked with a national charity network because of its reputation: *"They are a really large organisation, they cover the whole country. They make food available for people in need and have a thorough system of helping and selecting their customers. It's very much an organisation that our consumers really appreciate us working with."* Despite this nationalised charity's branches working independently and serving communities that are local to where their operations are, centralised administration helps them maintain a good reputation and publicise their work well.

Given that the interviews were conducted when the Covid-19 crisis was ongoing in the Netherlands, participants reflected on their experiences of dealing with lockdown measures and their impact. Particularly, participants working for charitable organisations felt the moral obligation to continue their work despite the restrictions that made it challenging to do so. The pandemic and its negative impact on food security appears to have bolstered these individuals' commitment to the cause of food waste valorisation.

4.2 Obligation to ensure food safety

Food safety was an important theme during most interviews. Participants reported that safety concerns regarding the valorisation of food processing by-products often arise due to supply chain inefficiencies and uncertainties regarding the legal status of the by-products. Regarding surplus food that is redistributed to consumers through

charities or alternative supply chains, reduced quality, allergens, and spoilage were the main concerns. Food safety was a sensitive subject for several participants, and they felt personally responsible for ensuring that food produced or redistributed by their organisation was safe and of good quality.

In the case of charitable organisations, some participants expressed concerns regarding the level of hygiene that volunteers could maintain: *"Nobody likes to talk or think about food safety in social restaurants. They never look into it because they are afraid of what they might see."* They expressed confidence regarding volunteers' benevolent intentions but felt that they needed additional training to ensure food safety: "*The challenge with food banks is that they are usually run by volunteers. They want to give as much support to those in need as they can. But the challenge lies in the fact that they have to recognise when it is safe to accept and redistribute this food. And this is not only with microbiological spoilage but also allergens, storage history, etc."*. For some participants working with food charities, 'providing food' was more important than 'providing good food'. They believed recipients could decide for themselves whether they wished to consume a certain product.

Participants working with small-scale charities shared that most did not have comprehensive hygiene rules, recall procedures, or offer regular food safety training to their volunteers. P6 explained that such matters were dealt with on an *ad hoc* basis: "*Ideally, you would want a protocol for food safety crises before they happen. But when running a volunteer-led organisation, you have so many things to do. We just try to keep our head above the water and things like these get attention only when really needed".* P1 attributes the lack of formal hygiene rules to the Dutch social norm of displaying trust in fellow citizens' good intentions: *"We have a lot of regulations in the Netherlands, but we are not very good at living according to regulations. So, despite having regulations, we don't check them. Not because we don't want to, but we don't believe in 'checking'. If manuals are introduced in charitable organisations, they will ask 'why do we need to have a manual? Why does somebody who would like to cook for charity need a manual and do all kinds of checks?".* Participants working with small-scale charities mentioned that the competent authority rarely ever audited such organisations. Therefore, volunteers did not consider it important to prepare for inspections or audits which are regularly conducted at larger, nationalised charities.

For those engaged in for-profit valorisation operations, such as the production of VASP, food safety was non-negotiable. Participants shared that being certified for food safety was important for them because it would allow their products retail access. However, considering that their operations and procurement deviated from regular food processing businesses, some participants found working with existing standards to be a challenge. P16, who at the time of the interview was working together with a certification bureau to get their operations certified for food safety, shared that existing certification schemes were unable to accommodate certain aspects of their production. They were of the opinion that if certification schemes made measured exceptions regarding these aspects or introduced addendums, it would make it easier for entrepreneurs to create a market for VASP. Additionally, the usefulness of certification schemes designed specifically for such products was discussed. While some participants thought this to be beneficial, others disagreed. For instance, some believed such certification could hamper innovation and existing certification schemes should simply adapt to the needs of sustainable businesses instead of creating new schemes. One interviewee, despite considering food safety to be important, did not feel that their organisation needed to be certified or have a detailed safety manual. This was due to the fact that their organisation was only a facilitator and not ultimately responsible for the products being valorised. P11 believed that certification tailored to the special processing needs of VASP could be beneficial if it conveyed the sustainable quality of the final product to the consumer. Regarding such certification, they shared: *"From a commercial perspective, it's very interesting to understand this trend. Creating ingredients out of by-products or waste has a certain mark up in the cost chain towards customers. So, we are looking for ways to make it clear to the consumer that the ingredients that you buy from us are coming from by-products".*

4.3 Ethics of food surplus valorisation

The participants of the study recounted various ethical dilemmas that they faced due to their professional or volunteer activities. Regarding the redistribution of surplus food products, participants working for charities and non-profit organisations described increasing competition from start-ups that connect consumers with surplus. They believed it was unethical for organisations to profit from selling food that would have

otherwise been donated to food insecure individuals. When one participant who works for such a start-up was requested for their opinion on this competition, they shared that private organisations having to provide food aid in a wealthy welfare state such as the Netherlands in itself was unethical. Some others shared that it was possible for both kinds of valorisation activities to coexist without competing for surplus food since there was enough to go around. Most participants considered it reasonable to allow consumers who wished to purchase groceries at discounted prices or contribute towards reducing food waste to purchase such products to do so. However, they also showed a strong interest in cooperating with charities and non-profits to redistribute surplus food in a fair way. Participants shared that competition existed between charities as well. Those working with small-scale charities believed bigger charities received a majority of all surplus food in the country because of their reputation and public relations prowess.

Competition from non-food industries was also discussed. Some participants, especially those working with non-profit organisations, described that they worked hard to convince stakeholders that keeping surplus food and by-products within the food supply chain was more sustainable than sending it to animal feed or turning it into biofuel. Others questioned whether that truly was the case. P14 described their dilemma as follows: *"So many initiatives are thinking of ways to keep surplus in the food supply chain. You can turn anything into a smoothie or into a soup or a quiche. But would that still make sense? Or am I then making a quiche that has a carbon footprint of a piece of beef?"*

Some participants deliberated whether valorisation of food surplus and by-products truly contributed to the reduction of food waste. Considering that surpluses were required by these organisations to continue with their operations, participants wondered whether they were creating a demand for food waste. P7 expressed their views on this as follows: *"We are in favour of reducing food waste but that also makes us 'thieves out of our own pocket' because every product that is not stamped as surplus stock or leftover, we won't get. So, you see that we are cutting our own supply line if we are working on reducing food waste".*

When food surplus was not valorised for charitable purposes, participants were conflicted about whether the buyer who wishes to valorise them into new products should have to pay for it. Expecting primary producers to give away their surplus for free so someone else could profit from it was thought of as unethical by some participants. They thought it to be particularly unfair when the processor sold VASP at a premium price due to its sustainability credentials. P9 shared their experience with such buyers: "*They come here saying they want my surplus or lower quality produce for free but that's not going to happen. I know that in the end, they will earn a lot of money with it because I see existing products which are based on this thought. They pick up the produce for free, process it into a product where you cannot see any more that it's from food waste and then ask for a higher price than regular products."* They further shared that processors and catering businesses often tried to label misshapen but otherwise good quality produce as waste to take it off producers' hands for free or for lower prices thus further inflating the cosmetic standards for fresh produce. Others argued that by taking in such produce without transaction costs, processors were helping producers not to pay to dispose of their waste.

4.4 Societal perception

Participants spoke at length about their ideas regarding how society perceives food waste valorisation. Those engaged in for-profit valorisation activities thought it important to understand consumer perception in order to improve their product's branding. Some believed that through raising awareness about food waste and the benefit of valorising surplus or by-products as new foods, it was possible to create a market for VASP products. They shared that they prefer to stay away from the word 'waste' while communicating their brand's story, so consumers do not feel like they are paying to purchase waste. P15 shared that they preferred using terms such as 'upcycled' which help circumvent the need for mentioning waste or surplus. They believed that persuading consumers to purchase VASP to reduce food waste was not an effective marketing strategy. They shared the example of an unsuccessful VASP business from the Netherlands: "*It was a very popular brand. People loved the 'end food waste' story at first. But that story could only take it so far because at some point, people just get tired of feeling guilty about whatever they're doing. Like, hey, you need*

to save the planet, so you buy this instead of that. Our approach is 'it's good for you' and in addition to that, it's also reducing food waste because we use surplus'.

Some other participants shared this sentiment and were of the opinion that VASP or misshapen produce should not warrant a higher price simply because of food waste reduction reasons. Other participants believed that establishing such supply chains was currently more expensive and therefore expecting consumers to pay a premium price was justified. However, this may not be the case in the future if food waste valorisation were to become the norm. One participant offered the example of plant-based meat replacement products*: "In the future, if more than half the food production is coming from waste, then it's not a unique selling point anymore. Look at plant-based meat replacement for example. People are currently willing to pay a premium for these products. But they are not a novelty anymore. It's becoming increasingly normal to consume these products instead of meat and eventually people will be less willing to pay a plus for it."* They believed that while this could be the case for VASP in the future, currently, the trend is at a nascent stage and therefore, premium retail prices were justified. Some others shared that consumers should adjust their expectations when purchasing VASP: "*For the circular economy to work, we have to be open to new foods and food concepts. If you keep trying to replicate an existing product while aiming for circularity, it's going to be impossible".*

Participants engaged in charitable redistribution also believed societal perception to be an important motivating factor for retailers to donate their surplus food. P7 was of the opinion that it was customer goodwill ('*gunfactor'* in Dutch) that motivated retailers to donate their surplus. They explained that supermarket brands wish to be viewed as organisations that fulfil their social responsibility. P5 shared that they had to often resort to appealing to the moral sensibilities of retail executives to convince them to donate their surplus. However, they shared that convincing them is getting especially challenging in the face of initiatives looking to sell close to expiry or surplus products to consumers at reduced prices. According to P5: *"Many initiatives try to sell leftover products for 25 cents per piece. This way, supermarkets sell their wares, but they are not making any profit. If they donated this food instead, they could tell their neighbourhood that they donate. This gives the supermarket a good name. We have seen customers choosing to buy at such supermarkets because of the goodwill it*

creates." However, several participants shared that despite being aware of this goodwill factor attached to donation, supermarkets were hesitant to donate because they did not wish to be responsible for food borne illnesses that could be caused if the donated products were mishandled.

4.5 Coping with uncertainty

Supply chains for food waste valorisation operations in the Netherlands are not as well established as regular food supply chains. Participants engaged in both, profitable as well as charitable valorisation experienced uncertainties regarding supply. Given that it is impossible to estimate the exact quantities and composition of incoming surplus food, participants shared that they have to undertake various strategic measures to ensure that their operations can continue despite the precarity. P10 shared that they dealt with the highly erratic supply by allocating additional resources to planning and logistics: "*How can you plan your operations if you don't know what to expect today? We always collect products within 24 hours. So that means, if somebody calls and says, 'we have 8000 kilos of paprika', we need to schedule it today. And then we need to pick it up today. This costs extra money because we cannot schedule anybody in advance".* Others working with similarly diverse and fluctuating raw materials also shared that they employed strategies such as developing adaptable recipes and cooperating with other food banks in the region to arrange barters. Interestingly, P12 shared that their organisation did not have to deal with uncertainty of this nature because they worked with peels from only one kind of fruit.

Several participants shared that legal uncertainty was among their biggest obstacles when valorising by-products or surplus. For instance, food processing by-products not falling under the ambit of the EU General Food Law (GFL) created bottlenecks for participants working with VASP. Since safety requirements for by-products such as peels, trimmings, pits, and other parts are excluded from the GFL, participants found it challenging to ensure that their products were legally safe for human consumption. P15 explained that this made it a challenge to find suppliers because they were uncertain about selling their 'waste' to a VASP producer: "*In the Netherlands, we have quite a large number of vegetable processing companies, but they just wouldn't sell their by-products to us! Unless the company is built specifically for handling this type*

of raw materials, they are unable to tick boxes and say 'hey, this is a by-product from this vegetable'. Because they have no space for it, they don't touch it". Another participant working with VASP shared that their organisation had the legal status of the by-product they work with changed from waste to food material in order to be able to legally use the by-product as a raw material.

Additionally, participants shared that they faced legal uncertainty in the process of innovation. For instance, P12 described that developing new products such as functional foods and additives was challenging because they did not fit existing categories under the GFL: "*We are working on developing new types of products. Let's say, functional fibre. The issue with such a product is that it doesn't currently exist in the market. The process is new because it's our own invention. Now the question is, what exactly is this product according to legislation? Is it an additive? What is its E number? For us as a small company, that is very difficult to figure out".*

Participants engaged in charitable redistribution experienced legal ambiguity as well. Adherence to use by dates, handling of frozen foods, labelling errors, and liability were some issues of concern for these participants. Those working with larger, better organised charities shared that they were able to manage these issues through special accommodations from the Dutch competent authority responsible for food safety. In turn, these charities assured authorities of their capability by implementing a hygiene guide styled as per the national food retail standard. Those working with small-scale charities shared that volunteers often flouted rules that caused inconvenience because the competent authority rarely audits such organisations.

Lastly, several participants shared that they were unable to keep abreast with policy development on topics such as sustainability and circular economy. They shared that despite these issues being discussed extensively by politicians and legislators, they were unable to grasp what the policy changes meant for their work. Some speculated that sharing this information in an accessible way would ensure that small businesses and charitable organisations valorising food waste can benefit from the developments in the field. One participant shared: "*You cannot expect everyone to speak the same level of English, French or whatever language these documents are written in. The*

people sitting in Brussels never visit the field where the farmer works to check whether their law suits the farmer's requirements".

5. Discussion

Existing literature rarely examines the role of non-consumer stakeholders in mitigating or managing food waste. The aim of this study was to explore the phenomenon of food waste and surplus valorisation by drawing on the experiences of supply chain actors engaged in it to better inform policy and legislative actions surrounding food waste management. Based on a phenomenological analysis of 16 in-depth unstructured interviews, our findings offer novel insights into food waste valorisation activities in the Netherlands. In this section, we dissect the aspects of our results that invite further deliberation and delve into their relevance to the field of food waste management.

5.1 Differences in perspectives of for-profit and non-profit professionals

Our sample for this study was composed of an equal number of participants working with for-profit and non-profit organisations. Given that both kinds of organisations are active in the food waste valorisation sector, we thought it to be important to include both perspectives. While participants engaged with either kind of organisations spoke about similar topics, their reasons for focusing on a certain theme were often diverging. It was evident during data analysis that organisational goals and visions had an impact on participants' personal views of food waste valorisation. For instance, all participants were keen on working at a local scale. However, those working with charitable or non-profit organisations focused on communities, neighbourhoods, and people. In comparison, professionals working with for-profit organisations were motivated by the prospect of establishing local food supply chains and collaborating with entrepreneurs from the region. Similarly, while non-profit workers were keen on addressing food insecurity through their involvement with food waste valorisation, participants from the other group were inspired by the possibility of improving resource efficiency. Table 2 summarises the differences in motivation that were observed.

Table 2 Differences in motivation of for-profit and non-profit workers

Theme	Motive	
	Non-profit personnel	*For-profit personnel*
Reducing food waste	Improving food security	Improving resource efficiency
Working on a local scale	Helping lower socio-economic status communities	Establishing short food supply chains
Concerns regarding food safety	Donor relations	Market requirements
Ethical dilemmas	Competition for surplus food	Paying for surplus food
Societal perception	Donor relations	Brand reputation

Against the background of food waste being a wicked problem, these diverging motivations to address it are not a surprising finding. However, it is interesting to note that the two groups did not have conflicting motives. In fact, many motives were complementary to one another. Awareness regarding which factors are important to which stakeholder can help in developing effective policy measures and governance tools. As suggested by Dentoni et al. (2018), wicked problems can be governed by harnessing their 'wickedness' i.e., by taking into account and responding to the different dimensions of the problem and thereby enabling networked action to achieve small wins.

5.2 The food waste prevention paradox

Study participants appeared to be markedly aware of the fact that they relied on the continued supply of food surplus or waste for their valorisation endeavours. This led them to question whether they were creating a market demand for food waste instead of aiding in its sustainable management. Some even reflected on whether they were disregarding the food waste hierarchy which suggests prevention as the topmost priority (Papargyropoulou et al., 2014). Although they were clearly motivated to reduce

food waste, the widely accepted food waste hierarchy approach made them think of their actions as paradoxical.

Messner and colleagues (2020) recognise this as a challenge and propose that different strategies should be used when tackling the problems of over production and overconsumption of food as opposed to the management of food that has already been or is likely to be classified as waste. The former can be addressed through prevention and the later through valorisation. They argue, based on the findings of Zorpas & Lasaridi (2013), that prevention has a different ontological quality compared to the physical management or transformation of tangible waste. In the same way as it not being possible to 'fix a flat tyre by reminding someone to avoid nails', they posit that prevention has no role to play in managing food waste (Bloom, 2011; Messner et al., 2020). Our results indicate that the inclusion of 'prevention' as a food waste management strategy creates confusion and scepticism among stakeholders. Therefore, this study empirically corroborates the proposition of Messner et al., (2020) regarding prevention not being a substantive method of waste management and in turn, its inclusion in the waste management hierarchy being problematic. However, another aspect of Messner and colleagues' work warrants discussion here. The authors suggest that the proliferation of businesses created to valorise food waste may cause a surge in the demand for waste, thus normalising unsustainable production and consumption. As discussed above, our participants reflected on this aspect of their work and expressed concern regarding the demand they were creating for food waste. This brings us back to the role of 'prevention' which, as established previously, does not prove effective as a food waste management strategy. Waste prevention, minimisation, and reduction must, in fact, preceed the management options and businesses that rely on food waste must take this into account when setting up shop.

The work of Närvänen et al. (2021) on food waste-focused start-ups in the circular economy touches upon this paradox as well. Their findings indicate that businesses that reuse food waste become reliant on its continued supply and that their income is often positively correlated with waste volumes they are able to acquire. As a result, circular food businesses may support or even actively maintain market mechanisms that create surpluses. It is important for policymakers to carefully consider this trade-off when developing policies that guide the circular economy's development and to

ensure that end goals of such policies are aligned with broader sustainability objectives.

5.3 Food waste valorisation professionals as transition brokers

Experiences shared by study participants showcase their commitment towards addressing the problem of food waste despite being faced with several obstacles such as food safety concerns, regulatory and supply chain uncertainties, and societal scepticism regarding food surplus redistribution and VASP products. Most participants expressed eagerness to cooperate and share knowledge with other professionals working with food waste and surplus. Several characteristics exhibited by these individuals such as enthusiasm to inspire others, entrepreneurial spirit, ability to think from a system perspective, acting in collective interest, and having broad knowledge of circular innovations in the field of food waste management match the competencies thought of as essential for transition brokers (Cramer, 2020). 'Transition brokers' in the context of the circular economy are described by Cramer (2020) as intermediate actors who enhance the process of change, build alliances, mediate between stakeholders, and help scale up and mainstream circular initiatives. Based on this, we posit that professionals engaged in food waste valorisation could be suitable candidates for brokering the transition to a circular food system.

Supply chain actors with an ambition to create a conducive ecosystem for food waste valorisation activities can employ their experience to identify market conditions required to realise the government's circularity ambitions. With private actors taking on this responsibility, local governments can better fulfil their conventional roles as regulators, facilitators, financers, and protectors of human wellbeing and common goods (Cramer, 2020).

5.4 The role of private standards and voluntary agreements

Results presented in this paper suggest that private actors, such as the participants interviewed for this study, are keen on regulating various aspects of food waste valorisation to better cope with the uncertainty that comes with rapid innovation. Developing hygiene guides, getting certified against private standards, and joining

formal or informal agreements for cooperation were some ways in which these individuals and their organisations have dealt with the challenges of working in the nascent sector that food waste valorisation is.

Some concerns raised by study participants are reflected in existing literature as well. For instance, regarding legal opacity surrounding food processing by-products, it is known from literature that such products (as raw material) do not find a place in any lists or annexes of the EU legislation outlining food safety criteria (Rao et al., 2021a). The adoption of private food safety standards that accommodate the specific requirements of food processing by-products has been suggested as way to bridge this gap in public legislation (Rao et al., 2021a, 2021b). Additionally, circular food supply chains pose new food safety risks (James et al., 2022). Public regulators are often unable to act swiftly while addressing these new risks due to procedural requirements and bureaucracy in law-making (Fagotto, 2014). In comparison, private standards can be negotiated relatively quickly and can provide a rapid solution to new risks (Fagotto, 2014).

In some cases, such as charitable redistribution of food, voluntary agreements could be used as a form of private governance as opposed to private standards which are often expensive to implement. Voluntary agreements are contracts between private actors regarding a certain goal and the means to achieve it. These agreements are popular in the context of environmental policy governance as demonstrated through cases involving forest management, water use, and energy efficiency (Cornelis, 2019; Hernández-Sancho et al., 2015; Miljand et al., 2021) and have the potential to strengthen private actors' position in the food waste valorisation sector. Private actors commit themselves to such agreements to gain regulatory reliefs, customer loyalty, and higher product prices.

6. Conclusion

This study explores the phenomenon of food waste valorisation by analysing the experiences of supply chain actors who are engaged in it. Despite our study being limited in its geographic scope and sample size, it offers a new perspective on the

complex and multifaceted problem of food waste management. We empirically demonstrate that supply chain actors involved in food waste valorisation find local embeddedness to be an important aspect of their work. They often take on the responsibility to ensure food safety as a personal duty and face various ethical dilemmas related to repurposing surplus or waste food as food fit for human consumption. Additionally, they are faced with concerns regarding how society perceives food waste valorisation and often grapple with the uncertainties that come with the job. We also discuss the differences in perspectives of participants working with for-profit and non-profit organisations and their implications for addressing the wicked problem of food waste. We propose that professionals with a penchant to help the food system transition to a circular way of operating could be suitable candidates to broker such a transition. Lastly, we posit that private governance tools such as private standards and voluntary agreements could be a way for private actors to better manage the various uncertainties that are characteristic of food waste valorisation endeavours.

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Ethics approval

This study received approval from the Ethics Review Committee Inner City faculties of Maastricht University under reference number ERCIC_196_10_06_2020.

Conflict of interests

The authors declare that there are no conflicts of interest.

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Availability of Data and Material

The first author can be contacted to request a copy of the code book.

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5

How COVID-19 Impacted Surplus Food Redistribution in the Netherlands: An Explorative Study

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Abstract

The COVID-19 pandemic has been detrimental to food security globally. The Netherlands, despite its advanced stage of development, saw a surge in food insecurity among its most vulnerable citizens. Dutch food aid is managed by private charities and social organisations that often aim to address the problems of food insecurity and food waste by redistributing surplus food that is safe to consume. This paper investigates how the pandemic impacted surplus food redistribution in the country by employing an Exploratory-Descriptive-Qualitative approach. This is done by analysing data from interviews with relevant stakeholders involved in redistributing surplus food in the Netherlands as well as media reports on the topic. Our findings indicate that the interviewed organisations experienced drastic fluctuations in supply and demand. To cope with these changes, rapid organisational and supply chain innovation was observed. Next to this, there seems to have been disproportionate negative impact on smaller charities in comparison to bigger, better-established organisations. Based on our findings, we discuss what the future of surplus food distribution in the Netherlands might look like and why changes made during the pandemic must be well documented and carefully analysed.

1. Introduction

At the time of writing this paper, more than two years have passed since the SARS-CoV-2 virus made its presence felt around the world. Based on reports from the media, national governments, and international organisations, it is widely known that the crisis has been detrimental for food security globally (Devereux et al., 2020; Laborde et al., 2020; Swinnen & McDermott, 2020). The Netherlands, despite its advanced stage of development, is home to close to a million people living below the poverty threshold (Centraal Bureau voor de Statistiek, 2021). This threshold is set at 60% of the national median disposable household income allocated to all persons belonging to one household (Centraal Bureau voor de Statistiek, 2021).[2] Poverty in the Netherlands is viewed and calculated in relation to the general level of prosperity of the society. The State ensures that all citizens have access to housing, health care, and food in quantities sufficient to prevent hunger. However, belonging to a low income household considerably affects individuals' ability to participate in society and live a fulfilling life (Centraal Bureau voor de Statistiek, 2019). In the context of food security, this could mean that individuals belonging to low-income households are unable to access nutritious or high-quality foods in sufficient quantities. Refugees, single-parent families, citizens receiving social assistance, individuals with lower levels of education, and those in the 55-65 age group were found to be the most vulnerable to being affected by poverty (Centraal Bureau voor de Statistiek, 2021).

For several individuals belonging to low income households in the Netherlands, food aid or discounted food packages from various privately run organisations across the country were a vital source of food security before the onset of the pandemic (van der Horst et al., 2020). The economic hurdles brought about by the crisis are likely to have made these resources even more crucial. The objective of this paper is to examine how the work of these organisations was impacted by the pandemic.

Surplus food is an important resource for organisations that assist food insecure individuals in the Netherlands. By redistributing this food while it is still safe to consume, these organisations seek to address the highly pertinent issues of food insecurity and food waste. Surplus food is defined as 'edible food that is produced,

manufactured, retailed or served but for various reasons is not sold to or consumed by the intended customer' (Garrone et al., 2014a). Redistribution in this context is to be understood as the distribution (of food) in a way that is different from what was originally planned. Although surplus redistribution alone cannot sufficiently improve food security and reduce food loss and waste, it remains an important way to prevent food from entering waste streams (Midgley, 2014). Ideally, from a resource efficiency perspective, the production of excess food should be prevented whenever this is possible (Papargyropoulou et al., 2014). When prevention is not possible due to technical, economic, regulatory, or other reasons, redistributing this surplus among consumers should be the next priority (Baglioni et al., 2017; Garrone et al., 2016). This can take on several different forms such as reusing surplus food in primary markets by repackaging or remanufacturing, selling it in secondary markets at discounted prices, or redistributing it to food insecure people (Baglioni et al., 2017). This paper looks at selling surplus food in secondary markets at discounted prices and redistributing it to food insecure people in the context of food redistribution operations in the Netherlands.

It is estimated that between 1.77 and 2.55 million tonnes of food is wasted in the Netherlands every year (Soethoudt & Burgh, 2017). Between 2009 and 2015, the Dutch government aimed to reduce the amount of food waste by 20% (Soethoudt & Burgh, 2017). Despite creating several initiatives, businesses and policy makers have not been able to achieve the desired reduction (Soethoudt & Burgh, 2017). At the same time, close to 1 million people out of the 17 million population belong to low-income households and require assistance in gaining access to sufficient quantities of nutritious food (Centraal Bureau voor de Statistiek, 2021; van der Horst et al., 2020). Therefore, redistributing food that is safe to consume and nutritious is an important way to reduce food loss while improving food security in the Netherlands. Globally, the issues of food waste and food insecurity have been exacerbated by the COVID-19 pandemic (Galanakis, 2020). Although national figures indicating the impact of the pandemic on food waste and food insecurity levels are not available at the time of writing this paper, we can speculate that the social and economic disruptions that the country experienced during this time negatively affected both issues.

The first officially recognised COVID-19 infection in the country occurred on February 27, 2020. On March 15, the first 'intelligent' lockdown was announced wherein the government sought to focus on moral appeal and self-discipline as opposed to repression to implement lockdown measures (Kuiper et al., 2020). The months that followed saw the lockdown getting extended, often with stricter measures.[2] Public gatherings, restaurants, and much of social life were heavily restricted in the country in the years 2020 and 2021. These restrictions negatively impacted the economy and in turn, individuals whose livelihood depended on affected sectors. The crisis magnified the vulnerability of the most deprived in Dutch society, who saw their access to healthy and nutritious food reduced (Candel & de Zwarte, 2020). A disruption in the operations of charity organisations is likely to impact those who are dependent on them to meet their nutritional needs as well as businesses who relied on them to manage their surpluses.

In recent years, improving food security in high income countries via surplus redistribution and donation has received much interest from a variety of academic fields. Existing literature examines this phenomena in Dutch (Neter et al., 2016, 2018; Rao et al., 2021; van der Horst et al., 2014, 2020; van der Velde et al., 2019), European (Alexander & Smaje, 2008; De Boeck et al., 2017; De Pieri et al., 2017; Garrone et al., 2014b; Lambie-Mumford, 2016, 2017), and global contexts (Caraher & Furey, 2017; Lambie-Mumford & Dowler, 2015; Riches, 2018; Silvasti & Riches, 2014). By providing the first empirical evidence on how food charity and surplus redistribution in the Netherlands was affected by COVID-19, this paper contributes towards the systematic documentation of the pandemic's impact on the food system and furthers the discourse on the role of private organisations in improving food security and preventing food waste.

2. Methods

Given that the pandemic is ongoing at the time of writing this paper and no previous empirical studies examining the impact of COVID-19 disruptions on food surplus redistribution in the Netherlands have been published, the Exploratory-Descriptive Qualitative (EDQ) method described by Hunter & Howes (2020) was seen as the most

suitable method to conduct this research. The EDQ method allowed us to use a purposeful sampling strategy, collect data through semi-structured interviews, and generate themes from the analysed data. It offered a broad-ranging and systematic approach to understanding and describing a previously unexplored area of social life.

This research is part of a broader study examining food waste valorisation in the Netherlands[2] and received an ethics approval from the Ethics Review Committee Inner City faculties of Maastricht University. All participants interviewed for the larger study were asked about the impact of the pandemic on their operations. Out of the larger sample, eight participants involved with five organisations redistributing surplus food in the Netherlands agreed to be interviewed about their professional experiences pertaining to the pandemic. Separate interviews were then planned with these participants in order to collect data pertinent to this study. Participants were asked how the pandemic and the measures implemented to contain it affected their operations. They were then requested to elaborate on whether they expected these changes to have any long and short-term consequences for their work. Furthermore, they were asked to reflect on the impacts on food security and food waste. Based on the provided answers, we asked additional questions to allow participants to further elaborate on their experiences with food surplus redistribution during this period. Most participants were in senior executive positions in their respective organisations and were directly involved in making pandemic-related changes to their operations. As a result, they were able to share vivid accounts on the subject. Additionally, the five included organisations are diverse in terms of size, mode of operation, and financing. Some have several branches throughout the country while others operate as single organisations. While two offer food parcels containing groceries, others serve prepared meals. Sources of financial support include the national government, local municipal corporations, and private donors. Therefore, despite the limited sample size, our dataset is comprehensive and offers ample insight into the subject. Table 1 provides information about each participant's background.

Table 1. Description of study participants

Participant	Position	Organisation

[2] Results from the broader are presented in Chapter 4 of this thesis

P1	Board member	A well-established network of food charities in the Netherlands with 150+ branches and 10 distribution centres across the country. This organisation donates surplus food to food insecure individuals by composing food parcels containing a variety of food products and ingredients. This organisation will be referred to as 'Charity Network' in this paper.
P2	Board member	
P3	Volunteer recruited for additional procurement during the pandemic	
P4	Chief operating officer	A non-profit organisation providing logistics support to businesses that wish to donate surplus food to soup kitchens and social restaurants. This organisation will be referred to as 'Logistics Help' in this paper.
P5	Project leader and volunteer	A non-profit that prepares free meals from salvaged food from supermarkets and catering at eleven locations in the country. This organisation will be referred to as 'Free Meals' in this paper.
P6	Key account manager	A digital platform that offers customers surplus food from retail stores and catering at discounted prices. This organisation will be referred to as 'Pay It Forward' in this paper.
P7	Co-founder and project manager	A non-profit organisation linking companies with food surpluses to social organizations that prepare meals for vulnerable local residents. This organisation will be referred to as 'Surplus Hero' in this paper.
P8	Founding member and volunteer	An unregulated charity shop with a refrigerator placed outside its premises for anyone to drop off or pick-up surplus food. This organisation will be referred to as 'Community Fridge' in this paper.

For data collection, we used a purposive, snowballing sampling strategy. Participants were originally contacted via email by the first author and interviews were planned after gauging participants' interest in discussing the subject during interviews conducted for another study. In line with the lockdown measures, interviews were conducted online via Zoom between August and November 2020 by the first author. During this period, six to nine months had passed since the virus was first detected in the country. The lockdown measures which were introduced in March and then reinforced more strictly in following months had been relaxed.[2] August to November 2020 also saw a steep increase in the number of infected people.[2] Interview questions were framed keeping these developments in mind. It is likely that these trends also informed how participants perceived the pandemic and its impact on their work. The interviews were in-depth, semi-structured and were conducted in the English language on a one-on-one basis. With the participants' consent, interviews were recorded and were later transcribed *verbatim* using the Otter.ai software. Transcripts were sent to participants via email to allow them to do a factual check. After all participants consented to the transcripts being used for this research, they were analysed using the Atlas.ti software (version 8.4).

In line with the explorative nature of this research, the data were analysed through an inductive approach. The first and third author undertook data analysis independently between December 2020 and February 2021 and later compared and consolidated their findings. The thematic analysis approach by Braun & Clarke (2006) was chosen because it offered theoretical freedom and high flexibility in the analysis of the collected data and fits well with the EDQ method (Hunter & Howes, 2020). The transcripts were first read on their own, allowing us to understand the premises of discussions and note the similarities and differences that arose. Then we used the *in vivo* coding method from Saldana (2021) to generate a first set of codes. This was followed by a second cycle of coding wherein codes that pertained to the same theme were grouped together. Finally, three themes were constructed from the codes. These themes are described in the next section. Wherever necessary, excerpts, quoted *verbatim*, unless modified to improve readability or ensure anonymity, have been used to underpin the findings.

To corroborate observations made from analysing data from the interviews, we used data triangulation as a validation strategy. Specifically, we employed the between-method triangulation strategy described by Flick (2004) because it allows us to use a secondary non-reactive data collection procedure to complement our primary reactive procedure of in-depth, semi-structured interviews. We did this by analysing Dutch media reports published between March and December 2020 about surplus food redistribution. Reports were obtained by searching the LexisNexis database (available via lexisnexis.nl) using '*voedseloverschotten', 'voedseldonatie', 'voedsel liefdadigheid',* and *'voedselhulp'* as keywords. Next to these keywords, names of the participants' organisations were also searched on the database. Analysing the contents of these reports allowed us to gain greater rigor in our analysis and rule out rival hypotheses that could be constructed from the primary data. It also helped us in substantiating factual information such as timelines, quantities of surplus food available, and the strictness of lockdown measures which were mentioned by the study participants.

3. Findings

3.1. Changes in demand and supply

Most participants reported experiencing fluctuations in demand and supply for surplus food. P1 and P2 from the Charity Network were of the opinion that a rise in unemployment might mean that more people will approach their organisation for food parcels. P1 spoke about expectations regarding this in the near future: *"That (increase in demand) has just started. In the big cities, we have already seen an increase of 20 - 25%. In the countryside, it's hardly increased. But if you look at the news, there is an expectation of an increase in the number of unemployed people. We do expect a 50% increase in total."*

The Central Agency for Statistics (Centraal Bureau voor de Statistiek) confirms that the pandemic has resulted in an unprecedented drop in the number of jobs and that the number of hours worked in the second quarter of 2020 was 6.1% lower than in the first quarter (Centraal Bureau voor de Statistiek, 2020). Observations by the FAO also

indicate that owing to an increase in the number of people affected due to the surge in unemployment, food banks across the developed world are expecting a sharp rise in the demand for their services (FAO, 2020). Given this, it is not surprising that the Charity Network recruited additional volunteers to procure food from new sources. P3 was one such volunteer whose service to the organisation included identifying new sources of surplus food and financial support. In the initial months of the lockdown, P3 recalled experiencing an increase in supply from restaurants and caterers and a dip in the quantities received from supermarkets. It can be speculated that having to deal with the disruptions in their own supply chains made supermarkets reluctant to donate. However, at the time of the interview (six months since the start of the lockdown), P3 mentioned that most supermarkets were back on track and regular supply had resumed.

The Charity Network's experience of an increase in demand was not shared by other small-scale organisations such as Free Meals and Surplus Hero. These organisations cook meals using surplus food and offer them to clients who eat together free of cost. Unlike the Charity Network, these organisations do not offer the option to pick up food parcels. Much like restaurants and catering organisations, both were compelled to stop receiving clients when lockdown measures were announced. P4 from Logistics Help informed us that their organisation works mostly with charities that cook meals and operations had to be halted until clients could be hosted for meals again. Despite a sharp fall in demand, Logistics Help received several offers from businesses that wished to donate food in the weeks that followed the lockdown.

Pay It Forward experienced a minor decrease in supply from supermarkets. P6 mentioned that fewer clients seemed to be willing to visit supermarkets to pick up the surplus parcels. Since supply and demand dropped in proportion to one another, the net result was that most of the surplus parcels offered though Pay It Forward were purchased. It is, however, important to note that not all participants or their organisations were able to keep an account of the demand and supply fluctuations. This might be especially true for smaller organisations that depend on volunteers and therefore did not have the resources required to systematically analyse fluctuations. For instance, P5 from Free Meals mentioned: *"It is hard to tell (whether there was a change in demand) because communication took a different route. People normally*

pass by our community houses. And now it is difficult to contact our guests. Some people totally isolated themselves. So, they might be in need of (food) donation but not feeling safe enough to actually open the door or pick it up. So yeah, it's hard to tell. We don't know the specific numbers and whether we actually surpassed normal amount (of meals provided) or not or if there was a higher demand than we could supply."

This fall in demand experienced by organisations that offer cooked meals is likely to be a reaction to the lockdown measures. Based on our findings and news reports that were analysed, it is unclear whether the supply of surplus food has increased in proportion to the demand for it.

3.2. Alternative modes of operating

Most participants mentioned that their organisations developed alternative ways of operating in order to continue redistributing surplus food while following the lockdown measures. Some branches of the Charity Network had to halt their operations and offered clients EUR 30 vouchers per week in lieu of the weekly food parcels. P4 from Logistics Help noticed that some charities they worked with started delivering cooked meals to clients' homes. Free Meals altered their operations in a similar manner and collaborated with professional cooks. P5 described the new way of operating as follows: *"We collaborated with restaurant kitchens that were closed and chefs who were at the moment unemployed and wanted to help us with cooking. They managed the operations in a very structured way; with as few people as possible while following the HACCP guidelines. They even used their own kitchens. From there on, we could just distribute meals to our clients. We were able to find their contact details and deliver meals instead of them stopping by for dinner".* This collaboration exhibits innovation in not only the mode of delivery but also recruiting new volunteers, procuring a new working space, and establishing contact with former clients.

During this period, several community-led initiatives focused on food waste and food insecurity were started in the Netherlands. Some examples include Benefrietjes[3], Aardappelberg[4], Kies Lokaal by Slowfood NL[5], and Support Your Locals[6]. Pay It Forward and Surplus Hero collaborated with some of these initiatives through

volunteering, advertising, and offering advice. Many initiatives that were started during this period were founded on an ad hoc basis and are not operational anymore. The lockdown measures left several farmers who normally supplied to hospitality and catering businesses with surplus fresh produce. Using its digital platform, Pay It Forward attempted to connect interested clients with this surplus. Describing the idea, P6 explained: *"What we did see is that suppliers to food service, mushroom farmers for instance, were left with excess produce. It was a huge pile that they suddenly got stuck with. There was real interest from people because they were sitting at home anyway. They were willing to go to a farmer and buy some mushrooms."* In addition to having the time to carry out this exercise, other factors could have motivated consumers to buy directly from farmers. Consumers could have had an interest in helping farmers, supporting the local economy, purchasing food in a new way, and preventing food from going to waste.

Some participants and media reports indicated that social media platforms played an important role in helping surplus food redistribution continue during this time. For instance, before the pandemic, Community Fridge relied on donors taking notice and stocking the refrigerator on their own accord. This turned out to be an ineffective strategy when lockdown measures were implemented. Under the given circumstances, Community Fridge found Facebook to be a useful tool to ensure that they had a steady supply of food. P8 described their use of Facebook to remind donors (private individuals residing in the neighbourhood) to continue donating: *"I posted a message on Facebook saying please don't forget about the refrigerator, especially now because we need to help each other. Then I saw that it was shared quite widely. And I think after that, the community became more actively involved in keeping the fridge full."*

At the time of their interviews, participants were unable to comment on whether some changes made during this time could be incorporated into their organisations' operations after the pandemic was over and normalcy had returned.

3.3. Disproportionate impact on small organisations

When studying or reporting about surplus food redistribution in the Netherlands, the Charity Network receives much attention from scholars and the media. However, it is not the only organisation in the country working towards improving food security and preventing food waste. Smaller organisations, some of which have been included in this study, play a crucial role in reaching individuals who cannot avail help from the Charity network. However, due to their small size, their work seems to go unnoticed at the national level. This lack of attention and support had severe consequences for smaller charity organisations and their clients during the pandemic.

While the Charity Network, with its large number of volunteers, strong public and donor relations, and structured way of operating was able to benefit from governmental and private support, smaller charity organisation and their work were hardly mentioned in the media. As per the information provided by relevant study participants as well as studied reports, the Charity Network was helped by the Dutch government via monetary support that amounts to several million euros. As of December 2020, the organisation had not spent any part of this amount because it was able to sustain itself without additional help from the government.

In order to avail food parcels from the Charity Network, prospective clients are required to pass a number of criteria related to their income, expenditure, status as a resident, among others. Smaller organisations tend to be less stringent about these criteria and as a result provide aid to those who do not qualify for receiving donations from the Charity Network or those who require additional help next to the parcels received from the Charity Network. P5 from Free Meals mentioned: *"We had to close our locations in March and that was a pain to our hearts. It really felt wrong to do so. We provide critical help for many people, even those who are undocumented immigrants."*

Another major difference between the Charity Network and smaller organisations is that branches of the Charity Network often operate out of premises that are either owned or rented by the parent organisation. As informed by various study participants, smaller non-profits operate out of community centres either by paying a nominal fee or free of cost. When community centres were shut down in line with the lockdown measures, these organisations were unable to continue with their work. A lack of operating premises meant that these organisations could not provide support to clients

even if there was surplus food available. P5 stated this as a reason for halting operations at Free Meals: *"The community houses told us that we could no longer run the operations on their premises. They were instructed by the municipality to not facilitate any group meetings."*

Multiple study participants speculated that had a certain portion of government funds or support from retail or other donors been directed towards smaller organisations, they could have continued to provide critical help to at least a part of the several food insecure individuals that depend on them. P7 from Surplus Hero expressed disappointment with regard to the Charity Network receiving more attention compared to other organisations: *"We saw that a lot of supermarkets are donating to the Charity Network. They only reach 10% of the poor people but everybody is focused only on them. Other social organisations are open for everybody. The 90% who cannot go to the Charity Network, they are helped by us. With the way we work, they not only have a free meal but also social contact. The Charity Network, of course, is doing good work but they only reach a small percentage of the people in need."*

Based on personal exchanges with supermarkets to urge them to resume donations after the lockdowns were eased, P7 wondered whether supermarkets were using the pandemic as an excuse to not donate: *"In the beginning all the supermarkets were really stressed and there was not much left. However, after a while they had surplus but still, they mentioned Corona virus or Corona crisis as a reason to just keep the door shut. A lot of the donation relations stopped for us."*

Overall, our findings indicate that smaller non-profit organisations redistributing surplus food have been severely impacted by the pandemic. In comparison, larger, better established organisations such as the Charity Network, Red Cross, and the Salvation Army were able to continue providing food aid either by purchasing food products or redistributing surplus (Het Leger des Heils, n.d.; Rode Kruis Nederland, 2020). We did not find any media reports discussing this issue, but we did observe that the Charity Network and other large organisations received a lot more media coverage compared to their smaller counterparts.

4. Discussion

Although explorative in nature, our findings indicate that the COVID-19 pandemic has brought about several changes in the way surplus food is redistributed in the Netherlands. As per the findings of this study, increase in demand for food aid, new modes of operating for redistribution organisations, and disproportionate negative impact on smaller charities are the most evident consequences of the pandemic on surplus food redistribution. The shockwaves created as a result of the drastic changes in food supply chains and increased demand for food aid have pushed surplus redistribution operations to transform themselves at an extraordinary pace. Several of these changes and new practices could have the potential to help the food redistribution system build back better.

Some changes presented in section 3 of this paper have the potential to have a positive impact in the long time if adopted systematically even after the pandemic is over. For instance, NGOs and social enterprises could help connect consumers with surplus from farmers or wholesale suppliers. The timely consumption of this food could reduce its likelihood of ending up as waste. Charities and soup kitchens collaborating with professional cooks could help improve the safety and quality of meals provided. If redistribution organisations continue to deliver food parcels or meals even after the pandemic is over, food aid could become more accessible to individuals living with disabilities. Smaller charities could gain social and financial support by strengthening their social media presence. To benefit from the changes that have taken place during the pandemic, it is vital that they are well documented. Larger organisations with sufficient resources can help with this process.

Conversely, changes made during the pandemic must also be critically examined to assess whether they are indeed sustainable in the long term. For instance, disrupted logistics and lesser focus on food waste could have made surplus food unavailable during this period. The Charity Network's plan to set up a foundation that purchases food instead of procuring surplus could be a result of this. On the one hand, surplus food which is available in abundance in the country might end up as waste if charities start purchasing food via conventional supply chains. Instead of allocating resources

for purchasing food, they could be used for improving the process and logistics of redistributing surplus food. On the other hand, critical scholars have suggested that using surplus to feed food insecure citizens is a demeaning practice. Caraher & Furey (2017) suggest that this practice takes away citizens' ability to choose food in socially acceptable and dignified ways. It allows others to make the choice on their behalf by repurposing food that is not considered saleable by the retail sector (Caraher & Furey, 2017). A way to find middle ground could be platforms such as Pay It Forward partnering with the government to provide surplus from retail and service to food insecure individuals free of cost. The fact that this surplus is available to and utilized by food secure individuals as well, albeit at a price, might take away the stigma attached to consuming surplus food.

Another significant finding of this paper has been that smaller organisations engaged in surplus redistribution have been largely excluded from public and private support. While it is understandable that well-established organisations are seen as more reliable due to their track record and visibility in the media, they cannot improve food security and reduce food waste alone. As shown in section 3.3, smaller organisations and community-led initiatives have the potential to reach sections of the society that are inaccessible to large organisations such as the Charity Network. Based on responses of our study participants, it can be speculated that factors such as being an undocumented migrant, cultural preferences, previous experiences with food aid and the requirement to disclose personal information might prevent some individuals from approaching larger organisations. Support in the form of monetary help or donating surplus food can provide a much-needed impetus to smaller organisations.

Our arguments supporting equitable redistribution of surplus food brings to the forefront criticism regarding private entities taking on the role of providing aid to food insecure citizens. The existence of such charities in developed countries has attracted the critique of several researchers who see it as a failure of the State welfare mechanisms (Dowler & O'Connor, 2012; Lambie-Mumford, 2017; Poppendieck, 1999; Riches & Silvasti, 2014). As put forth by van der Horst et al., (2020), hunger brings with it a moral imperative to act. Discussions around whose responsibility it is to provide aid are not an immediate concern (van der Horst et al., 2020). However, the Netherlands' dependence on private organisations to provide aid to the food insecure

and alleviate the problem of food waste is not a reaction to the pandemic. Over the course of the last two decades, private charities have become an important part of looking for a solution to both problems in the Netherlands. When private entities are in charge of addressing such systematic and widespread issues, gaps may emerge in the State's welfare provision and structural problems may go unnoticed or be neglected (van der Horst et al., 2020).

As per Candel & de Zwarte (2020), the COVID-19 crisis shows that the privatisation of food aid harms the most vulnerable in society. They implore the State to view the outcomes of the crisis as an opportunity to make structural improvements to reduce inequalities and food insecurity. Codifying the right-to-food as a formal law would be a step in this direction. Our work affords relevant actors in the Netherlands as well as other high-income countries with similar food redistribution systems an opportunity to address the systemic inefficiencies in food security and food waste management that were brought to the forefront by the pandemic.

5. Limitations and future directions

While the findings discussed in this paper are intriguing, they represent only a first foray into understanding how the COVID-19 pandemic might have impacted surplus food redistribution. Being exploratory in its approach, our study presents some limitations; the first one being the limited sample size. Using this paper as a foundation, an in-depth study with a larger sample size can help validate our findings. Collecting and analysing data on how doners of the surplus food, for example retail, catering, and wholesale establishments, experienced the pandemic could provide a more complete and multi-perspective picture of surplus food redistribution during this period.

A second limitation is that we were unable to cite or provide information about the media reports analysed for data triangulation. This was done so as to maintain anonymity and protect study participants. The need to maintain anonymity posed restrictions on the literature that could be cited in this paper as well. We exclude several papers focusing on specific organisations included in this study to ensure that our participants are protected.

However, no previous studies have presented empirical findings on the topic, and this makes our study an important first step in identifying how COVID-19 affected surplus food redistribution in the country. Once the pandemic subsides, it could be interesting to explore whether any changes made during this period have been incorporated into the regular operations of relevant organisations. This study could also be replicated in other regions of the world to infer how surplus redistribution was impacted on a global scale.

6. Concluding remarks

The aim of this paper was to identify how the COVID-19 pandemic impacted surplus redistribution in the Netherlands. Based on our findings, we conclude that the crisis has led to an increased pressure on food charities that provide aid to food insecure individuals by redistributing surplus food. At the moment of writing this paper, it is unclear whether the supply of surplus food has increased in proportion to the demand. Next to this, smaller organisations in the country received little to no support from the government and the retail sector, both of whom focused on larger, better- established charities. Lastly, the pandemic has led to new ways to redistribute surplus food. Some of these new practices could potentially help in addressing the issues of food waste and food insecurity in a post-pandemic world as well.

Governments, legislative bodies, and civil societies should view the consequences of the pandemic as an opportunity to initiate a conversation regarding the private governance of surplus food redistribution. Given that food waste and food insecurity are significant global problems, stakeholders should start thinking of ways to use this surplus to help feed those who are in need without compromising their dignity.

Notes:

1. A chronological account of the COVID-19 measures in the Netherlands from February 2020 to February 2021 can be found here: https://perma.cc/5YTE-37UV

2. In 2020, EUR 1020 was considered to be the minimum disposable income required by a single person household for subsistence (Centraal Bureau voor de Statistiek, 2021).
3. Benefrietjes was an initiative to help use up the surplus stock of potatoes in the country by encouraging consumers to buy more fries
4. Aardappelberg, translating to 'potato mountain', was an initiative wherein consumers could purchase surplus potatoes from farmers in various Dutch cities at a reduced price.
5. Etenover.nl was a digital platform connecting consumers with surplus from catering and hospitality suppliers.
6. Kies Lokaal by Slowfood NL is an interactive map collating multiple food security and food waste prevention initiatives throughout the Netherlands
7. Support your locals is a website that helps small food businesses by allowing visitors to search for local entrepreneurs in their neighbourhoods and purchase from them directly.

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Data availability

The first author can be contacted to request a copy of the code book.

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6

Food Waste to Biogas and Biofuel: Law & Policy

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Abstract

Waste and surplus from various stages of the food supply chain can be transformed into biogas and biofuel. Based on the EU waste hierarchy, Member States should ensure that food waste is reused to produce bioenergy instead of being incinerated or disposed of in landfills. However, before considering energy recovery, more sustainable ways of dealing with this biomass such as redistribution or donation, reprocessing into new food products, and use as animal feed must be prioritised. To enable this, food and energy policies and legal frameworks must be congruent in their outlook towards circularity. In this chapter, we highlight the current state of these policy areas and examine whether they are moving towards improved coordination. Additionally, we reflect on how waste-to-bioenergy is viewed by relevant stakeholders in comparison to other food waste valorisation options. We also posit that increased interconnectedness among food, feed, and bioenergy private standards could help food business operators better valorise their food waste and surplus.

1. Introduction

Globally, one in three people do not have access to sufficient quantities of safe food. At the same time, one-third of the food produced for human consumption ends up as waste every year. The co-existence of these extremes suggests a need to recalibrate our food system if it is to meet the nutritional needs of the growing population while operating within planetary boundaries. Transitioning towards a circular way of operating, where resources are utilised to their utmost potential, is one way to address both issues. In the context of food waste, circularity would imply developing novel ways of utilising food that becomes unfit for human consumption. Dependent on the field of study and geographic location, many definitions of food waste exist in current literature.[3] In this chapter we define food waste as proposed by the European Commission-funded FUSIONS (2012 – 2016), a project which focused on the harmonisation of food waste monitoring: *'Food waste is any food, and inedible parts of food, removed from the food supply chain to be recovered or disposed'* (Gustavsson et al., 2014). By including biomass from all stages of the supply chain, whether edible or not, this definition provides the possibility to discuss food waste valorisation in the broadest possible way.

Using food waste as feedstock for bioenergy is widely accepted as a way to create value out of surplus or waste food material. The chemical composition of food waste allows for conversion to energy in several ways. Some methods currently employed for this purpose include the transesterification of fats for biodiesel production, fermentation of carbohydrates for bioethanol or biobutanol production, anaerobic digestion for biogas production, and incineration (Girotto et al., 2015; Pham et al., 2015). For the bioenergy industry, recovering energy from food waste is a lucrative opportunity because waste is considered a zero cost material and its composition allows for the development of cost-effective and commercially viable methods to produce biofuel and biogas (Karmee & Lin, 2014). Bioenergy created from food, which

[3] Of the various definitions of food waste that are currently in use, many make the distinction between food loss and waste. For instance, the FAO (2011) defines food waste as "decrease in the quantity or quality of food resulting from decisions and actions by retailers, food service providers and consumers". Decrease in quantity and quality of food in earlier stages of the supply chain such as agriculture is termed as food loss. However, in this chapter we will work with the definition proposed by EU FUSIONS which does not distinguish between loss and waste.

would have otherwise ended up expanding landfills, is lauded for its two-fold contribution towards sustainability. First, it offers partial replacement for conventional energy resources that face the threat of dissipation. Second, using food waste, a biomass that is at the end of its life cycle, instead of food crops for generating bioenergy circumvents the food versus fuel debate.[4] Therefore, from the perspective of energy policy, biofuel and biogas that use food waste as feedstock merit an elevated status. In line with this, policy and legislation surrounding the topic have incentivised the redirection of food waste towards energy recovery in recent years. As a result, businesses in the European Union (EU) have been increasingly investing in infrastructure that enables this kind of valorisation. However, from a food policy perspective, using food material for generating bioenergy may not be seen as an ideal valorisation route; it robs this biomass of the opportunity to be utilised for some of its unique characteristics such as nutritionally or biologically valuable compounds.

This chapter will address both food and energy policies and compare their considerations of food waste as feedstock for bioenergy. Section 2 provides an overview of current laws and policies that govern food waste valorisation in the EU. Section 3 elaborates on the end-of-waste status in the context of food waste valorisation. Section 4 sets out how waste-to-bioenergy is perceived in comparison to other valorisation options by relevant stakeholders and whether its low position in the food waste hierarchy is justified. Section 5 explores whether better cooperation between food, feed, and energy private standards could aid food business operators (FBOs) in making the right decision when valorising food biomass. Section 6 present concluding remarks.

2. Current state of food waste valorisation in the EU

The 2011 ‘Roadmap to a Resource Efficient Europe’ was the first EU policy document to explicitly mention a food waste reduction goal. The roadmap recommended a 20% reduction in the food chain's resource input by 2020 (European Commission, 2011). It suggested that this should be achieved by halving the disposal of edible food, but the roadmap did not provide further guidance. Since then, several discussions have been

[4] See Tafesework Geletu & Poto, 2019; Tomei & Helliwell, 2016.

had at EU as well as MSs-levels regarding reducing food waste, first through preventative actions and then via valorisation of any remaining food materials.[5]

Although relatively new on the policy agenda, food waste has rapidly become an environmental issue requiring urgent attention. In 2017, the Commission adopted the 'Resource Efficiency: Reducing Food Waste, Improving Food Safety' resolution which reiterates previous EU-level discussions on the subject (European Parliament, 2017). It invited Member States (MS) to measure food waste levels using a common methodology, officially adopt a food waste hierarchy based on Article 4 of Directive 2008/98/EC and provide clarification regarding the implication of various pieces of domestic legislation on food waste. Most notably, the resolution called on MS to examine the possibility of setting up binding, Union-wide food waste reduction targets by December 2020 (European Parliament, 2017). This is the first ever mention of legally binding targets with regard to food waste.

In May 2020, the Farm to Fork Strategy indicated that the Commission would propose legally binding targets for food waste reduction based on data expected from Member States in 2022 (European Commission, 2020). While the intention to set up legally binding targets shows political will to reduce and better utilise food waste, tangible actions in the direction are yet to be seen across all MS. Currently, no legislation or policy document at the EU level provides concrete guidance regarding food waste valorisation (European Commission, 2020). However, the Commission's Sustainable Food System Framework Initiative, (European Commission, n.d.) which at the time of writing this chapter is pending public consultation, has the potential to change this. The impact assessment for this proposed regulation mentions improved food loss and waste management as well as better recovery and redistribution of surplus food as one of its likely impacts (European Commission, 2021a). When adopted in 2023, it is probable that it will be among the first food-focused regulations to address the reduction and valorisation of food waste (European Commission, 2021a).

[5] Some notable discussions and documents that focused on food waste to varying degrees include the 2012 resolution on how to avoid food wastage, the 2013 consultation on Communication on Sustainable Food, the 2013 (7th) Environmental Action Programme, the 2014 Circular Economy Package, and the 2015 Closing the Loop action plan.

Of the numerous legal and policy areas that affect food waste valorisation, waste law is perhaps the most significant. Food law (Regulation (EC) No 178/2002) comes a close second but excludes food that is no longer considered fit for human consumption. Instead, it focuses on consumer interest, human health, and effective functioning of the internal market. It is therefore the Waste Framework Directive (Directive 2008/98/EC, WFD hereafter) that regulates food waste and its valorisation. The WFD lays down definitions and best practices related to waste management and includes environmental protection, human health, and resource efficiency in its scope. The current version of the WFD was adopted in November 2008.

In May 2018, the WFD was amended through the adoption of Directive (EU) 2018/851. With this amending directive, food waste was recognised as a special category within biodegradable waste. This is a noteworthy change because the 2008 Directive simply considered food waste as part of bio-waste; detaching it from its value as a basic human need and natural resource different from other biomass (Bradshaw, 2018). By contrast, the amending directive includes a separate definition for food waste, derived from the EU General Food Law's (GFL) definition of food. For the first time since 1975, when the first WFD was adopted, a link between legislation on food and waste has been established. However, it is interesting to note that the GFL defines food as "any substance or product, whether processed, partially processed or unprocessed, intended to be, or reasonably expected to be ingested by humans" (Regulation (EC) No 178/2002, Article 2). Therefore, the WFD's definition only considers the wastage of food that humans can be reasonably expected to ingest as food waste. In contrast to this, the EU FUSIONS definition considers wasted inedible parts of food to be food waste as well. By excluding inedible parts such as pits, peels, and trimmings from the definition, the current WFD deprives a significant volume of food waste from being considered as such. Therefore, despite the WFD adopting a definition for food waste, food processing by-products may end up being categorised as bio-waste instead of food waste.

Article 9 of Directive (EU) 2018/851 guides MS to take measures to reduce food waste at all stages of the supply chain in line with the (non-binding) United Nations' Sustainable Development Goal 12. Article 9(h) also states that donation and redistribution should be prioritised over use in animal feed or reprocessing into non-

food products. This change is highly relevant with regard to food waste valorisation because never before in the history of EU waste law has the waste hierarchy been modified to accommodate the unique characteristics of food waste. Additionally, in May 2019, a Commission delegated decision (Commission Delegated Decision (EU) 2019/1597) supplementing the WFD was adopted. This decision establishes a common methodology and minimum quality requirements for the uniform measurement of levels of food waste in MS. Considering that data on the measurement of food waste is an important step towards its valorisation, the delegated decision is a step in the right direction if binding targets are to be set in the coming years.

In the context of valorising food waste as feedstock for bioenergy, legislation on renewable energy is relevant as well. In December 2018, (RED II) replaced the existing Directive 2009/28/EC on the promotion of the use of energy from renewable sources (RED I). When considering bioenergy that uses waste as feedstock, RED II relies on the principles of the WFD by referring to 2008/98/EC wherever relevant. In comparison, RED I considered waste biomass independently, without referring to legislation on waste management. This connection between legislation on renewable energy and waste management has the potential to improve the way in which MS valorise their food waste. RED II directs MS to consider the principles of the circular economy and the waste hierarchy when developing support schemes for renewable energy (Directive (EU) 2018/2001). Additionally, with regard to meeting renewable energy targets for the transportation sector, RED I (art 21 (2)) considered the contribution made by biofuels produced from waste to be twice that of other biofuels. RED II introduces an important nuance to this. Annex IX (part A (d)) of RED II listing feedstocks for the production of biofuels that can be considered twice for their energy content specifies that only biomass which is 'not fit for use in the food or feed chain' can be counted as such.[6] This is a significant addition with the potential to prevent material fit for higher levels of valorisation from being redirected for energy production. Another salient feature of RED II is that it explicitly states that waste prevention and recycling should be given priority over being used as feedstock for biofuel and that MS

[6] An exception is applicable in the case of used cooking oil and animal fats classified as categories 1 and 2 in accordance with Regulation (EC) No 1069/2009. Section 3 will discuss this further.

should avoid creating support schemes leading to the inefficient use of waste that is recyclable (Directive (EU) 2018/2001, para. 21). The transposition to RED II was to be achieved by MS by June 2021 and therefore, at the time of writing this chapter,[7] there is no data available to indicate whether RED II has made a significant difference to the way in which food waste is utilised as feedstock for bioenergy.

In line with the rapid developments in this area, a proposal to amend RED II was published by the Commission in July 2021 (European Commission, 2021). When addressing food as feedstock for biofuel, the proposal focuses on food and feed crops. Changes likely to impact how food waste is used for energy recovery are numbered. One among these is a proposal to remove biomass from the list of renewable resources. Ninety-nine percent of the 38,786 participants involved in the creation of the proposal voted to limit the use of biomass for energy recovery to locally available waste and residues (European Commission, 2021). If approved, this change would make waste streams exceedingly important as feedstock for biofuels while allowing biomass such as food and feed crops, along with the land required for their production, to be available for their primary purpose of ensuring food security.

Overall, recent changes to waste and renewable energy law have improved the interconnectedness between the two areas and recognised food waste biomass as different from other biomass. Contingent on the interpretation and implementation by MS, these changes have the potential to make sure that food waste is used as feedstock for bioenergy only if higher priority valorisation options such as donation, use in animal feed, or extraction of valuable biological compounds are not feasible. In addition, both legislations prioritise other valorisation routes for food waste over being utilised as bioenergy feedstock. This is likely to reduce the incidence of competing policy goals at MS level.

3. End-of-waste criteria and food waste

To transition to a circular economy, materials that are classified as waste at the end of their lifecycle must be transformed in a way that enables their reintroduction into the

[7] Chapter written in November 2021.

economy. In the 2008 update of the WFD, legal provisions for conferring end-of-waste (EoW) status to such transformed material were introduced (Directive 2008/98/EC). The directive states *inter alia* that waste materials that had undergone specific recycling or recovery processes could be classified as EoW if market demand for them existed and if their use would have no adverse environmental or health impacts (Directive 2008/98/EC, Article 6). Despite the EU Joint Research Centre developing EoW criteria for several materials, currently EU-level criteria exist only for three kinds of waste; iron scrap, copper scrap and glass cullet.(Johansson & Forsgren, 2020) For most other materials, MS are responsible for deciding when a certain waste material ceases to be waste (Johansson & Forsgren, 2020). Discussions on EoW do not often overlap those concerning the valorisation of food waste. However, a 2019 decision of the Court of Justice of the European Union had a significant impact on the valorisation of waste vegetable oil as biofuel.

In 2016, Prato Nevoso Termo Energy Srl ('Prato Nevoso'), an Italian power plant operator, wished to replace methane that was used in its operations with a bioliquid obtained by chemically treating used cooking oil and its residues. The producer of this product had the permit to market it as in EoW product within the ambit of the relevant Italian law. The EoW status was granted in relation with its use for biodiesel production. Since used vegetable oil was not part of a national list indicating the categories of biomass fuels that could be used in operations producing atmospheric emissions, a provincial court denied Prato Nevoso the authorisation to use it as an EoW product. This decision was challenged by Prato Nevoso on the basis of its violation of Article 6 of the WFD setting rules on EoW as well as Article 13 of the RED I that obliges MS to streamline administrative procedures concerning the use of renewable energy. The European Court of Justice (ECJ) was therefore requested by the involved parties for a preliminary ruling.

The ECJ referred to its decision in the *Tallina Vesi* case wherein it was found that Article 6 of the WFD does not, in principle, allow the waste holder to demand the recognition of EoW status by a competent authority or court of the MS (*Prato Nevoso Termo Energy* vs *Provincia di Cuneo and ARPA Piemonte,* 2019, para 31). Furthermore, the ECJ confirmed that MS have a wide margin of discretion with regard to establishing appropriate procedural arrangements as well as the substantive

examination of compliance with the conditions for EoW status (*Prato Nevoso Termo Energy* vs *Provincia di Cuneo and ARPA Piemonte,* 2019, para 36). The Court's judgement established that since the used vegetable oil was not included in the list of authorised fuels, the bioliquid in question must be regarded as waste and not as a fuel (*Prato Nevoso Termo Energy* vs *Provincia di Cuneo and ARPA Piemonte,* 2019, para 41).

This decision of the ECJ highlights that in the EU, food waste valorisation by way of energy recovery is dependent on MS's interpretation and application of relevant legislation. Despite waste material such as used vegetable oil, husks, cobs, nut shells, and residues from processing such as crude glycerine and bagasse having low greenhouse gas emission values as per RED II, whether they can be used as EoW products is, in many cases, left to the discretion of competent authorities and courts of individual MSs.[8]

4. Competing valorisation options

In recent years, the waste hierarchy has been adapted by various institutions and scholars to address food waste.[9] In all versions of the adapted hierarchy, prevention is the topmost priority. The least preferred option is disposal without obtaining any value from the biomass. All options listed between the most and least preferred ones are valorisation routes because they seek to derive value out of material that would have otherwise gone unexploited. Figure 1 presents a version of the waste hierarchy adapted by REFRESH (2015 - 2019), a European Commission-funded project focused on food waste reduction (Wunder et al., 2018). This model places the option of recovering energy from food waste at the bottom of the hierarchy, making it the least preferred valorisation option. However, in practice, the waste-to energy route might be preferred by FBOs over other options. This section will explore if energy recovery competes with higher priority options and whether the low priority designated to it is justified.

[8] These materials, among others, are listed as having low emissions in Annex V of Directive (EU) 2018/2001 (RED II) which lays down the rules for calculating the greenhouse gas impact of biofuels, bioliquids and their fossil fuel comparators.

The most preferred valorisation option as per the hierarchy is redistribution and reprocessing of safe and edible surplus food for human consumption. Redistribution is traditionally carried out by hunger relief organisations and social enterprises that

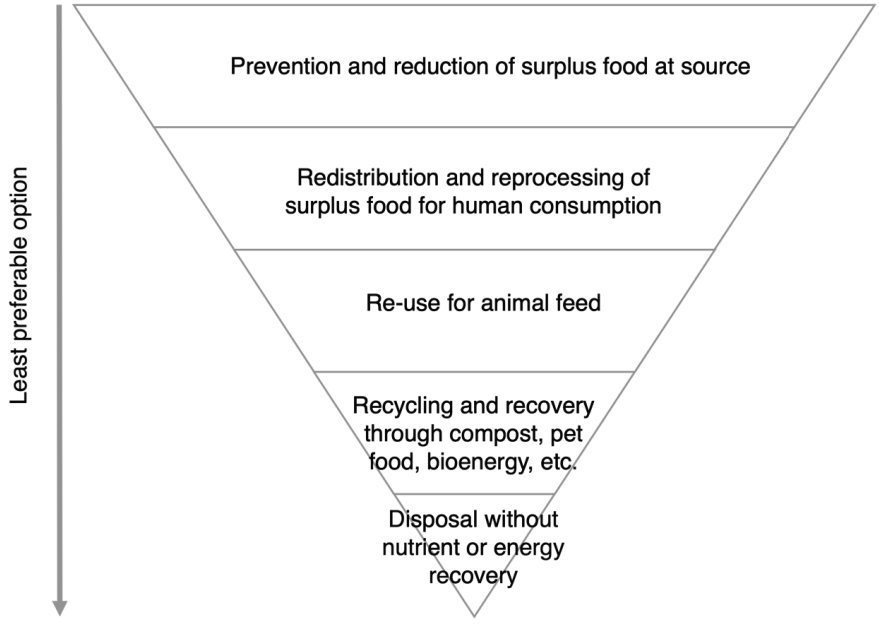

Figure 1 The Food Use Hierarchy as presented by Wunder et. al. (2018)

collect surplus food from retailers and redistribute it to those in need. However, taxation and food safety related liability are two critical bottlenecks in this kind of valorisation. Under normal circumstances, value-added tax (VAT) is paid by consumers when they purchase the food product. However, if food is donated, the retailer must pay VAT unless MS level legislation allows otherwise (Eriksson et al., 2020). Next to this, food safety is an important concern. When retailers or suppliers choose to donate food, they often have little or no control over its handling and storage, but the GFL holds FBOs liable if any food safety issues arise. This can have serious legal and reputational consequences for businesses. As a result, discarding surplus food or removing it from the food supply chain becomes cheaper and easier than donating it (Eriksson et al., 2020).

Food or its by-products that are fit for human consumption may also be retained in the food supply chain through reprocessing. Such surplus is usually generated at the

manufacturing or processing stage and is easier to valorise compared to surplus from other stages due to its homogeneous nature. Trimmings from fresh produce, whey from the dairy industry, oil seed cakes, and spent grains are examples of by-products that can be valorised in this manner through the extraction of valuable biological components (Rao et al., 2021b). However, FBOs must deal food safety risks such as higher pesticide concentration and biological deterioration during storage or transportation (Rao et al., 2021b). Reprocessing by-products also often requires investment in new technologies and legal accommodations (Rao et al., 2021b).

Against this background, if FBOs are offered fiscal incentives to send their waste to energy recovery, it is likely that they will consider it a more inviting choice (O'Connor et al., 2014). For instance, Bowman et al. (2020) point out that 19,898 tonnes of food fit for human consumption was redirected to anaerobic digestion by UK's largest food retailer in 2017-18. Some MS even prioritise waste-to-energy valorisation over redistribution of surplus to improve food security. Sweden, for example, frames food waste as an environmental and economic issue and therefore does not consider the social dimension of food security while making policies that tackle food waste (Johansson, 2021). In 2017, the Commission published guidelines on food donation with the aim to clarify relevant provisions in EU legislation and promote a common interpretation of rules across MS and regulatory authorities (European Commission, 2017). Given the non-binding nature of these guidelines, it is up to MS to amend relevant pieces of legislation and to ensure that donating or reprocessing surplus food for human consumption becomes the most favoured valorisation option.

Reusing food waste for animal feed is the next level of the hierarchy. This practice can address two pressing environmental issues simultaneously: reducing the negative impacts of meat production and reducing food waste. Several food processing by-products such as spent grains, fresh produce trimmings, and oilseed meals are currently successfully valorised as animal feed in the EU (Rao et al., 2021b). Next to this, surplus food from various stages of the food supply chain, known as former food products, are also redirected to animal feed (Luciano et al., 2020). By using food waste and surplus to feed livestock, the biomass partially fulfils its original purpose by remaining within the food supply chain. However, not all food surplus and by-products can be valorised in this manner. EU feed regulation heavily restricts the use of animal

products in animal feed to prevent the spread of prion disease. These restrictions are informed by the 1986 bovine spongiform encephalopathy (BSE) outbreak which was caused largely due to the mismanagement of animal feeding. As a result, animal by-products are often excluded from higher valorisation routes (Rao et al., 2021b). This not only includes products from meat processing operations but also domestic food waste and leftovers from catering operations that may contain traces of meat or cannot be verified for the absence of meat.

EU regulations in this area are known to be among the most stringent in the world and only a small volume of products that may contain meat and animal by-products are currently used for the purpose of animal feeding despite the high nutritional value they offer (Jędrejek et al., 2016). According to results from REFRESH, these restrictions cannot be scientifically justified in the case of non-ruminant livestock that are not susceptible to prion disease (Broeze & Luyckx, 2019). REFRESH underlined that changes in legislation could allow over 14 million tonnes of surplus food to be safely valorised as non-ruminant feed (Luyckx et al., 2019). Results from the project indicated the need to adjust Regulation (EC) 999/2001 which prohibited the feeding of meat to all herbivorous and omnivorous farmed animals (Broeze & Luyckx, 2019). Excluded from animal feeding, conversion to bioenergy becomes the most feasible valorisation route for animal by-products and food waste that has come in contact with animal products.[9] In doing this, however, animal products are insupportably removed from the food supply chain. However, a recent amendment to Regulation (EC) 999/2001 has the potential to change this. In August 2021, Commission Regulation (EU) 2021/1372 was adopted. Subject to various hygiene, safety, and traceability conditions, the new regulation reauthorises the use of processed animal proteins derived from pigs and insects in poultry feed, processed animal proteins derived from poultry and insect in pig feed, and gelatine and collagen of ruminant origin in the feed of non-ruminant farmed animals (Commission Regulation (EU) 2021/1372). Combined with appropriate market incentives and strict enforcement, this amendment can be a game changer for valorising food waste as animal feed.

[9] Within this valorisation route as well, many animal products end up being incinerated as opposed to be being sent to anaerobic digestion plants. Regulation EC No. 1069/2009 allows only certain kind of animal products (categories 2 and 3) to be sent to anaerobic digestion plants.

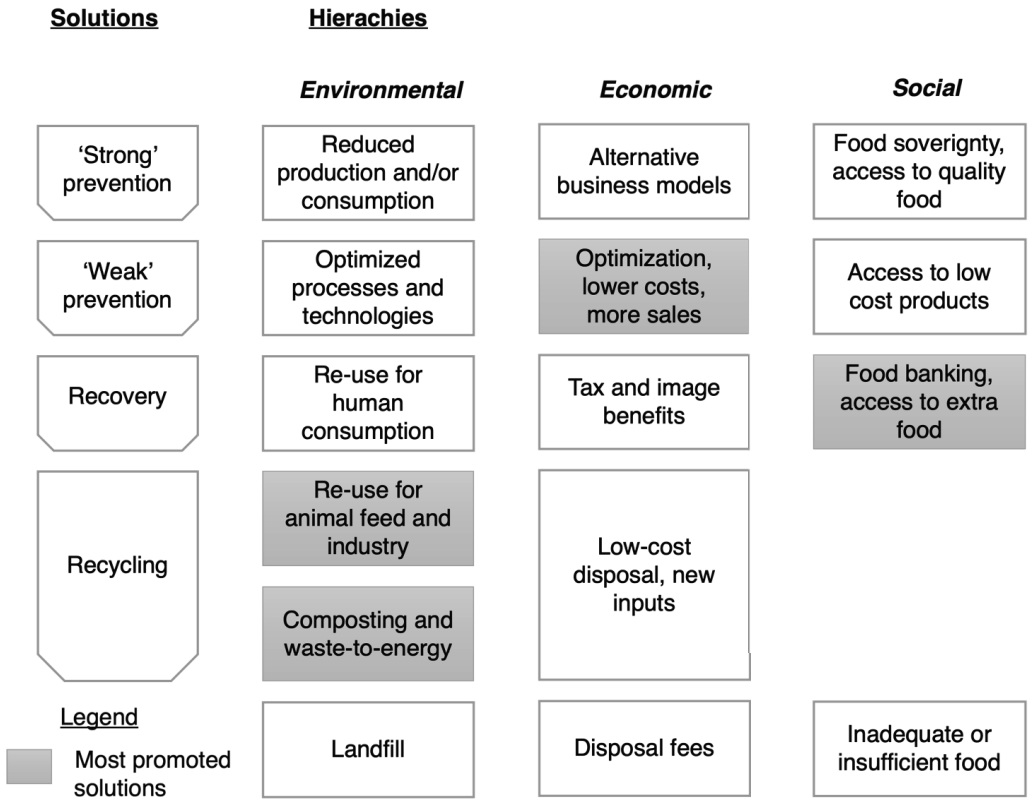

Figure 2 Competing hierarchies of solutions to food waste as presented by Mourad (2016)

When comparing the position of various valorisation options, Marie Mourad's work on competing hierarchies of food waste solutions is especially noteworthy (Mourad, 2016). As illustrated by figure 2, her research indicates that different valorisation routes may be seen as the best fit depending on which lens the issue is viewed through. In the environmental sustainability context, waste-to-energy is seen as more desirable than other options such as food donation or the sale of food products for lower prices. This is due to the success of different valorisation options being evaluated using different criteria. For instance, environmental impact is measured by parameters such as carbon dioxide emissions and effect on soil and water whereas social impact is measured by the number and kind of calories, and economic impact by savings or profits (Mourad, 2016).

Results from Mourad's work indicate that despite being at the bottom of the hierarchy, companies and municipalities show a strong preference for the waste-to-energy route. A notable advantage of this kind of valorisation is that its positive impact can be easily measured by quantifying waste diverted from landfills (Mourad, 2016). The legislative push to use waste, food or otherwise, to fulfil renewable energy targets has also led to MS undertaking fiscal measures such as tax incentives to reward businesses that send their waste to energy recovery (Mourad, 2016; Wunder et al., 2018). She concludes that in terms of social, environmental, and economic values, various valorisation routes constitute competing categories when positioned in a hierarchical manner (Mourad, 2016).

This brings us to the question of whether the ranking of valorisation options through a hierarchy can be justified in the first place. When considered on its own, converting food waste to bioenergy presents much promise in the circular bioeconomy. It allows for biomass to be valorised without the health and safety risks associated with higher priority valorisation options while at the same time, reducing dependence on fossil fuels and first-generation biofuels. Nadine Arnold (2021), in her work on competition in the food waste hierarchy, discusses this from the perspective of organisation theory. Unique to the situation of food waste valorisation is the likelihood that actors involved in lower-ranking valorisation operations do not have any interest in achieving a 'better' position in the hierarchy (Arnold, 2021). Arnold elaborates that bioenergy producers (Swiss biogas plants in the case of her study) dissociate themselves from the broader field of food waste by creating their own sub-field centred on food waste recovery. By exercising linguistic nuances, these actors shape the discourse in their sub-field to their advantage (Arnold, 2021). In the Swiss case, terms that signal 'food waste' (*Verschwendung* in German and *gaspillage* in French) are rarely used. Instead, terms like *Abfall* (German) and *déchets* (French), meaning unwanted material, are used. This way, the biogas plants convey the message that they transform unwanted and worthless materials into something of value. Despite bioenergy created from food waste ranking low in the food waste hierarchy, it is viewed favourably when compared to other sources of energy. It can therefore be argued that it is not the actors involved in these various valorisation operations that compete with one another. It is, instead, FBOs that feel the pressure to choose the most sustainable option and justify this

choice. In doing this, their social (people), environmental (planet) and economic (profit) priorities may come in conflict with one another.

It is worthwhile at this point to discuss whether the people-planet-profit approach to sustainability, also known as the triple bottom line, is effective when designing policies aimed at optimising food waste valorisation. The concept of the triple bottom line is rooted in the field of management science and was proposed by Elkington (1994) to operationalise corporate social responsibility. Kuhlman & Farrington (2010) propose that separating the environmental aspect from the social and economic ones might be a more sensible approach when it comes to assessing the impacts of sustainability policies. They suggest that because the social and economic dimensions of sustainability consider the needs of the present while the environmental dimension considers the needs of the future, they must be viewed separately. Kuhlman and Farrington propose to call the former well-being and the latter sustainability.

Applying this reasoning to food waste, we suggest setting different priorities for the different stages of food biomass. When food is a commodity that is saleable to consumers for its nutritional value, it is of greater consequence for meeting the needs of today. This kind of food must be prevented from turning into waste. At this stage, both strong (systemic change) and weak (process optimisation) prevention strategies as described by Mourad (2016) must be applied. If prevention fails, redistribution and donation of such food must be considered and supported by relevant legislation. If food processing by-products can be safely reprocessed into new food products, this must be considered after or alongside donation and redistribution. In doing this, however, once food is no longer safe for human consumption, environmental sustainability must become a priority. This is because the way in which this biomass is dealt with will impact the future. Whenever feasible from a safety and nutrition perspective, such food must be reused as animal feed because it offers more environmental benefits as compared to valorisation in the form of energy recovery (Salemdeeb et al., 2017). If the biomass is unfit for use in animal feed, it must be

considered for energy recovery, first through anaerobic digestion and then incineration (Papargyropoulou et al., 2014). Figure 3 presents this bifurcated hierarchy.

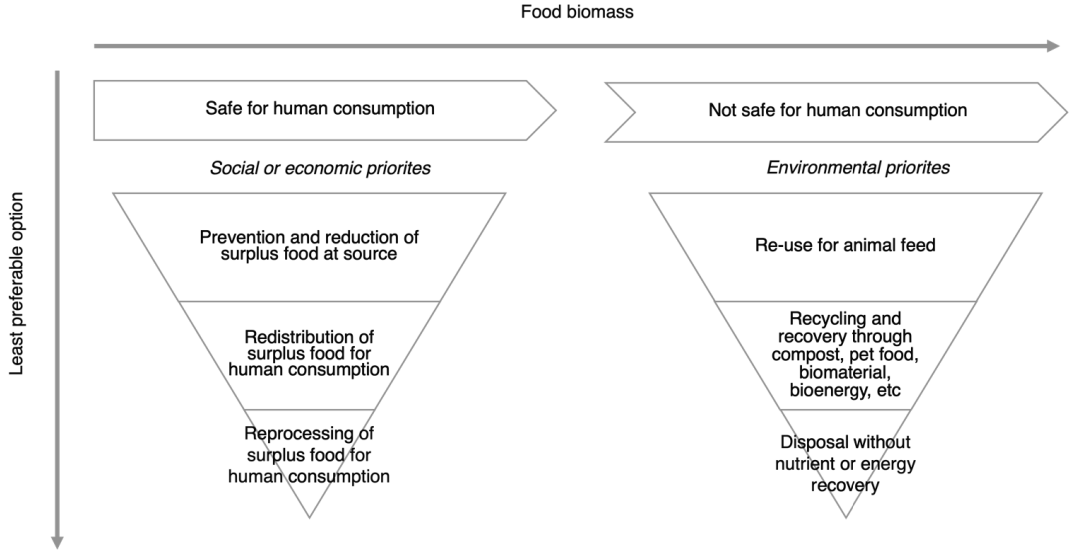

Figure 3 Bifurcated food use hierarchy

For this approach to be practicable, FBOs must be provided with pragmatic guidelines. While public law plays an important role in facilitating this, co-regulation by private actors may be able to help businesses deal with the liability and risks that come with food waste valorisation. FBOs have utilised private standards, a means of private co-regulation, as a tool to cope with regulatory uncertainty for over two decades now. In the following section, we will deliberate on whether such standards can help facilitate better food waste valorisation.

5. Private standards and food waste

As described above, safety for human consumption is key when choosing the most fitting valorisation option for food surplus and waste. In the EU, food safety is overseen by the GFL (Regulation (EC) No 178/2002). Since its introduction, the GFL has developed around the idea of food safety being the combined responsibility of the State and private actors (Rao et al., 2021a). Paragraph 30 of the preamble to the GFL

explicitly places responsibility on FBOs by stating that they have the primary legal responsibility for ensuring food safety. Regarding the responsibility of businesses, Article 17 states: *'Food and feed business operators at all stages of production, processing and distribution within the businesses under their control shall ensure that foods or feeds satisfy the requirements of food law which are relevant to their activities and shall verify that such requirements are met'.*

Given that the exact means to fulfil this responsibility are not specified, FBOs are left in a state of regulatory uncertainty (Charlier & Valceschini, 2010). To cope with ambiguity, FBOs use contracts, hygiene guides, and food safety management systems to specify criteria such as contaminant levels, handling and storage requirements, and quality specifications (Appelhof & van den Heuvel, 2011; van der Meulen, 2011). Influential actors like supermarket chains, trade organisations, and multinational corporations develop and enforce their own food safety management systems (Appelhof & van den Heuvel, 2011; Rao et al., 2021a). In addition to compliance with GFL and international law, these systems also cover consumer expectations (Appelhof & van den Heuvel, 2011). Although technically voluntary in nature, food safety management systems (also known as standards or schemes) that are created or favoured by influential actors have become *de facto* mandatory in agri-food supply chains (Rao et al., 2021a). Standards that were once established with the aim of regulating food safety have expanded their scope to include several contemporary issues such as labour conditions, animal welfare, and environmental impacts of food production (Henson & Humphrey, 2010; Rao et al., 2021a). This is often done by adding plug-ins to existing standards or through collaborations between two private standards specialising in different aspects of food production and trade. We posit that food waste prevention and valorisation could also be incorporated into private food safety standards in a similar manner.

It is expected that private standards already influence the state of food loss and waste. On the one hand, through prescriptive and often unduly strict product specifications, private standards can cause perfectly safe food products to be classified as unwanted or unsalable (Rao et al., 2021a). On the other hand, they can help prevent food waste by improving traceability, aiding in the early identification of food safety issues, and reducing product failure (Rao et al., 2021a). By taking cognizance of these impacts,

standards can be optimised to prevent food waste. Where prevention is not possible, they can help FBOs decide on the most suitable valorisation option. In the case of reuse as animal feed, private standards are already instrumental in helping FBOs adhere to feed safety requirements.[10] This cooperation can be replicated in food-to-energy or feed-to-energy valorisation.

Similar to the food sector, the European bioenergy sector is no stranger to private standards. RED II encourages co-regulation by directing actors to demonstrate compliance with sustainability criteria through Commission-recognised voluntary schemes (Majer et al., 2018). In fact, this model of compliance checking has inspired several other sectors of the bioeconomy to develop similar certification schemes (Selbmann & Pforte, 2016). As a result, actors in the bioenergy supply chain, like those in the food and feed supply chains, work according to the chain of custody principle (Romppanen, 2012). Connecting food and feed safety standards with bioenergy standards could aid FBOs in directing biomass that can no longer be used for food and feed purposes to energy recovery. In line with public legislation on waste, renewable energy, and food moving towards improved interconnectedness, private standards must follow suit to allow for these changes to be practicable for market actors. For the circular bioeconomy model to succeed, it is critical that the traceability of biomass is ensured in not only individual supply chains but also when biomass is transferred from one supply chain to another. Majer and colleagues (2018) propose the development of meta-standards based on the mutual recognition of different certification frameworks that play a role in the bioeconomy. They also point out that most standards, whether food, feed, or energy, do not consider the end-of-life (EOL) scenario for biomass (Majer et al., 2018). It is likely that standards, even those focused on sustainability related issues, are designed for linear, cradle-to-grave or cradle-to gate operations. Therefore, EOL scenarios are either not given much importance or included as an afterthought. Instead, if standards are designed keeping in mind that many supply chains, especially those dealing with biomass, are likely to move to a circular, cradle-to-cradle way of operating in the future, EOL scenarios would become significantly more important.

[10] See for example standards such as GMP+, Qualimat, and FAMI-QS that work with several food producers to set requirements regarding food products that can be valorised through reuse in animal feed.

Private regulation, especially in the United States, seems to already be moving in this direction. Cradle to Cradle Certified® is a US-based scheme that certifies the 'circularity' of materials, products, and systems. The Upcycled Certified Program, which is also US-based, certifies the environmental credential of food products made from by-products. It is, however, important that such standards develop in tandem with other standards that regulate this area. Like it is the case with public policy, cooperation instead of competition is the need of the hour in the private regulation space if biomass is to be utilised in a manner that is fair and environmentally sustainable.

This brings us back to Mourad's distinction between strong and weak measures to prevent food waste. As defined in her work, a weak food waste prevention strategy is one that '*relies on the belief that improved processes and technologies without a fundamental change in business models are enough to significantly prevent and almost eradicate waste*' (Mourad, 2016). This approach is criticised because it relies primarily on companies' voluntary commitment to reducing waste (Mourad, 2016). However, considering the urgent need to address the issue of food waste, the role of private actors can be no longer be seen as voluntary or optional. In contrast to weak prevention is strong prevention which proposes to reduce food waste through comprehensive, systemic changes such as the implementation of short food supply chain models and avoiding overproduction (Mourad, 2016). Modifying private standards, without changing the way in which business that implement them operate, would be classified as weak prevention. However, even weak prevention strategies have the potential to drive systemic change in the long run. Increased cooperation among food, feed, and bioenergy private standards can help drive this change by translating the new interconnectedness in public law on these topics to a language that businesses are well-versed in.

6. Conclusion

This chapter discusses the valorisation of food as energy in the European Union. It is evident that the pressure to meet global and regional sustainability goals is driving EU

legislators to consider food waste as a multidimensional issue that is impacted by a broad range of policy areas. The legal patchwork that oversaw food waste valorisation is gradually being replaced by pieces of legislation that are better aligned with one another. However, the food waste hierarchy model that forms the backbone of all legislative changes concerning food waste might cause various valorisation options to compete with one another. Despite energy recovery being ranked the lowest among valorisation options, it may end up being seen more favourably by FBOs since it helps keep food out of landfills while avoiding the safety risks and costs associated with reuse as food or feed.

To prevent such competition, we propose that valorisation options for food be based on its safety for human consumption. By prioritising economic and social wellbeing when food is fit for human consumption and environmental sustainability when it is not, conflicts between FBOs' economic, social, and environmental priorities may largely avoided. At the same time, businesses are likely to require additional support in their decision-making process when it comes to choosing the most suitable option for their food surplus or waste. In both the food and energy sector, public law affords private actors the opportunity to self-regulate some aspects of decision making and compliance. Private regulation measures such as voluntary standards may offer a bridge that allows the sustainable and fair valorisation of food waste. In line with the legislation on these subjects, private standards on food, feed, and energy must better cooperate to enable transitioning to a future where biomass at the end of its life in one supply chain is safely utilised in another.

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7

What does it take to close the loop? Lessons from a successful citrus waste valorisation business

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Abstract

Like many other sectors of the economy, the food industry has been working towards utilising resources more efficiently. This often involves valorising food processing by-products into new ingredients and raw materials. To successfully carry out such valorisation, food business operators must fulfil several requirements pertaining to the safety and sustainability of their operations. In this case study, we examine how a citrus peel valorising company based in the Netherlands was able to adopt a circular business model while navigating regulatory, managerial, and supply chain-related barriers. Results from our study indicate that the regulatory and political contexts in the Netherlands were critical to the company's success. Like in the case of most fruitful industrial symbioses, partnerships founded on mutual trust and economically appealing value propositions played a crucial role in establishing operational supply chains and ensuring commercial viability. Collaborating with larger corporations and maintaining ongoing, transparent communication with stakeholders were also significant contributing factors. Lastly, employees' enthusiasm towards the concept of circular economy and their willingness to learn new skills were found to have played an important role as well.

1. Introduction

As over eight billion of us prepare to share the limited resources our planet affords us, difficult questions about our continued sustenance are inevitable. With the area of arable land available to us remaining limited, stakeholders in the food system are compelled to seek out new ways to meet the world's dietary needs. To continue producing nourishing food while respecting planetary boundaries, the food system of the Anthropocene must endeavour to become frugal and innovative in its use of raw materials (Hadjikakou et al., 2023; Rockström et al., 2009; Willett et al., 2019). It is perhaps this realisation that has generated immense interest in the concept of the circular economy among food businesses. Becoming circular entails designing systems that allow raw materials to be used to their full potential before they are discarded. However, 'circularising' the food system comes with a unique set of challenges due to concerns regarding food safety and consumer preferences (James et al., 2022; Rao et al., 2021).

Unlike textiles, electronics, and even some other kinds of biomass, food must be consumed within a relatively short period of time after harvesting. Once unsuitable for human consumption, it can be used for other purposes such as the production of animal feed, biofuel, or chemicals for industrial use. However, this way of utilising food materials has been proven to be less socially and environmentally sustainable compared to (re)using it for human consumption (Papargyropoulou et al., 2014). Therefore, there is a strong interest in developing new ways of retaining food and agricultural raw material within food supply chains for as long as possible. However, the path to establishing such processes is riddled with a several barriers. Ada et al. (2021) elaborate on the cultural, financial, regulatory, technological, managerial, supply-chain management, and knowledge related barriers that food businesses face while adopting a circular business model. Despite these challenges, some entrepreneurs have been able to successfully set up operations that valorise food waste into new food products. This case study focuses on one such company – PeelPioneers B.V. (hereafter PeelPioneers) – based in the Netherlands.

Our rationale behind studying the operations of PeelPioneers, a scale-up company that manufactures food and other high-value ingredients using citrus waste, was to identify factors that enable a food business to adopt a circular business model and overcome the barriers listed above. PeelPioneers employs what Vermunt et al. (2019) describe as a 'resource recovery' model which is a type of circular business model focusing on the transformation of the residual value of resources into new forms of value. This model seeks to reduce the environmental impact of industrial production systems by reducing the continuous demand for resources, closing material loops, and using waste streams as useful inputs to other products and processes (Bocken et al., 2014). As per the archetyping system proposed by Henry et al. (2020), PeelPioneers' business model would be classified as 'waste-based' with its innovation category being 'industrial symbiosis'. Such businesses seek to extract value from unexploited waste streams from an external organisation, relying mostly on innovative process-based solutions (Henry et al., 2020). Industrial symbiosis is a concept from the field of industrial ecology wherein actors from (traditionally) separate industries collaborate to share materials, energy, water, and/or by-products to gain a competitive advantage (Chertow, 2000).

Three characteristics of PeelPioneers' operations informed our decision to study it. First, the business uses a recycle strategy as opposed to the reuse, redistribute, reprocess, or resell strategies that are more common in the food sector (Huang et al., 2021). This is especially true at the retail-consumer interface from where PeelPioneers obtains its raw material. Huang and colleagues' systematic review on the subject reveals that most retailers recycle their food surpluses by donating or selling them to producers of animal feed, biofuel, or compost. Recycling food waste from supermarkets to produce ingredients that can be used in the production of food products makes PeelPioneers' operations noteworthy. Second, alongside products such as oil, colourings, and candied orange peels, the business produces dietary fibre from citrus waste. Dietary fibre can be used as a functional ingredient due to its potential to improve the nutritional profile of several food products such as bread, yogurt, various spreads, and plant-based milks. Consumption of dietary fibre is known to enhance faecal bulking efficiency, improve colonic fermentation, maintain insulin levels, lower postprandial blood glucose response, and attenuate blood cholesterol (Champ et al., 2003; Fuentes-Zaragoza et al., 2010). The fact that the fibre is produced

by valorising food waste further enhances its relevance for the food manufacturing sector which seeks to constantly improve its own sustainability credentials. Finally, PeelPioneers' use of citrus waste was also a deciding factor in its selection. At 144 million metric tonnes of production per year, citrus is among the most popular fruit crops in the world (FAO, 2021, 2023). Around one third of all citrus production undergoes some form of processing, making the management of citrus by-products a pertinent issue at the global level (FAO, 2023). Valorising citrus waste is known to be fraught with several organisational, regulatory, and market-related uncertainties (Ferrari et al., 2016). The management of solid waste produced during the juice extraction process also presents a significant environmental burden because of its highly fermentable nature (Lin et al., 2013; Satari & Karimi, 2018). With traditional waste management strategies such as incineration and landfilling being seen as environmentally unsustainable (Wei et al., 2017), the citrus processing industry is pushed to work with alternative valorisation and disposal strategies. Given that PeelPioneers works with one such valorisation strategy, we posit that a case study on their operations would be of interest to researchers and practitioners in the field.

2. Methods

We conducted a single, explanatory, qualitative case study to examine the operations of PeelPioneers. As described by Yin (2009), case study is the most suited methodology when undertaking an in-depth examination of a contemporary phenomenon within its real-world context. Therefore, one of the main strengths of a case study is the ability to cover both the context and the phenomenon. As is typical to this method, we collected and analysed multiple forms of data. In-depth, unstructured interviews with key personnel in the company, notes from field observations, photographs of the production process, and documents from a legal judgement served as sources of data.

The starting point of data collection was the recruitment of interviewees, which was initiated by the first author through contact with an employee via email. The inclusion criteria required participants to be working at the company for more than one month, therefore possessing relevant knowledge of internal operations and the products. To

accurately capture the phenomenon, it was necessary to obtain multiple viewpoints. Therefore, a purposive sampling strategy, which relies on researchers' judgement in choosing participants based on a set of characteristics, was seen as fitting (Etikan, 2016). Specifically, a maximum variation sampling strategy (Suri, 2011)was chosen in order to allow the phenomenon to be studied from as many different angles as possible. Our sampling strategy allowed us to select participants from various departments, including marketing, management, production, quality assurance, and research and development. Given participants' diverse skill sets and areas of expertise, we conducted unstructured interviews. During the interviews, we aimed to create an inviting atmosphere, and refrained from guiding the conversation in a particular direction. All interviews were conducted in-person in English and were recorded with the participants' consent and then transcribed *verbatim*. Considering that case studies typically analyse data from multiple sources (Yin, 2009), notes and pictures taken while observing PeelPioneers' production process were also used as data. A third source of data were the legal judgements by the Dutch Ministry of Infrastructure and Water Management allowing PeelPioneers to use citrus waste to extract oil and produce animal feed at a commercial scale.[11] Data were collected by the first, second, and fourth authors via visits to PeelPioneers' factory in 's-Hertogenbosch in the Netherlands on three separate occasions between January and April 2022.

Interview transcripts, notes, photographs, and legal documents were coded inductively using the in vivo technique described by Saldaña (2021), using the software Atlas.ti. The first round of coding generated 39 codes. This was followed by a subsequent round wherein related codes were grouped together into 12 categories. These categories were further developed into four themes as well as the case description. The first two authors independently coded the data and later collated their analyses. To support the findings, direct quotations have been utilized in appropriate cases, either unaltered or modified for the sake of clarity or confidentiality.

[11] The judgements (in Dutch) can be accessed via this link: https://www.afvalcirculair.nl/onderwerpen/afval/toetsing-afval/. Last accessed 31.03.2023.

The study was reviewed and approved by the Ethical Review Committee Inner City Faculties of Maastricht University. Prior to conducting interviews, informed consent forms were signed by all participants. Measures were taken to ensure privacy and protect informants from potential negative consequences of participation. For example, all data were anonymised during the analysis phase and the employees' functions will be described broadly throughout the paper. All participants were informed about their right to revoke participation at any moment. They were given the chance to correct, clarify or redact parts of their transcripts. Photographs were taken with the permission of the relevant authorities within the company. Personnel from the company had no influence on the analysis or the findings presented in this paper. Management was, however, asked permission to use the company's and its partners' names in this paper.

3. Findings

3.1 Case description

PeelPioneers was co-founded by three entrepreneurs in 2016 in Son, the Netherlands. The company received funding based on the founders' idea of valorising citrus peel waste from the food retail sector. The company extracts valuable compounds from citrus waste and transforms them into new products that are then sold to business customers for either further use in food, animal feed, cosmetic, or industrial applications. According to PeelPioneers, before their operations commenced in 2016, around 250 million kilos of citrus peels were being thrown away or incinerated in the Netherlands every year. This was seen as a valorisation opportunity by one of the founders who applied for a seed fund to set up the company.

Supermarkets in the Netherlands produce high volumes of orange peel and pulp waste because orange pressing machines have become ubiquitous in Dutch supermarkets. Customers have access to these machines and can operate them themselves. After the oranges have been pressed, the peel and pulp that remain behind (peels henceforward) are collected in a bin placed under the machine. Conventionally, these peels were classified as waste material and therefore legally ineligible for further use

in the food sector. By leveraging their citrus processing technology and partnership with supermarkets and waste management company Renewi plc (hereafter Renewi), PeelPioneers appealed to the Ministry of Infrastructure and Water Management for these peels to be categorised as a raw material fit for use in the food industry.

In partnership with Renewi, PeelPioneers opened its first manufacturing facility in 2018. Renewi ensured that the waste was collected and transported to the manufacturing site in a safe and timely manner. At this point, the capacity of the processing line was around 40,000 kg citrus waste per day. PeelPioneers continued to reach out to more retailers to avail access to higher volumes of citrus waste. In 2021, following a €10 million investment, PeelPioneers' operations moved to a new premises in 's-Hertogenbosch in the Netherlands with the capacity to process 30,000 tonnes of citrus waste per year. Along with the production capacity, the employee numbers rose from 18 to over 35. As of 2022, participants shared that around 80% of Dutch supermarkets with a citrus waste stream delivered to them, with procurement lines stretching into Germany and Belgium. Supplying establishments pay the company to take their citrus waste

At the time of data collection, PeelPioneers' valorisation process was organised as follows: waste is collected separately from retailer stores in plastic bags and transported by trucks in large bins which fit up to 200kgs of peel. The bins are unloaded with a forklift into the station dock, which is when the processing starts. The first step includes tearing up the bags and manually emptying them. Then, employees visually inspect the peels, picking out any unwanted materials (e.g., other fruits and vegetables, cleaning towels or wipes, bottle caps). The peels are then washed and divided into zones. Peels that will be valorised into food products are separated from those meant for the production of oil and feedstock. In the food production zone, an additional round of washing takes place, followed by flipping and mechanical removal of pulp cells, leaving only the albedo and flavedo (the orange and white part of the peel). The peel is then cut into 4-6mm pieces that are sold to business customers (e.g., bakeries), who use them as confectionary. The non-food use zone is divided into a line for oil production and another one for feed. At the oil line, peels are squeezed, and oil is separated from solids and water. When used as an ingredient the cold

pressed oil adds aroma, orange colour, flavour. It is used by PeelPioneers' clients in food products such as muffins, yogurt, and beer, among others. The oil can be further concentrated and processed into five-fold oil, which is also used in food applications that require the addition of a strong citrus aroma. In a separate process, D-limonene is also distilled from the oil and sold to businesses that use it the production of cleaning agents. The processing line makes use of several machines that have been patented by the company.

A separate production line in the factory produces dietary fibre from the orange peels. Researchers were not allowed to access this part of the factory to safeguard the company's trade secrets. However, we were able to observe the end product – a white-coloured powder, devoid of the citrus odour and taste. During our visits to the factory, tests were underway to determine the range of applications for this fibre. At the time of writing this paper (March 2023), the company's website lists 'Finix Citrus Fibre' as one of its saleable products and highlights sugar and fat reduction, binding, thickening, emulsifying, and water retention as its applications in the food and cosmetics sector.

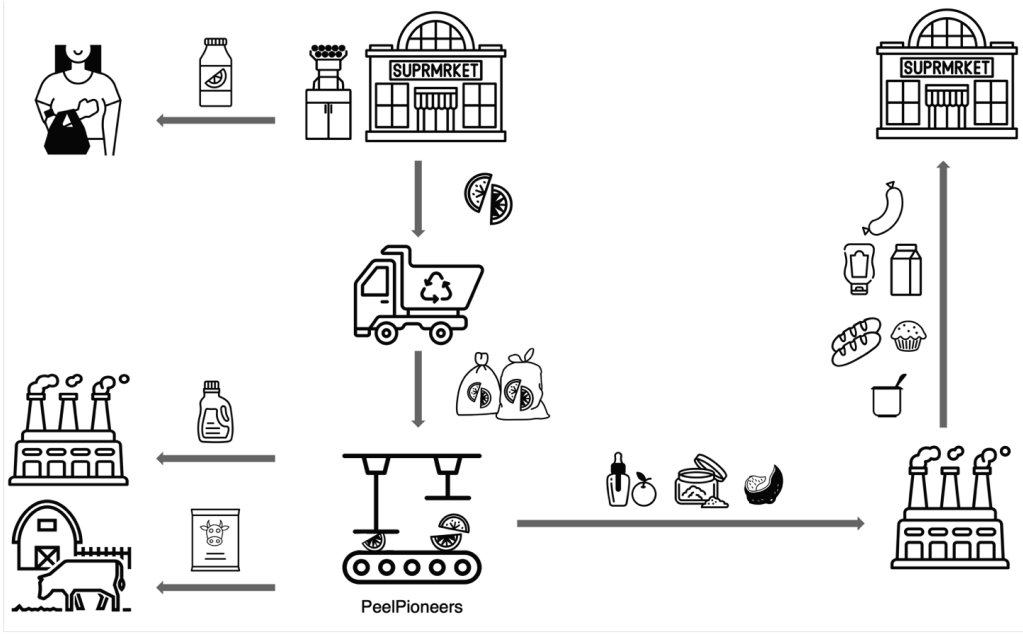

Figure 1 PeelPioneers' supply chain

At the time of data collection, participants informed us that us that health claims regarding the fibre being recognised as a functional food were under investigation. Figure 1 illustrates the company's current supply chain.

PeelPioneers' ambitions for the future include improving current production processes, experimenting with new ways of valorising citrus waste, and expanding operations to other European countries. The company's goal is to process all received peels into products that can be used for higher ranking valorisation activities such as food and pharmaceutical applications. The company's management wishes to expand operations to other European countries and is currently investigating the possibility of procuring orange and other citrus peels from industrial production sites for local processing. Other plans include the extraction of hesperidin, an antioxidant used in health foods due to its high phenolic content as well as the production of natural colorants. Establishing higher valorisation routes of their own waste streams such as sugar water and pectin is high on the agenda as well.

3.2 Factors enabling PeelPioneers' success

3.2.2 Regulatory and political situation

In September 2016, the Dutch government published 'A Circular Economy in the Netherlands by 2050' – a document outlining how public and private actors would work towards achieving a waste free economy in the coming decades. In this document, it is acknowledged that existing waste management and other supporting regulations must be better adapted to the circular economy concept if raw materials at the end of their life in one supply chain are to be better utilised in another (Government of the Netherlands, 2016). PeelPioneers' experience with the legal process to change the status of the citrus peels is indicative of this willingness to adapt. In 2017, the company appealed to the Knowledge Centre for Circular Economy of the Dutch Ministry of Infrastructure and Water Management to change the legal status of the peels from 'waste' to 'raw material for continued use'. Two separate applications – one for use in animal feed and other for oil production – were submitted at the same time. The legal judgement document states that three factors were considered when assessing the application – certainty regarding the demand for the products that PeelPioneers would manufacture if the status change was approved, the lawfulness of such an approval, as well as the quality of the end product. The European Waste Framework Directive (Directive 2008/98/EC), the Dutch Environmental Management Act, and the third Dutch National Waste Management Plan were applied to assess whether the peels could be used as a raw material for continued use.

The legal process took place over 22 weeks and involved continuous communication between the Ministry and the company's representatives. Relevant participants informed us that despite the anxiety that comes with a critical step such as this one, they felt sufficiently supported and confident throughout the process. They shared that despite the European Union's (EU) legislation on the subject being complex and confusing, the Dutch implementation of it was accessible: *"European legislation on this topic is just hell. I mean, even for people with a high level of education, it's quite difficult to fully grasp what it says. And that's because it's so broad and needs to cover so many things. And so many people get to have a say. But when you take it all down to a national level, it worked pretty well (for us)."* Preparing the applications was

described as a taxing process but was balanced by the positive and relatively fast outcome. PeelPioneers also benefitted from the appointment of a highly skilled legal consultant employed by Royal HaskoningDHV, one of the Netherlands' leading consultancy firms in the field of sustainable innovation and engineering.

To hire skilled personnel and set up a supply chain and basic infrastructure, PeelPioneers, next to the co-founders' own investments, availed funding from various sources at the provincial, national, and European levels. The political will to transition to a circular economy in the Netherlands and in Europe made these funding sources available to a start-up company. A co-founder mentioned that the circular economy being in the limelight gave them the opportunity to speak about their business idea at various national events. This ultimately helped the company gain recognition and funding. Some relevant funds, grants, and investors that the company has received investments and endowments from include the European Circular Bioeconomy Fund, Brabantse Ontwikkelings Maatschappij (the Brabant Development Company), Stichting Doen (The Doen Foundation, funded by Dutch lotteries), Climate-KIC International Foundation, ABN AMRO Bank, Rabobank, het Nationale Groenfonds (The Dutch National Fund for Green Investments) and the Top Sector Energy Grant initiated by the Dutch Ministry of Economic Affairs. PeelPioneers raised money for their operations in multiple rounds, starting with several thousand euros at the very beginning, followed by €1 million seed capital, and most recently €10 million early venture capital. Participants believed that having access to Dutch and European funding instruments, expertise, and innovation sandboxes has played a critical role in the company's success so far.

However, participants were also cognisant of the advantage their political environment affords them. One of the founders shared that having access to such resources also comes with a certain responsibility: "*We're in a very privileged position because the Netherlands is a very wealthy country. We can afford to look at these things. In poorer countries, people often struggle to meet their basic necessities so they cannot spend too much time thinking about what they are going to do with the waste they produce. I think we have a role to play there. We can afford to experiment and through that, show what is possible".*

3.2.2 Meeting food safety requirements

Food safety is one of the major barriers when valorising waste into new food products. In order to obtain permission to use citrus peels from supermarkets and restaurants, PeelPioneers had to provide detailed information regarding how risks such as pesticide contamination and biological spoilage would be dealt with throughout their operations. Assessors considered the nature and origin of the peels, procedures involved in valorisation, as well as the application of the resultant substances.

Like any other food business operating in the European Union, PeelPioneers is obligated to follow various requirements laid down by the EU General Food Law (EC/178/2002). Specifically, the legal judgements mentions that the company's operations must adhere to regulations EC/1829/2003 and EC/1830/2003 requiring food and feed to be free from genetically modified organisms, directives EC/2007/13 and EC/2007/68 on the reporting of allergens[12], regulation EC/1334/2008 prescribing rules regarding the use of certain food flavourings, regulation EC/1881/2006 which sets the maximum levels for contaminants in certain foodstuffs, and EC/396/2005 on maximum residue levels of pesticides. In addition, the importance of following the HACCP principles as recommended by the World Health Organisation in the Codex Alimentarius was highlighted. Employees working on food safety and quality assurance at PeelPioneers shared that following these requirements while working with citrus peels was achievable and not any more complicated than with other kinds of (non-valorised) raw materials. However, given their unusual source, the company works together with an accredited laboratory, an independent inspection company, a panel of food safety experts, as well as the Dutch food safety authority to develop and maintain a robust food safety management system. This was taken into consideration by the Ministry while assessing the status change application.

The presence of pesticides in the citrus peels is among PeelPioneers' biggest food safety hurdles. By developing measures such as a sampling and testing strategy, an early warning system, and a recall protocol, the company was able to convince the

[12] At the time of writing this paper, regulation (EU) No 1169/2011 on the provision of food information to consumers has replaced directives EC/2007/13 and EC/2007/68 with regard to the reporting of allergens.

Ministry of its ability to manage the contaminant. Private food safety standards play an important role in helping PeelPioneers comply with food safety regulations as well. Participants mentioned that they were busy preparing for certification against the FSSC 22000 and ISO 22000 standards so as to gain the trust of their customers and meet market requirements. The legal judgement also acknowledges the company's efforts to improve its food safety and quality credentials by showing willingness to get certified. As of January 2023, PeelPioneers' operations are certified against the FSSC 22000 standard.

3.3.3 Collaborative partnerships

Since its inception, PeelPioneers has focused on developing collaborative partnerships with relevant actors in its supply chain. Study participants spoke extensively about the importance of creating value for all involved partners and developing relationships that are rooted in mutual trust. They described how a successful collaboration with Renewi – the company in charge of collecting and discarding citrus peels from supermarkets and hospitality establishments across the country – was critical for their own success.

Regarding their strategy while approaching Renewi, one of the co-founders explained: "*We looked at what kind of problem we could solve for them. Because approaching someone with 'I can solve your problem' is a much better strategy than simply saying 'we should cooperate'.* Renewi struggled with fermenting the peels due to their high acidity but could not refuse to take them from customers because it would hamper business relations. Therefore, PeelPioneers' offer to valorise the peels helped Renewi's operations. Additionally, they were able to leverage Renewi's expertise and position to get supermarkets and hospitality establishment on board as well: "*We offered them (Renewi) a potential business proposition, saying if we work together on an exclusive basis, then you're the only party in the Netherlands that can offer the peel owners a way to dispose of their peels in a more sustainable way while helping fulfil their corporate social responsibility".* This proposition was received with much enthusiasm by peel owners because next to sustainability credentials, it also offered an interesting economic avenue. Sending the peels to PeelPioneers, even if at a small fee, was cheaper than paying Renewi to ferment them in a digestor or sending them

to the incinerator. Even before the company applied for the status change, several supermarkets had provided a letter of intent declaring their interest in the partnership.

Another important partnership for the company was the one with their first major buyer. By cooperating with International Flavors & Fragrances Inc (hereafter IFF), PeelPioneers was able to convince the Ministry that its products have market demand. An important player in the flavour and fragrance additive business, IFF's interest in the sustainably produced citrus oil cemented the relevance of such a product in the food and cosmetic sectors. This collaborative partnership approach extends into other aspects of the business as well. For example, a participant mentioned about the ongoing talks with Zumex – the company that manufactures the juice pressing machines which have become ubiquitous in Dutch supermarkets – regarding the possibility to enclose the peel collecting unit of the machine. This would allow for an improvement in the quality of the peels by keeping other waste products out of the bins. Such a collaboration would give Zumex the opportunity to contribute to the sustainable valorisation of the waste created as a result of their machine's use. Participants holding senior positions PeelPioneers also expressed great interest in partnerships that facilitate the exchange of knowledge and the replication of their business model in other contexts.

3.3.4 Personnel skills and outlook towards sustainability

Most interviewed employees showed a strong interest in the concepts of circularity and sustainability. Some spoke about how they felt a sense of responsibility towards their children as well as the next generation at large and were hence keen on applying their skills towards building a waste free society: "*I know I cannot save the world. But I can try to do my best using what I have. And if everybody does that, I think we will all be a little better off*". Those involved in hiring shared that next to being interested in sustainability, potential employees must also be willing to learn new skills and adapt to doing things differently compared to their previous jobs. One participant elaborated on this as follows: "*We look for a certain kind of proactivity while hiring. There's so much going on all the time, so employees need to be able to think for themselves. It's not that we want everyone to have an entrepreneurial mindset, but we do need our colleagues to ask a lot of questions."*

The economic and social aspects of sustainability were also brought up frequently. While environmental sustainability inspired the business idea, interviewed employees thought of it as an insufficient driving factor for the business on its own. Being able to scale-up, maintain a steadily growing revenue, and create new jobs was considered to be as important as reducing the environmental impact of discarding citrus peels. One of the founders elaborated on this as follows: "*Many people think that circularity is this cute, green fad but we see it as something that can create a lot of economic value. Through our company, at least 40 people earn their wages by processing orange peels. These jobs did not exist before. Through our business, we show that a circular 'economy' is actually possible!"*

Regarding the social aspect of sustainability, the discussion focussed on training workers to apply their skills in a way that matches the demands of a circular business. While employees with a higher level of education were thought of as important, those engaged in manual jobs were also considered critical to the company's operations. In a way, next to circulating raw material, personnel's skills in other sectors or jobs were being 'recycled' and applied in a new, circular context.

4. Discussion

In this study, we identified factors that enabled the success of a start-up company employing a circular business model to valorise citrus waste. Our findings illustrate that a combination of factors internal and external to the business were instrumental in its commercial success. By juxtaposing empirical evidence against theoretical ideas on the subject, our study strengthens existing literature on circular food businesses. However, it is imperative that we point out that the specific circumstances and opportunities described in this paper are particular to the context in question and may not apply directly to circular businesses in other industries or parts of the world. All the same, our objective while conducting this research was not to establish generalisability. Instead, we aimed to materialise a piece of the larger circularity puzzle; to build a bridge between purely theoretical propositions and a full-fledged hypothesis that can be tested empirically and generalised to different contexts. Like

most case studies (Piekkari & Welch, 2018), our research serves as an intermediate step in the pursuit of generalisation rather than an end in itself. Nevertheless, some observations from our study merit a deeper embedding in extant literature in order to explore their broader relevance. In this section, we use the example of PeelPioneers to explore what it takes to close material loops and establish a successful circular food business.

4.1 The Dutch approach to circularity

In recent years, the circular economy concept has featured prominently in many political discussions in the Netherlands. This enthusiasm trickles down into Dutch society in several ways including the media (Calisto Friant et al., 2022; Russell et al., 2020), higher education curricula (Kirchherr & Piscicelli, 2019; Kopnina, 2018), as well as subsidies for businesses and seed funds for start-ups (van Langen & Passaro, 2021). This was an important external factor that enabled PeelPioneers to publicise and grow their business. As seen with PeelPioneers' partner organisations, even if this push for circularity does not translate into all businesses changing the way they operate, it certainly makes them enthusiastic about supporting and cooperating with value chain actors engaged in it.

This blossoming interest in circularity is a result of seeds sown several decades ago. Cramer (2022) attributes the Netherlands' present-day affinity for the circular economy to a 40-year track record of addressing matters connected to the subject. Being geographically ill suited to landfilling, the Netherlands has devised several policy measures to dispose of waste in other ways since the 1970s (Cramer, 2022; Martens & Spaargaren, 2005; Reike et al., 2018). Extended producer responsibility, eco-design, and cradle-to-cradle design are concepts that pre-date the circular economy in the Netherlands (Cramer, 2022). As a result, when the EU and various international organisations started promoting the concept a decade ago, Dutch businesses and policymakers had blueprints in place already. Emphasis on recycling and reuse of material across a broad range of industries has also created a workforce that is well adjusted to the skill, knowledge, and ethical expectations related to circularity. This observation is reflected in other studies as well. For instance, van Langen & Passaro

(2021) analyse the numerous urban and regional green deals made in the Netherlands which played an important role in creating awareness about the circular economy and mobilising governmental action. Similar to PeelPioneers' business model, economic benefits associated with circularity greatly emphasised in these deals.

Industries like textile (Reike et al., 2018), construction (Zhang et al., 2020), logistics (Van Buren et al., 2016), defence (Soufani et al., 2018), and plastic (Leslie et al., 2016) are at the forefront of the circular transition in the Netherlands. Relative to materials from these industries, food is a new focus. However, as evidenced by detailed action plans and participation in international projects on the topic, it has quickly become a top priority (Government of the Netherlands, 2016; Planbureau voor de Leefomgeving, 2017). The report treats food waste and surpluses as a distinct form of biomass which allows room for special considerations connected to consumer safety. This is apparent in the legal judgements analysed as part of this study as well. The public, bureaucratic, and technical expertise related support that PeelPioneers received can be observed in other cases too. Schagen et al. (2022) describe how media attention combined with support from the Ministry of Agriculture and Food Quality, top research institutions in the country, and consumers played a pivotal role in the success of Kipster and Herenboeren – two other circular food businesses in the country.

Circular economies cannot be governed using a one-size-fits-all approach (Cramer, 2022) and therefore, replicating the Netherlands' ecosystem in other contexts may not yield identical results. It is, however, possible to adapt best practices to the economic, social, and political conditions elsewhere. Tested methods to advance the circular economy that have worked in the Dutch context include creating synergies between various policy domains, highlighting the economic benefits of circularity, adapting legislation to business needs, and encouraging partnerships and knowledge exchange among value chain actors.

Learning opportunities can be identified from the shortcomings of the Dutch approach as well. Lack of specific policy targets, failure to address the free-rider problem, government abstinence from implementing strong legal instruments, and lack of measures to divert waste streams from incinerators have been identified as factors impeding the realisation of circularity targets (Piras et al., 2018; Reike et al., 2023; van

Langen & Passaro, 2021). Additionally, the Netherlands Environmental Assessment Agency has identified that efforts to achieve certain circularity targets such as reduction in food waste volumes and improved material efficiency across industries are lagging considerably (Planbureau voor de Leefomgeving, 2017, 2022). Publications from the agency also highlight that most circular economy initiatives in the country focus largely on 'recycle' and 'repair' strategies (Planbureau voor de Leefomgeving, 2022). In comparison, rethink' and 'reuse' strategies requiring wider societal change are largely ignored.

4.2 Value creation and stakeholder engagement

Engaging stakeholders through robust value propositions allowed PeelPioneers to establish a commercially successful citrus waste valorisation business. Without partnerships with various actors in their supply chain, it would have perhaps been impossible for the company to overcome the regulatory and other bureaucratic barriers it faced in its early days. Salvioni & Almici (2020) posit that companies working with circular business models should focus on sharing their circularity goals with suppliers to align values and ensure sustainable procurement. Regarding the engagement of industry partners and investors, they suggest sharing the company's strategic objectives and ensuring compliance with the principles of fair competition and transparency. By fostering employee engagement and investing in skill development, Salvioni & Almici (2020) indicate that innovative processes and circularity-aligned work culture can be established. Lastly, cooperating and engaging in long-term dialogues with relevant government bodies and knowledge institutions is recommended. PeelPioneers' stakeholder engagement strategy closely matches these ideas.

Reike et al. (2018) propose that circular businesses engage their stakeholders by offering six value types – sustainability, economic, political, ecological, social, and safety and quality. PeelPioneers offers one or more of these values to their stakeholders in exchange for their cooperation. It offers its customers sustainability value through its products. It generates economic and social value by creating jobs and helping suppliers fulfil their corporate social responsibility. Given the nation and EU wide spotlight on the transition to a circular economy, public institutions and investors derive political value by engaging with the company. Ecological value, which

is linked to the benefits created for the natural environment, is observed in the company's relationship with Renewi. Lastly, safety and quality value is offered to legislators and competent authorities who are responsible for protecting consumer health. It was not surprising to see this level of stakeholder engagement in our case study since circular business models inherently operate within intricate networks of interdependent but autonomous actors, necessitating cooperation, communication, and coordination (Antikainen & Valkokari, 2016).

PeelPioneers' partnership with large multinational corporations – IFF, Renewi, and various retail chains across the country – is worth discussing here as well. In their paper examining entrepreneur-corporation partnerships in the circular economy, Veleva & Bodkin (2018) elaborate on the benefits of such partnerships. They highlight that larger corporations can gain reputation, sustainability credentials, and economic benefits by partnering with entrepreneurs employing circular business models. In turn, entrepreneurs are able to leverage green technologies and ideas to valorise waste streams to create highly marketable products (Veleva & Bodkin, 2018). Such partnerships also allow circular businesses to achieve economies of scale while slowing down (if not closing) material loops for corporations.

5. Concluding remarks and implications

In this article, we identify the circumstances and strategic decisions that have enabled a medium-sized Dutch enterprise to valorise citrus waste at a commercial scale. We found that the regulatory and political contexts in the Netherlands were instrumental in the company's success. Our analysis indicates that the Dutch government has been able to adapt the demanding and at times nebulous requirements of EU General Food Law and the Waste Framework Directive to business needs without compromising consumer or environmental safety. Like in the case of most fruitful industrial symbioses, partnerships built on mutual trust and economically attractive value propositions were important to the establishment of functioning supply chains and commercial viability. Partnering with larger corporations and engaging stakeholders through continued and transparent communication also emerged as contributing

factors. Additionally, positive employee outlook towards circularity combined with willingness to learn new skills drive the business forward in its trajectory.

In addition to making an empirical contribution to the scholarship on the circular economy, our findings have implications for policymakers as well. Creating public awareness about the circular economy, designing mechanisms to adapt legislation to business needs, harmonising the goals of various policy domains such as agriculture, waste management, and climate change, and facilitating knowledge and skill development can have far reaching positive impacts on a country's ability to support sustainability-focused entrepreneurs. Practitioners might benefit from this case study by adapting various strategies discussed in this paper to their own contexts. For example, as seen in the case of PeelPioneers, capitalising on unusual streams of raw material, engaging stakeholders through robust value propositions, and partnering with corporations looking to circularise their operations benefit entrepreneurs who can leverage innovative technologies or services.

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Ethics approval

This study received approval from the Ethics Review Committee Inner City faculties of Maastricht University under reference number ERCIC_336_23_03_2022.

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8

Holding Retail Corporations Accountable for Food Waste: A Due Diligence Framework Informed by Business and Human Rights Principles

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Abstract

Retail corporations orchestrate much of what happens in today's food supply chains. From setting sky-high cosmetic standards for fresh produce to bundling off close-to-expiry products at discounted prices, retail's contribution to food waste often extends beyond its in-store numbers. By occupying a powerful position in a globalised food system, these corporations enable chronic overproduction and consequently, the removal of surplus food from supply chains. This, in turn, contributes to the unfair distribution and overexploitation of food resources, further exacerbating the globally pervasive problem of food insecurity. To realise the right to food and the United Nations' Sustainable Development Goal of halving global per capita food waste by 2030, we argue that retail corporations must be held accountable for their direct and indirect contribution to food waste. We posit that to make a tangible difference, they must move away from the current voluntary corporate social responsibility approach to food waste reduction and instead invest in robust due diligence mechanisms and transparent reporting systems in line with the UN Guiding Principles on Business and Human Rights and the upcoming EU Corporate Sustainability Due Diligence Directive. Based on Pillar II of the Guiding Principles, we propose a five-step approach to accountability for food waste that may lead to serious actions towards the relaxation of cosmetic standards, abolition of unfair trading practices, and improvement in demand forecasting; thereby reducing the volume of food that ends up as waste.

1. Introduction

A rapidly growing body of scientific literature suggests that food waste exacerbates climate change, negatively impacts food security, and causes grave economic harm (Papargyropoulou et al., 2014; Vermeulen et al., 2012; West et al., 2014). In the last decade, food waste has made its way to the top of policy agendas around the world. From national and regional institutions to the United Nations, there has been palpable political will to take action to reduce the amount of food that ends up in landfills and incinerators.

Calculating food waste volumes at various stages of the supply chain is a critical first step towards implementing prevention and valorisation strategies (Parfitt et al., 2010). The most reliable global estimates for food waste are currently provided by the Food and Agriculture Organization of the United Nations (FAO) and the United Nations Environment Programme (UNEP), who are custodian agencies for the Food Loss Index and the Food Waste Index respectively. Both these indexes were developed in connection with the United Nations Sustainable Development Goal (SDG) target 12.3, which aims to halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains by 2030. Food material that gets removed from the food supply chain before the retail stage is referred to as food loss (UNEP, 2021). When food is removed during or after retail, it is known as food waste (UNEP, 2021). However, the scope of this commentary does not necessitate the use of such a dichotomy. Therefore, we use the term ‘food waste’ to refer to both, food loss and food waste.

As per the latest measurements, the annual food loss and waste volume is estimated to be around 1.3 billion tonnes (UNEP, 2021). This is one third of all food grown on the planet every year. The Food Waste Index which monitors and reports on waste from the last stages of the food supply chain including retail, food service, and households estimates that 931 million tonnes of food is wasted at these stages every year. As per the 2021 Food Waste Index report, 61.1% of this 931 million tonnes comes from households (UNEP, 2021). A further 26.2% comes from food service operations. And lastly, a modest 12.6% from retail (UNEP, 2021). The remaining 369 million tonnes of the total volume is lost before it even reaches the retail or food service

stages. These numbers have inspired several consumer focussed interventions and a broad range of studies that aim to understand the drivers of household food waste and reduce its occurrence (Hebrok and Boks, 2017). Meanwhile, food loss reduction efforts have been working towards optimising post-harvest techniques and improving storage infrastructure (Hodges et al., 2011). Studies examining retail-level food waste often focus on the quantities of food discarded by supermarkets (Xue et al., 2017).

In this commentary, we contend that retail's impact on food waste extends much beyond its own tangible waste. By holding a pivotal position in today's food system, retail corporations influence how much food is discarded by actors throughout the chain. We further argue that CSR strategies are of limited use in this context and conceptualise the possibility of addressing the issue of food waste through an accountability-based system rooted in the realisation of the human right to food. The piece is organised as follows. Section 2 describes the various ways in which retail corporations exert power over upstream actors in the food supply chain as well as consumers and political processes. In section 3, we investigate corporate social responsibility strategies employed by retailers to address food waste in their supply chains and examine the shortcomings of this approach. This is followed by section 4 wherein we look at food waste through a business and human rights lens and propose an accountability-based system to address it. The commentary ends with section 5 which presents concluding remarks.

2. Retail power in food supply chains

A major advantage that retailers have over other actors in the supply chain is their proximity to consumers. Having access to consumer preferences allows retail to take on the guardianship of consumer interests and dictate what and how much to produce to upstream actors. Since the late 90s, retail corporations have gained considerable market power, creating an oligopolistic market structure (Rossignoli and Moruzzo, 2014). Retail conglomerates from developed countries in the Global North, especially those incorporated in the European Union, command immense influence over producers and processors all over the world (Bui et al., 2019; Fuchs and Kalfagianni, 2009; Rao et al., 2021; Rossignoli and Moruzzo, 2014). These corporations dictate

safety and quality specifications through contractual agreements with their suppliers, often through various 'voluntary' private standards developed by them.

Private standards started out with the aim of harmonising food safety requirements in a rapidly globalising market in the late 90s and early 2000s. However, wanting to establish export credentials made them *de facto* mandatory among suppliers throughout the world. Eventually, private standards became the minimum requirement for simply existing in the market, and retailers started using them to create product differentiation and enter new markets (Konefal et al., 2005; Trienekens and Zuurbier, 2008). To retain their compliance certification for these standards, producers and other actors are compelled to adhere to new and changing demands regarding their products and processes. These requirements can range from specifications regarding the cosmetic standards for fresh produce to the use of a certain packaging material for finished products. While actors in developed countries are often offered flexibility regarding the adoption of new requirements, those in developing countries are compelled to accede (Naiki, 2014).

Although the connection between private standards and food waste has not been studied as extensively as some other aspects of food waste management, it is known that the prescriptive and demanding nature of these standards leads to the wastage of food that is fit for human consumption. Consignments of food are known to be rejected and produce is known to get left unharvested on fields if found to even slightly deviate from standard requirements (Hansen and Trifković, 2014; Parfitt et al., 2010; Rao et al., 2021). Retail corporations are also known to use private standards to carry out unfair trading practices (Thompson & Lockie, 2013), both at the international as well as national and local levels (Ghosh & Eriksson, 2019). Retailers are also able to reject perfectly compliant products if cheaper options are accessible elsewhere. Due to 'take-back agreements', manufacturers are obligated to take back unsold products without retail corporations having to pay for the now unsaleable products. Overall, it is well recognised that cosmetic standards for food products enforced by retail corporations play a key role in sustenance of unfair trading practices that in turn lead to food waste generation (Devin and Richards, 2018; Piras et al., 2018 Richards et al., 2012; Messner et al 2022).

Next to directly impacting supply chain actors through business relations, retail corporations are known to influence the governance of the food system more broadly as well. Fuchs and Kalfagianni (2009) for instance, show that retailers define and mould the discourse on sustainability in public policies and political processes. Certain sustainability issues are thereby prioritised over others, in a manner that fits the agenda of the retail corporations (Fuchs and Kalfagianni, 2009). Given food waste's absence from the sustainability reports of some of the world's biggest retail corporations (Pulker et al., 2018), it appears to be among issues that have been assigned low priority. The work of Wakeman et al., (2022) explores this phenomenon through the lens of bounded ethicality. They suggest that heterogeneity of moral values combined with limited time and resources to address a plethora of sustainability objectives allows actors to cherry pick causes they address. Despite being aware of the social and economic consequences associated with food waste, retailers may not act on it if they do not see it as an ethical dilemma requiring urgent attention (Wakeman et al., 2022). Considering the complex and scattered nature of the food waste problem, Wakeman and colleagues conclude that retailers may not understand how their (in)actions are in fact morally charged and contribute to food waste. Additionally, they may also not think of food waste to be as critical a sustainability goal as other social, economic, and environmental issues in the food system.

Retail's relationship with consumers is worth discussing here as well. It is well known that retailers transfer close-to-expiry products from their stores to consumers' homes through multi-buy promotions, up-sizing coupons, and high-pressure marketing tactics (Aschemann-Witzel et al., 2015; Calvo-Porral et al., 2017). In response to recent studies indicating that such promotions cause consumers to purchase more food than they can consume before the expiration date, some retailers have moved away from 'buy one get one free' schemes (Aschemann-Witzel et al., 2016; Evans et al., 2017). However, the sector continues to inform consumer choices in other ways. Dixon (2007) suggests that supermarkets have taken on a paternalistic role in today's society by subtly but proactively taking charge of various aspects of consumers' lifestyle choices. Evans et al., (2017) observed this in the context of food waste management as well. In their study, retailers sought to position themselves as cultural and lifestyle authorities who benevolently offered to help consumers solve the problem of domestic food waste in their households through generic food storage tips and low waste

recipes. Thus, as illustrated in figure 1, it is clear that the retail sector exerts its power in not only its upstream relationships but also downstream, with its customers.

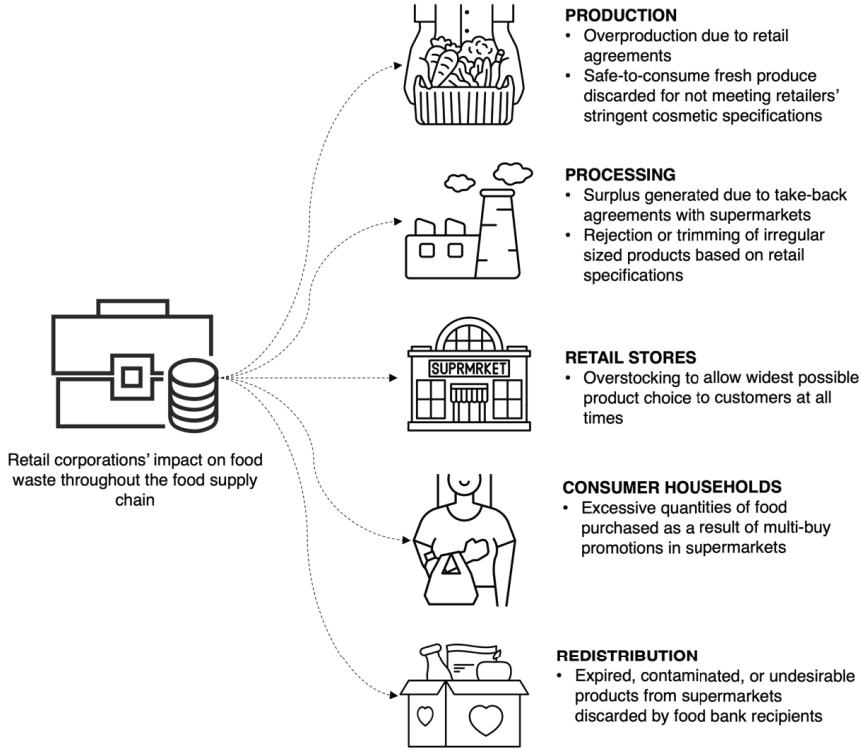

Figure 1 Retail corporations' impact on food waste throughout the food supply chain

Several of the studies discussed in this section study retailers from the periphery. To gain a better understanding of the sector's views on the issue of food waste, results from case studies and theory-based literature must be supplemented by additional cross-sectional research on the subject. However, empirically studying retail's contribution to global food waste levels and its plans to act on the problem will require the sector's participation. Through personal attempts to recruit participants for such studies as well as accounts described by other researchers (Devin and Richards, 2018; Parfitt et al., 2010), we know that the retail sector is reluctant to divulge information about the negative impacts of its market power. Often, suppliers are also hesitant to participate in this kind of research or speak up against retail's impact on

their food waste volumes so as to not 'bite the hand that feeds' (Devin and Richards, 2018).

3. Corporate social responsibility and food waste

Carroll's foundational work on Corporate Social Responsibility (CSR) suggests that a business may be considered socially responsible if it fulfils society's economic, legal, ethical, and philanthropic expectations (Carroll, 1991, 1979). Several commentators have contested this definition over the years (Sheehy, 2015), but most agree that CSR focuses on causes that are marketable, 'good for business', and allow for the improvement of business relations with stakeholders and customers (Cantrell et al., 2015; Rodriguez-Gomez et al., 2020; Rost and Ehrmann, 2017). Some guidelines on CSR, such as the ISO 26000, seek to frame CSR as an accountability tool by stating that organisations must take on responsibility for the impact of their decisions and activities on society and the environment (Moggi et al., 2018). However, considering that such guidelines remain legally non-binding, a shift in the definition or scope of CSR is unlikely to change the fact that corporations can choose which social or environmental issues they engage with.

The food industry's strong dependence on natural and human resources offers it several CSR avenues to act upon (Hartmann, 2011; Maloni and Brown, 2006). Anselmsson and Johansson (2007) identify human, product, and environmental responsibility as the three dimensions of CSR relevant for food retailers. In the context of this analysis, food waste reduction can be classified as an environmental responsibility since the connection between food waste and environmental degradation has been well established. Food waste's connection with food insecurity also makes it a human responsibility. However, given that CSR is deeply rooted in corporate volunteerism, food waste reduction competes with several other environmental and human responsibility issues for a place on retailer's CSR agendas.

Of all the ways in which retail corporations contribute to food waste, in-store food waste is the most noticeable to its customers. With activists and NGOs bringing public attention to supermarket food waste volumes, retailers are pressured into managing their surpluses in a way that society deems appropriate (Aschemann-Witzel et al.,

2022). Donating to food banks, social supermarkets, and other charitable organisations has been a popular CSR strategy for managing in-store surpluses in a socially acceptable manner while earning 'green credit' (Filimonau and Gherbin, 2017; Hermsdorf et al., 2017; Shaw and Shaw, 2019). However, studies investigating the contents of food banks parcels have reported that they often contain products that recipients are unable to or do not wish to consume (Shaw and Shaw, 2019; van der Horst et al., 2014). Next to unpopular formulations that get left behind on supermarket shelves, expired and even contaminated products are known to end up in food bank parcels; a phenomenon that deeply impacts recipients' dignity and sense of self-worth (Shaw and Shaw, 2019; van der Horst et al., 2014). Food banks' reliance on donations from private actors such as retailers has also been criticised as failure of state welfare mechanisms, especially in developed countries (Dowler and O'Connor, 2012; Lambie-Mumford, 2017; Poppendieck, 1999; Riches and Silvasti, 2014). Therefore, while donation does aid in the mitigation of hunger and offer a practical solution for using surplus food, dumping excess food onto socio-economically marginalised populations can neither be seen as a long-term solution to food insecurity nor can it effectively address the root causes of food waste (Messner et al., 2020). Other valorisation strategies that retailers employ include sending surplus food to farms to be used as animal feed or to digesters for conversion to biofuel. These strategies, although better than sending food waste to landfills, are environmentally inefficient when compared to preventing surplus food from being generated or using it for human consumption (Papargyropoulou et al., 2014).

Recent empirical findings suggest that CSR initiatives employed by retail corporations may create a façade regarding their commitment towards reducing food waste without requiring them to make systemic changes (Devin and Richards, 2018; Pulker et al., 2018). The most recent and comprehensive study analysing the CSR reports of the 100 biggest food retailers around the world found that only 22 of these organisations reported on their food waste reduction initiatives (Pulker et al., 2018). Some promised to be more transparent about their food waste numbers and others described partnerships with food rescue platforms and charities that allow consumers to take home their surplus food for free or at a reduced price (Pulker et al., 2018). Only one retailer, Tesco Plc, discussed plans to address food waste throughout its supply chain (Pulker et al., 2018). When retail corporations attempt to address the problem of food

waste by focusing on solely reducing their own waste volumes, they merely treat a symptom of the systemic problem of overproduction. In wanting to appease consumer wishes for perpetually full supermarket shelves, a wide range of product variety, and perfectly shaped produce, retailers continue to enable a system that suffers from chronic overproduction.

4. Conceptualising a human rights-based due diligence framework to address food waste

Free-market capitalism allows retail corporations to operate with the singular aim of maximising profits, without having to address the issue of overproduction. Some scholars believe that the socio-environmental nature of the food waste problem warrants government action via economic incentives and sanctions. This view often excludes businesses from having to take responsibility beyond voluntary CSR initiatives. An opposing view, captured in the business and human rights discourse (Ramasastry, 2015) and legal and policy developments (United Nations, 2011; European Commission, 2022), contends that corporations must be held to account for not acting on business practices that actively harm the wellbeing of communities and obstruct the fulfilment of human rights.

The right to food has been recognised in two international human rights instruments, the Universal Declaration of Human Rights and the International Covenant on Economic, Social and Cultural Rights (hereafter the Covenant). Like other economic and social rights, the right to food is often misunderstood. It is not about the 'government doing everything for everyone', nor is it 'the right to be fed' (Riches, 2018), except in situations of emergency such as war or natural disasters. The right to food is multifaceted, and includes four interrelated elements: availability, adequacy, accessibility, and sustainability, which have been developed by the Committee on Economic Social and Cultural Rights (hereafter the Committee), the UN body tasked with monitoring the implementation of the Covenant (General Comment no 12 of the Covenant). Under the Covenant, states have the primary legal responsibility to ensure the right is fulfilled.

As argued by Telesetsky (2013), minimising food waste should be regarded as a means of realising the right to food. The Covenant does not explicitly mention food waste. However, it does require states to take measures to "improve methods of (…) conservation and distribution of food by making full use of technical and scientific knowledge, (…) and by developing or reforming agrarian systems in such a way as to achieve the most efficient development and utilization of natural resources" (Article 11(2)(a)). Telesetsky thus contends that "while this language may have been intended to be narrowly tailored to the food waste that happens as food loss in the fields as part of agricultural systems, it can also be read to apply to a lack of storage, markets, commodity networks, and small-scale processing industries since the obligation includes 'developing or reforming agrarian systems". Building on her argument, we also note the availability component of the right to food, which is defined in the General Comment as "the possibilities (…) for well-functioning distribution, processing and market systems that can move food from the site of production to where it is needed in accordance with demand". There too, the language used can be read as a recommendation to minimise food waste in order to realise the right to food.

Having connected food waste and the right to food, her paper focuses on suggested public policy interventions to reduce food waste. The interplay between corporate activity and the right to food framework is generally not well researched, with some exceptions. For instance, Černič (2018) posits that the corporate obligation to avoid causing any harm to individuals' enjoyment of food is irrefutable and that corporations in the food industry must strive to guarantee the protection of the right to food across their supply chains and business relationships. In the European context, Corini (2015) argues that the increasing attention paid to food safety has possibly led to state as well as non-state actors ignoring economic issues pertaining to food security, thereby failing to fulfil citizens' right to food. Other scholars such as Riches (2018) and Narula (2006) have criticized corporate food banking from the perspective of the right to food and discussed the role of state and civil society actors in holding corporations responsible for infringing the human right to food respectively.

Building on the existing literature, we go one step further, and conceptualise food waste as a right to food issue, and in turn as a topic relevant to the business and human rights agenda. The Committee itself recognised as early as 1999 that the

private sector has responsibilities in the realisation of the right to adequate food (General Comment, paragraph 20), but did not elaborate on this point. However, we now know that by enabling chronic overproduction, and consequently the removal of surplus food from food supply chains, retail corporations contribute to the unfair distribution and overexploitation of food resources, which hinders the right to food. Moreover, since 1999, the normative landscape on business and human rights (BHR) has strengthened significantly, notably thanks to the adoption of the 2011 UN Guiding Principles on Business and Human Rights (UNGPs), thus allowing us to argue that food retailers should tackle food waste as a human rights issue in order to meet their existing and future responsibilities.

The UNGPs establish that corporations have a responsibility to respect human rights. To discharge this responsibility, they should have due diligence processes in place to identify, prevent, and mitigate their human rights impacts (United Nations, 2011). This responsibility extends beyond their own internal operations. It entails the scrutiny of the entire supply chain to ensure that the corporation is not linked to human rights harm through its business relations (United Nations, 2011). While CSR focuses on self-guided corporate volunteerism and philanthropy towards social causes, BHR aims to hold corporations accountable for harmful behaviours (Ramasastry, 2015). The UNGPs also emphasise that states have a duty to ensure that corporations respect human rights for example through the adoption of corporate due diligence legislation as a way to operationalise the corporate responsibility to respect human rights. We note recent legislative developments in this direction in France, Germany, and Norway, as well as the publication by the EU Commission of a Draft Directive on Corporate Sustainability Due Diligence (European Commission, 2022; Krajewski et al., 2021; Savourey and Brabant, 2021).

The connection between SDG 12.3 and BHR principles is pertinent here as well. Since their establishment in 2015, the SDGs have received an enthusiastic response from businesses. With organisations such as the World Business Council for Sustainable Development and PricewaterhouseCoopers highlighting the economic benefits of aligning business models with the SDGs, industry associations and business think tanks have been able to build a ‘business case’ narrative around the sustainable development agenda which is inherently linked to serval human rights issues (Vives

Gabriel and Wettstein, 2020). In the near future, due diligence obligations will fall on all large EU corporations, including food retailers.

In relation to reducing food waste, the impact of the UN SDG agenda is evidenced by the proliferation of voluntary agreements created with the aim of achieving SDG 12.3. Examples of such agreements include the UK Courtauld Agreement, the French national pact on combating food wastage, and initiatives led by organisations like Stop Food Waste Australia and Denmark Against Food Waste. While the goal of environment-focussed voluntary agreements is to take substantive actions to minimise the negative impacts of business operations, it is the prospect of public recognition of their efforts and a convincing business case around financial savings that often motivates firms to join them (Delmas & Terlaak 2001; Piras et al., 2018). Participation in voluntary agreements allows businesses to alert consumers about their willingness and ability to provide products or services with enhanced environmental credentials, thereby creating the opportunity for product differentiation (Arora & Cason 1999; Reinhardt 1998). Furthermore, given the non-binding nature of such agreements and the lack of penalties for non-compliance, concerns regarding free riding cannot be overlooked (King and Lenox, 2000; Rivera and DeLeon, 2004). Similar to CSR, as discussed in section 3, businesses are likely to join voluntary agreements to improve the marketability of their brands and enhance business relations. In the context of SDG-inspired voluntary agreements, this is unsurprising given that the UN frames the role of businesses in the accomplishment of SDGs very broadly, mirroring the CSR rhetoric of voluntary actions, discretionary measures, and the absence of accountability mechanisms (Vives Gabriel and Wettstein, 2020).

However, a BHR reading of paragraph 67 of the UN's agenda for SDGs creates the possibility for an accountability-based framing of the role of businesses in achievement of the SDGs. Paragraph 67 highlights the responsibility of the private sector in helping solve sustainable development challenges while 'protecting labour rights and environmental and health standards' in accordance with relevant international agreements and guidelines, including the UNGPs (United Nations, 2011). Some BHR scholars regard this as an exciting opportunity to steer business efforts to achieve the SDGs in a human rights-principled direction (Buhmann et al., 2018). Others suggest that unless the UN explicitly integrates a BHR approach into its SDG agenda, the

UNGPs and SDGs will not overlap significantly despite several of their end goals being obviously complementary (Vives Gabriel and Wettstein, 2020).

Pillar II of the UNGPs establishes the corporate responsibility to respect human rights and asks companies to carry out human rights due diligence in order to meet this responsibility (UNGP 15). Under the UNGPs, the process includes five steps: (a) identify and assess adverse human rights impact of their own, or with which they may be connected through a business relationship (UNGP 18); (b) integrate their findings and take appropriate action (UNGP 19); (c) track how effective their actions have been (UNGP 20); (d) communicate about their due diligence process (UNGP 21); and (e) provide remediation in case they have caused or contributed to adverse impact (UNGP 22). While companies themselves have this responsibility and should drive the process, the UNGPs stipulate that (potentially) affected rights-holders must be included and empowered.

Applying this framework to food waste, we propose a five-step approach that retail corporations could take on to reduce the occurrence and negative impacts of food waste in their supply chains. The first step would be to map the drivers of food waste generation along the supply chain followed by an assessment of their negative impacts, focusing especially on the impediment to citizens' right to food. The scope of this step must extend not only to direct impediments but also more broadly to communities and food system stakeholders who are indirectly impacted by food waste in the short as well as long term. Following such an assessment, the next step would be to develop and implement policies and procedures that integrate the reduction of food waste into all aspects of business operations while complying with state-stipulated food safety requirements. Any additional safety or quality requirements will need to be justified along with an explanation regarding the steps taken to ensure that they do not contribute to food waste. Retailers would also need to account for how their food waste management practices (or lack thereof) impact those of their suppliers and set targets for reducing food waste along the supply chain. The devised policies and procedures must have a robust connection to improved food security and must help advance citizens' access to food. The third step would require retailers to monitor and evaluate the effectiveness of their policies and procedures by tracking and analysing data on food waste reduction and its impact on food security. At this stage,

retailers must meaningfully engage with stakeholders to gather feedback on their actions and progress. Relevant inputs provided by stakeholders should inform the next cycle of due diligence that the business will carry out. At the fourth step, companies should provide remediation, wherein any identified drivers of food waste are addressed and affected actors are compensated. Depending on the context, remediation could encompass a variety of measures such as taking (at least partial) financial responsibility for wasted food, partnering with food banks to improve food security in the long term, offering incentives to suppliers who make efforts to reduce food waste, and undertaking actions to offset the climate impacts of food waste. Finally, at the last step, identified food waste drivers, their social and environmental impacts, and business efforts to address them should be communicated to stakeholders, including investors, customers, and affected communities. Relevant inputs provided by stakeholders should inform the next cycle of due diligence that the business will carry out. Figure 2 provides a graphical summary of the accountability-based five-step approach to food waste reduction.

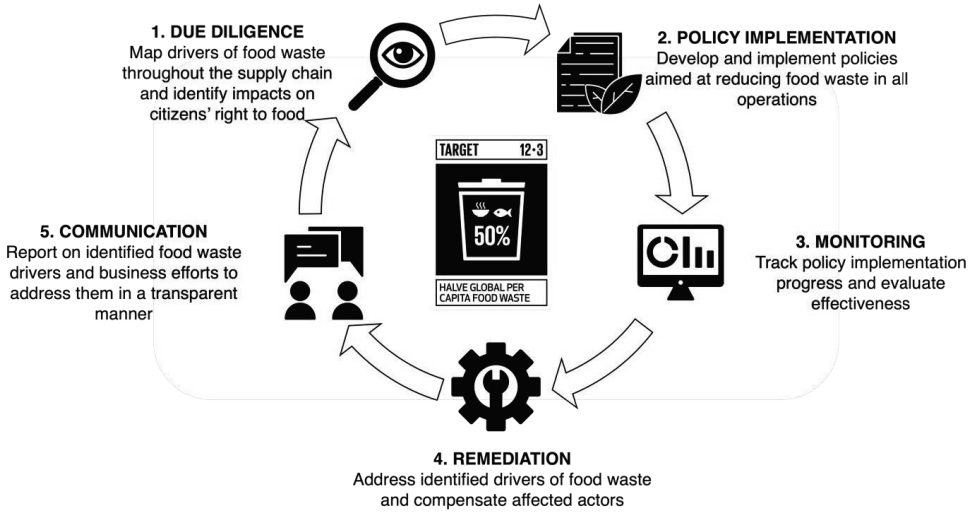

Figure 2 BHR based five-step approach to retail accountability for food waste

Several of the steps described above are often part of voluntary agreements as well. However, a key difference is that creators of voluntary agreements are able to cherry pick measures that suit the CSR agendas of signatories, shielding them from the more tedious or profit-impeding measures. In the BHR-based approach we suggest, this is

not a possibility. In order to align with Pillar II of the UNGPs, all five steps must be undertaken as opposed to only those that that help public relations and bolster profits. Additionally, by centring its attention exclusively on retail corporations, the focus of the five-step approach significantly differs from that of voluntary agreements where all involved stakeholders are seen as equally responsible without much regard to power dynamics. Unlike the CSR-adjacent approach of voluntary agreements, this framework is centred around retailers being answerable to relevant stakeholders, supply chain partners, and the state actors regarding their efforts to reduce food waste. These distinctions play a pivotal role in distinguishing our approach from voluntary agreements. In contrast to the fragmented and discretionary form of involvement promoted by voluntary agreements, our framework charts a coherent trajectory that harmonises the ambitions of sustainable development, human rights, and ethical business practices. The dynamic and cyclical nature of this approach also allows for continuous improvement and adaptation to changing circumstances, policy and regulatory measures, and technology in the field of food waste management. Considering the serious lack of attention to the human rights practices of retailers, the application of the five-step approach would pave the way for improved transparency regarding the business ethics of food retailers and aid in the implementation of upcoming legislation on sustainability due diligence. Furthermore, by specifically considering the human right to food, this framework addresses a social and economic right often overlooked in traditional corporate social responsibility strategies. It recognises that food waste not only has environmental implications but also ethical and social consequences. By emphasising the responsibility of retailers to respect and protect the right to food, this framework underscores the importance of fair distribution and access to nutritious food for all right-holders. Figure 2 provides a graphical summary of the accountability-based five-step approach to food waste reduction.

BHR in the context of the food industry often focuses on other acute issues such as forced labour, displacement of indigenous communities and generally poor working conditions (Boudreaux and Schang, 2019; Lebaron, 2021; Rao and Bernaz, 2020). More generally, corporate accountability for economic and social rights such as the right to food remains elusive (Černič, 2018). This commentary, which presents food waste as a BHR issue due to its impact on the right to food while suggesting ways for companies to address it through a due diligence process, is a timely proposition in

light of the Draft Directive on Corporate Sustainability Due Diligence. If adopted, the Directive will bring human rights issues in supply chains to the fore in the European Union. It would require businesses to trace and identify risks related to human rights and the environment throughout their operations, further strengthening the accountability-based system that we suggest in this commentary. The involvement of public authorities would help alleviate the steep power asymmetries prevalent in the agri-food sector, mitigating the possibility of retail corporations pushing the burden of due diligence onto weaker upstream actors.

5. Concluding remarks

This commentary is the first to explore the connection between retail corporations, business accountability for human rights, and food waste. The bridge that we have created between food waste reduction and retail accountability opens a Pandora's box, for it leaves several questions unanswered. Is it feasible for businesses to accurately measure and monitor waste in today's complex, globalised food supply chains? Should emerging due diligence legislation be accompanied by industry-specific guidance addressing human rights issues, beyond those most commonly discussed? How can the fields of CSR and BHR coalesce to improve the state of global food waste? We invite scholars and practitioners whose work intersects with such questions to build on the discourse initiated in this commentary.

Our work also invites business ethics scholars to further investigate the powerful position retail corporations hold in today's food supply chains and what this means for broader discourse on the responsibility of businesses towards the environment and connected societal issues. Located at the interface between consumers and the rest of the chain, retailers have strategically used their understanding of consumer wishes to establish themselves as dominant actors who are able to influence global food production. By illustrating the extent of retail corporations' influence on other actors in the food supply chain, we highlight how they contribute to food waste in more ways than discarding in-store surpluses. Retailers employ private safety and quality standards to dictate intrinsic and extrinsic qualities of food products. These standards allow only the most perfect foods to enter supermarkets, leaving behind imperfect products as surplus or waste with upstream actors. Retailers are also able to further

reduce their food waste numbers by shifting close-to-expiry products from their stores to the garbage bins of their customers.

If one were to check global food waste numbers, the retail sector appears to be among the least culpable actors in the supply chain. However, a closer look at their operations reveals that the sector indirectly contributes to food waste in several ways. Food chain actors that accrue food waste due to this are rarely able to act on the issue by themselves due to retail's position in the market. While some retailers are investing in CSR initiatives to minimise the occurrence of food waste, they focus almost exclusively on their own waste volumes and rely on arbitrary solutions such as donation to charities to appease their customers and stakeholders. Furthermore, the non-binding nature of CSR guidelines enables corporations to choose which social and environmental issues they engage with. This often results in other trendier sustainability challenges beating food waste to retailers' corporate agendas.

Having underscored the deficiencies of CSR strategies in this context, we conceptualise the possibility of addressing the issue of food waste through an accountability-based system. Based on Pillar II of the UNGPs, our proposed framework serves as a preliminary measure to increase accountability at the company level, acting in synergy with potential state or sector-based interventions. By mapping human rights impacts, developing guidelines tailored to business operations, monitoring progress, carrying out remediation, and transparently reporting business impact and ongoing efforts, this approach harnesses the pivotal position of retail corporations in the food system to instil accountability for their actions, while acknowledging the need for broader, complementary interventions to effectively tackle the persisting issue of food waste.

Abbreviations

BHR – Business and Human Rights
CSR – Corporate Social Responsibility
FAO – Food and Agriculture Organisation of the United Nations
NGO – Non-Governmental Organisation

SDGs – Sustainable Development Goals

UN – United Nations

UNEP – United Nations Environment Programme

UNGPs – United Nations Guiding Principles on Business and human rights

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9

Summary and General Discussion

The aim of this thesis was to investigate public policy, governance, and regulatory opportunities to facilitate the safe and sustainable valorisation of food waste within the European Union while striking a balance between the economic interests of private actors and the socio-environmental objectives of public institutions. Results from the seven studies undertaken as part of this research indicate that the complex and expansive nature of the food waste problem necessitates concerted action from stakeholders across the food system and other connected areas of the economy. In light of the EU's ambition to move towards a circular economy in the near future (Fitch-Roy et al., 2020), public institutions must recognise the critical role of private actors such as food business operators in reducing food waste. By creating practicable governance mechanisms, public institutions can facilitate the safe, environmentally beneficial, and nutritionally sensible repurposing of food waste and surpluses. In the sections that follow this one, I further elaborate on these results and connect them with the broader topic of governing food waste valorisation.

1. Summary of key findings

Chapter 2 examines the current state of industrial food waste in the EU by focusing on the most relevant food processing by-products in the region – spent grains, fresh produce, dairy, meat, and oil seed cakes and meals. To highlight the diversity of these waste streams, the safety hazards, economic and nutritional value, and current valorisation pathways are discussed for each stream. This analysis emphasises that an all-encompassing solution cannot be used to valorise food waste. Other than the physical properties of the waste streams, legal barriers and consumer perception must be considered. In order to aid food business operators who seek to valorise their waste streams, we propose a decision tree that accounts for food safety, sustainability, and nutritional value.

Venturing into empirical inquiry, Chapter 3 explores a waste stream born out of policy change. The aim of this study was to investigate the feasibility of incorporating more fish in the food parcels provided by Dutch food banks through the utilisation of unwanted fishing catch. To achieve this objective, we first ascertained the interest of food bank recipients in receiving such fish. Subsequently, we analysed the viewpoints

of relevant stakeholders such as fisheries governance experts, marine ecologists, seafood traders, professional associations representatives, and food safety professionals. Data collected by interviewing these participants indicated that although valorising such fish through charitable redistribution was socially and environmentally favourable, economic and legislative barriers, stakeholder relations, and the state of logistics and infrastructure would currently make the donation of unwanted catch to food banks challenging.

The study presented in Chapter 4 investigated the 'human' side of food waste valorisation. Here, we illustrate the broad range of values and ideas that are of importance to supply chain actors engaged in food waste valorisation in the Netherlands. Findings from this study indicate that supply chain actors who engage in food waste valorisation consider local embeddedness to be a crucial aspect of their work. They often assume personal responsibility for ensuring food safety and confront various ethical dilemmas associated with converting surplus or waste food into food that is suitable for human consumption. Furthermore, they encounter apprehensions about how society views food waste valorisation and frequently grapple with the regulatory and supply chain-related uncertainties that are characteristic of their jobs. We also examine the differing perspectives of participants working in for-profit and non-profit organisations and the implications for addressing the complex issue of food waste. We suggest that professionals who are committed to facilitating the transition of the food system to a circular operating model may be suitable candidates for mediating such a shift by taking on the role of transition brokers.

Chapter 5 presents results from an exploratory study that examined the impact of the COVID-19 pandemic on surplus food redistribution in the Netherlands. The paper's key findings indicate that the pandemic caused disruptions in the food supply chain, leading to increased levels of surplus food. At the same time, unemployment resulting from the lockdown led to a steep rise in the number of citizens seeking food aid. However, this did not necessarily result in surplus food reaching those in need. Challenges in terms of safety, logistics, and capacity obstructed the effective functioning of redistribution organisations, especially in the case of smaller charity organisations. Through community-led initiatives, innovative use of social media, and unusual collaborations, food redistribution systems remained active. Building on

lessons from the pandemic, this chapter invites governments, legislative bodies, and civil societies to initiate a conversation regarding the private governance of surplus food redistribution.

Chapter 6 analyses relevant legislations and policy goals with regard to using food waste to create biofuel and biogas. An important contribution of this chapter lies in its identification of how the food waste hierarchy model that underpins all legislative changes in connection to food waste valorisation may inadvertently create competition between different valorisation options. Despite being ranked as the least preferable option, energy recovery may be more appealing to food business operators due to its potential to keep food waste out of landfills and avoid the safety risks and expenses associated with reusing waste as food or feed. To avoid such competition, we suggest that valorisation options for food should be based on their safety for human consumption. By prioritising economic and social well-being when food is suitable for human consumption and environmental sustainability when it is not, conflicts between food business operators' economic, social, and environmental priorities can be largely prevented. However, businesses may require additional support in deciding the most appropriate option for their food surplus or waste. Private regulation measures, such as voluntary standards, may provide a means to enable the sustainable and equitable valorisation of food waste. In alignment with relevant legislation, private standards on food, feed, and energy must collaborate better to enable a transition to a future where biomass at the end of its life in one supply chain is safely used in another.

Chapter 7 presents a case study that explores the circumstances and strategic decisions that allowed a medium-sized enterprise in the Netherlands to achieve commercial-scale valorisation of citrus waste. Our analysis reveals that the regulatory and political contexts in the Netherlands played a pivotal role in the success of the company. Results shared in this chapter indicate that the Dutch government has been able to adapt the demanding and sometimes ambiguous requirements of EU General Food Law and the Waste Framework Directive to meet the needs of businesses, while maintaining consumer and environmental safety. We found that the formation of partnerships based on mutual trust and economically viable propositions was crucial for establishing functional supply chains and achieving commercial viability. Collaborating with larger corporations and involving stakeholders through consistent

and transparent communication also contributed to the success of the enterprise. Moreover, the positive outlook of employees towards circularity, along with their willingness to learn new skills, have been driving forces behind the company's growth trajectory. The organization's focus on circularity has allowed it to operate within a circular economy framework, where it maximizes the value of waste materials by converting them into new products or resources. Overall, the case study highlights the importance of a supportive regulatory and political context, as well as strategic partnerships, stakeholder engagement, and employee commitment in achieving commercial-scale valorisation of waste materials.

Chapter 8 presents a commentary on the role of retail corporations in reducing food waste. The numerous ways in which these corporations impact the state of food waste directly and indirectly are discussed alongside the surface-level initiatives taken to assuage the problem. Drawing on the legal framework for business and human rights, we propose an accountability-based system to address the issue of food waste. We suggest that the first step towards improved retail accountability for food waste is to conduct due diligence, followed by developing appropriate policies, monitoring progress, carrying out remediation, and reporting business impact and ongoing efforts in a transparent manner. This approach offers the possibility of using retailers' pivotal position in the food system as a fulcrum to balance their immense power with accountability for their actions. Although this approach is unlikely to solve the persistent and seemingly unrelenting issue of food waste in its entirety, it provides a way to address it by holding retailers accountable for their actions. We also recommend that governments and civil society organisations support this approach by developing legal frameworks and monitoring systems to ensure compliance. Overall, the chapter highlights the need for increased accountability and transparency in the retail sector to tackle the issue of food waste.

2. A reflection on research methods

Chapters 2, 6, and 8 form the conceptual foundation of this thesis and explore existing knowledge in the context of the research questions I seek to answer. Qualitative inquiry dominates chapters 3, 4, 5, and 7, which form the empirical aspects of this dissertation. This choice was made based on the nature of the research questions I seek to answer: what are stakeholders’ experiences and perspectives in connection

to food waste valorisation? How do social norms and cultural factors impact the use of surplus food and waste biomass? What are the underlying motivations and meanings behind the actions taken by involved actors? How do stakeholders adapt to and navigate challenges that impede food waste valorisation? Answering such questions necessitates the exploration of human experiences, behaviours, and social phenomena – a task most suited for the application of qualitative research methods.

Depending on the goal of individual empirical chapters, a variety of techniques have been employed for the collection and analysis of data. Chapter 3 takes on a mixed methods approach wherein surveys are used to statistically determine whether food bank users are interested in receiving more fish as part of their weekly food parcels. This is combined with a qualitative approach by using in-depth semi-structured interviews to establish whether experts working with the Dutch Food Bank Foundation and the fisheries sector consider it feasible to donate unwanted catch to charities. In Chapter 4, we seek to understand how relevant actors experience the phenomenon of food waste valorisation. Therefore, the phenomenology approach as described by Creswell & Poth (2016) and Sorrell & Redmond (1995) was seen as fitting to study a detail-rich and contextual account of participants' experiences. A subsection of the participants interviewed for the study presented in Chapter 4 were separately interviewed for the study presented in Chapter 5. Despite this commonality, the two studies employed different approaches to data collection and analysis. Given the exploratory nature of the study presented in Chapter 5, the Exploratory-Descriptive Qualitative method as described by Hunter & Howes (2020) was applied to understand the impact of the Covid-19 pandemic on the redistribution of surplus food in the Netherlands. Finally, in Chapter 7, a single case study based on the guidelines provided by Yin (2009) is presented to demonstrate how a food business operator was able to valorise food waste in a commercially successful way. Interviews, process and participant observation, and document analysis were used to collect data for the abovementioned studies.

For the studies presented in chapters 4, 5, and 7, the Ethical Review Committee Inner City Faculties of Maastricht University was consulted. The Committee reviewed various aspects of our research proposals including provisions regarding informed consent, the questions to be asked during interviews, protocols regarding anonymising

data, and data storage plans. The Committee did not review the proposal for the study presented in Chapter 3. This study is the result of an undergraduate research project I supervised in 2021. The project was created on an ad-hoc basis and was not set up with the intention to publish the results. It therefore did not qualify for a review by the Committee. However, as part of the educational activities, an internal committee composed of qualified researchers at Maastricht University's Campus Venlo did review the proposal and help ensure ethical integrity of the study.

As is the case with all qualitative investigations, the results presented in this dissertation are context-specific and therefore not entirely global in their applicability. Given that the Netherlands is the geographic focus of all four empirical chapters, it is important to acknowledge that the social, political, and regulatory conditions prevailing in the country at the time of data collection have impacted the results presented in this dissertation. Additionally, my personal philosophical position as a researcher as well as my social position while interacting with study participants are of consequence as well.[13] Having approached the research through a post-positivist lens, I have strived to assume a 'learning' role as opposed to a 'testing' one when seeking answers to the questions I pose above. In the tradition of the post-positivist philosophy (Ryan, 2006), I have attempted to mobilise study participants' knowledge and understanding of food waste valorisation in order to engage in the construction of new knowledge. Shaped by the unique perspectives, interpretations, and social contexts of the study participants and myself, this new knowledge is rich in detail and juxtaposed against existing knowledge wherever possible but subjective in nature. Rather than striving for an ultimate truth or objective reality, I aim to showcase the rich tapestry of interpretations and meanings that emerge from the lived experiences of those involved.

My own social position as an 'outsider' in Dutch society is likely to have impacted the findings presented in this dissertation as well. At times, this position granted me the identity of a neutral third party, inviting participants to reflect upon and explain social

[13] None of the research chapters of this dissertation are single-author papers. However, being the first author of all chapters, I have played a key role in designing the studies, collecting and analysing the data, and describing the results. Therefore, my personal philosophical position as well as my social standing have had a considerable impact on the development of this thesis.

contexts in more depth than they would have to someone they considered a full-fledged member of their society. At other times, this identity caused participants to become hesitant to open up about the shortcomings in their social environments. Furthermore, being in the position of an educated expert 'analysing' the lived experiences of study participants is likely to have created an imbalance of power (Dodgson, 2019), leading to study participants feeling a certain level of vulnerability or apprehension in sharing their perspectives fully.

Recognising the potential influence of my outsider and expert statuses, I made continuous efforts to establish trust and rapport with participants, emphasising the value of their insights and experiences. To mitigate any potential power imbalance, I endeavoured to create a safe and supportive environment by employing various strategies such as active listening, respecting confidentiality, ensuring anonymity, and creating the possibility for participants to check raw data prior to analysis. Additionally, I adopted a reflexive stance throughout the research process, critically examining my own biases and assumptions together with my co-authors to minimise any undue influence on the interpretation of the data. Nonetheless, it is crucial to acknowledge that the impact of power differentials and social positions in research cannot be entirely eliminated.

By taking cognisance of these limitations and potential biases, this dissertation aims to promote transparency and reflexivity in the presentation of findings. It is my hope that this acknowledgement will encourage further dialogue and reflection within the academic community, ultimately contributing to a more nuanced understanding of the complexities involved in studying social phenomena.

3. Key theoretical contributions

3.1 Emphasising the importance of food safety in the circular bioeconomy

From the results and discussions presented in this dissertation, it becomes clear that food safety and food waste valorisation share a contentious relationship. In all research chapters, food safety comes up as a barrier to the effective and commercially viable valorisation of food surpluses and waste, particularly in the context of retaining

these materials in the food supply chains. At times, risks from contaminants inherent to these materials and processes are a direct cause for concern. But several other barriers to food waste valorisation are indirectly connected to safety as well. For instance, regulatory bottlenecks often arise because competent authorities and legislators enforce precautions to protect public health. Liability concerns often discourage larger businesses from cooperating with smaller ones to valorise their by-products. Supermarkets are reluctant to donate close-to-expiry products to charities due to similar apprehensions as well. Supply chain operations also require logistical redesigning and in turn, investment of resources, to ensure the safety of such material.

This safety-sustainability trade-off is a well-recognised dilemma not only when valorising food waste but also in the broader discourse surrounding the circular bioeconomy. In their review on this subject, Focker et al. (2022) recognise that the potential presence and accumulation of emerging food safety hazards are a significant hurdle in moving towards a circular food system. Although extant literature extensively surveys contaminants such as pharmaceutical residues, dioxins, heavy metals, and pathogens, additional research is required to identify and control emerging chemical and microbiological hazards (Focker et al., 2022). Given the changing climate and circularising (bio)economy, examining the presence and impacts of contaminants such as mycotoxins from fungi and phycotoxins from algae is of particular importance if public health crises are to be averted (Miraglia et al., 2009). Additionally, pesticide residues require more attention. The changing climate brings novel biological threats to crops and this may result in new, and potentially more persistent plant protection products being used to ensure high crop yields (Miraglia et al., 2009). Without appropriate measures, these products may enter the food supply chain.

As vexing as they are, food safety challenges must be overcome in order to innovate for a food system that is resilient in the face of a warming planet and capable of providing for the growing population. While effective governance alone cannot balance the delicate safety-sustainability equilibrium, public authorities must create mechanisms that foster meaningful innovation that lead to tangible impacts without compromising food safety (Kristinsson & Jörundsdóttir, 2019). Public institutions may also want to support circularity in the food system to improve food security (Zhang et al., 2022). Implementing the circular economy principles in the agri-food sector can

result in better use of land resources, higher crop yields, and better quality of agricultural products (Yazdani et al., 2019).

Since innovation in the food sector is largely propelled by the effort of the private sector today, reshaping private actors' outlook towards food safety in the food waste valorisation process, and more broadly, the circular bioeconomy, is critical as well. Instead of being an afterthought, food safety must be integrated into the design and development of new products, processes, or systems. This 'safety-by-design' approach has shown immense promise in other fields such as nanotechnology and synthetic biology (van de Poel & Robaey, 2017) and could potentially transform the way safety is dealt with in the food system (Focker et al., 2022).

Consumers' concerns regarding food safety have also been mentioned in this dissertation as a barrier to circular innovation in the food system. However, the next generation of consumers is likely to be more educated, socially responsible, and in tune with the stretching limits of the planet than the generations before them (Kristinsson & Jörundsdóttir, 2019). This gives food business operators the opportunity to involve consumers more directly in the product development process, possibly leading to an overall improvement in the consumer perception towards risks that come with innovation.

3.2 Reimagining the food waste hierarchy

At the time of writing this thesis, Papargyropoulou and colleagues' (2014) pioneering paper on the food waste hierarchy has been cited over 1300 times. When synonymous concepts are searched, the popularity of the food waste hierarchy in academic literature and policy documents is only bolstered. This is for good reason, of course. Based on extensive life cycle assessments and consideration of social, economic, and environmental issues, the hierarchy is indeed scientifically and morally well-founded. However, as evidenced in this dissertation as well as the literature on the subject (Arnold, 2021; Messner et al., 2020; Mourad, 2016), the food waste hierarchy often fails in pragmatic contexts as food business operators struggle to pick the higher valorisation options over the lower ones. We propose two possible modifications to the hierarchy to improve its operability.

In Chapter 4, we propose that 'prevention' – the most favoured pathway – should be excluded from the food waste hierarchy for being ontologically different from other waste management approaches. Highlighting this difference, Bloom (2011) suggests that using prevention as a strategy to manage food waste that has already been created is akin to reminding someone to 'avoid nails' as a way to fix a flat tyre. The empirical findings shared in Chapter 4 indicate that stakeholders working towards the valorisation of food waste struggle with the prevention pathway, creating doubt and confusion regarding whether their actions to make use of food waste material was in fact damaging the effort to reduce food waste volumes. Corroborating with the proposition of Messner et al. (2020), we suggest that prevention should be used as a strategy to deal with the problems of overproduction and overconsumption, leaving reuse, recycle, and recover as the only strategies used for the management of the waste or surplus that has already been created.

Chapter 6 describes how the social (people), environmental (planet) and economic (profit) priorities of food business operators come into conflict with each other when choosing a fitting valorisation pathway from the hierarchy. Building on this, we argue that the people-planet-profit approach to sustainability, also known as the triple bottom line approach, may not be suitable in this context. Instead, applying the ideas developed by Kuhlman & Farrington (2010), we suggest that the social and economic dimensions of sustainability must be separated from the environmental one because the former consider the needs of today and the latter, the needs of tomorrow.

Based on this, we propose a bifurcated food waste hierarchy which centres the safety of food when deciding how to use it. When food is safe for consumption and saleable to consumers for its nutritional value, it is of greater consequence for meeting the needs of today. At this stage, we propose that the focus should be on preventing it from turning into or being classified as waste or surplus. If the food in question cannot be sold for reasons other than food safety, it should be donated to hunger relief organisations or reprocessed into new food products. However, when food reaches a state where it is no longer safe for human consumption, it turns into waste. At this stage, it becomes crucial to prioritise environmental sustainability because the way in which we handle this biomass will have an impact on the future. Whenever possible,

considering both safety and nutritional aspects, such food should be repurposed as animal feed. This approach provides greater environmental benefits compared to utilising it solely for energy recovery. In cases where the biomass cannot be used as animal feed, it should be used for energy recovery, initially through anaerobic digestion and, if not feasible, through incineration. If we were to draw a connection to the approach discussed in Chapter 4, the strategies employed when food is safe for human consumption would be classified as 'food waste prevention'. On the other hand, the strategies utilised when food is no longer suitable for human consumption would be categorised as 'food waste management'.

Both proposed modifications to the food waste hierarchy are based on observations from literature as well as the findings from the research undertaken as part of this thesis. They were developed with the aim of customising the model to better fit the unique characteristics of food as biomass as well as the needs of the food industry. Our reimagination of the food waste hierarchy recognises the significance of two distinct but interconnected policy objectives: preventing food from turning into waste and effectively managing the biomass that cannot be prevented from turning into waste. Both objectives are crucial and need to work in tandem with each other to achieve the ultimate goal of all food waste reduction efforts – fewer tonnes of food ending up in landfills.

3.3 The promise of private standards and voluntary agreements

The European Union's food safety regulation operates under the premise that food business operators bear the responsibility of ensuring the safety of the food they make available to consumers. To fulfil this responsibility, private actors in food supply chains have developed extensive sets of rules – often referred to as 'standards' – that allow them to comply with food safety legislation and specify additional product qualities (Rao et al., 2021). Private standards, although technically voluntary in nature, have become ubiquitous in today's globalised food supply chains (Rossignoli & Moruzzo, 2014). Voluntary agreements, in contrast, are self-determined commitments or pacts made by private actors to achieve certain qualitative or quantitative goals (Burgos et al., 2018). Voluntary agreements are non-binding in nature and are often used for achieving certain targets related to environmental protection. Since food safety and

environmental sustainability are both relevant to the topic of food waste valorisation, this thesis explored their usefulness as tools to achieve cooperation between public and private actors working on the issue.

Private standards and voluntary agreements hold great potential in facilitating the safe and sustainable valorisation of food waste. Directly and indirectly, private standards already influence the state of food waste around the world. By being overly stringent and excessively prescriptive, they cause food products that are fit for human consumption to be classified as waste due to cosmetic imperfections (Devin & Richards, 2018). On the other hand, they also contribute towards the prevention of food waste by enhancing traceability, facilitating the early detection of food safety concerns, and minimizing product failures (Rao et al., 2021). Therefore, by acknowledging and studying the impact on private standards on the state of food waste, it is, in theory, possible to optimise them to aid food business operators in preventing and managing food waste.

Voluntary agreements are examined less frequently in this dissertation but merit discussion as well. As part of the EU REFRESH project, Piras et al. (2018) undertook extensive research to identify whether voluntary agreements were effective policy tools to reduce food waste. Their work largely focuses on food waste prevention as opposed to valorisation, but some of their conclusions are relevant for valorisation as well. The report found that political contexts, funding schemes, the involvement of neutral third parties, the tangibility of benefits (for businesses), and diversity of actors involved greatly affect the effectiveness of voluntary agreements.

The relevance of private standards and voluntary agreements to food waste valorisation activities has been explored in several chapters of this dissertation. Chapter 2 suggests that private standards could be a way to introduce safety requirements for food processing by-products that do not find a mention in legislation. In Chapter 3, voluntary agreements are recommended as a tool to improve cooperation between the fisheries industry and food charities in order to better valorise by-catch that cannot be sold in the market. Participants we interviewed in Chapter 4 shared that developing hygiene guides, getting certified against private standards, and joining formal or informal agreements for cooperation were instrumental in their

professional (food waste valorisation) endeavours. Chapter 6 emphasises the need to synergise private standards in various sectors of the circular bioeconomy in order to allow the safe and barrier-free transfer of food biomass from one sector to another. Finally, in Chapter 7, private food safety standards are identified as an instrument that can help businesses convince regulators of their capacity to safely valorise food waste.

While private standards and voluntary agreements do hold the promise to help businesses better utilise food waste and surpluses, their implementation must be undertaken with caution. It has been well-established in literature that through private standards, powerful actors in the food supply chain create barriers to market access for smaller businesses and impede their growth by imposing gruelling and ever-increasing requirements pertaining to quality and credence attributes (Fuchs & Kalfagianni, 2009; Hansen & Trifković, 2014; Henson & Humphrey, 2010; Rossignoli & Moruzzo, 2014). This is discussed at length in Chapter 8 wherein we highlight the ways in which retail corporations – the most powerful actors in today's food supply chains – negatively impact the state of global food waste through the enforcement of private standards developed by them. Stakeholders in the food system must collectively ensure that private standards do not create further barriers for small businesses that wish to leverage their innovations to better utilise food waste and surpluses. Additionally, voluntary agreements should not become a way for powerful corporations to greenwash their image while minimising their responsibility towards systemic food waste reduction.

4. Concluding remarks

The findings of this research, aimed at exploring the safe and sustainable valorisation of food waste while considering the interests of various stakeholders in the food system, provide several noteworthy conclusions. A prominent theme throughout this dissertation has been the delicate balance between ensuring food safety and realizing innovative processes for extracting value from food waste. To overcome the challenges this poses, it is important to recognise that the food system is constantly evolving to match the needs of its consumers. Innovations previously thought of as impracticable and unsafe have undergone meticulous refinement, ultimately transforming the food system for the greater good. Therefore, while food safety may

appear to be a formidable challenge, it can be solved through collaborative efforts throughout the supply chain and by working towards changing society's outlook towards food waste.

With the exception of charitable redistribution, innovation in the food waste valorisation space is often driven by economic incentives. It is therefore critical for public institutions to recognise the societal and environmental benefits of these initiatives and improve access to regulatory and economic mechanisms, enabling the food industry to achieve its maximum potential in this respect. Creating mechanisms that tailor legislation to meet the requirements of businesses, aligning the goals of connected policy domains such as agriculture, waste management, and climate change, and integrating skills required to achieve the circularisation of food systems into higher education curricula can significantly enhance a country's capacity to foster a safe and sustainable food system. Private actors must realise that food waste valorisation is an activity that can be carried out most successfully by cooperating with other stakeholders in the food system. By forming partnerships based on mutual trust and transparent communication, it is possible to establish successful symbioses that allow for the sharing of resources, improving technical know-how, and creating of society-wide awareness about food waste and its valorisation.

Regarding charitable redistribution of surplus food, especially in the context of wealthy welfare states, it is important to question whether private actors making use of leftover surplus food to feed those in need is a long-term solution to the systemic issue of food insecurity. While it is indeed a resourceful use of surplus food, the advancement of the circular bioeconomy and improvements in demand forecasting are going to leave such charities without sufficient food to redistribute in the near future. In addition, volunteers running such operations often do not have sufficient knowledge regarding food safety requirements, potentially endangering the health of already vulnerable recipients of food charities.

Lastly, addressing the power imbalance in the food system is of paramount importance to the attainment of food waste reduction goals. Particularly, governments must hold influential actors such as retail corporations accountable for their contribution to food waste and seek to decentralise power in the food system. Given the gravity of the food

waste problem, it is clear that self-guided corporate volunteerism and philanthropy cannot durably reduce food waste.

In conclusion, while challenges exist, this research highlights the potential for a positive transformation of the food system through collaborative efforts, integrated policies, and a shift in societal perceptions. By embracing practices embedded in innovation, sustainability, and equity, it is possible to engineer a future where food waste is minimised, food safety is assured, and circular supply chains is the norm.

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Impact

Food waste valorisation is often hailed as a novel, game-changing idea that holds the key to a sustainable and resource-efficient food system. The concept of maximising the potential of food materials through creative applications, however, is as old as the agrarian society itself. Despite its longevity, valorising food waste in the present day is more challenging than it was a thousand years ago. Our globalised food supply chains of today have been built to operate as efficiently and cost-effectively as possible, leaving little room for incorporating non-standard material flows. We also know a lot more about food safety risks and their impact on public health now than we did in the past, making us wary of taking bold steps despite having access to cutting-edge technology. In addition, the highly competitive and profit-oriented outlook of the food industry makes it challenging for business operators to share resources and invest in long-term, sustainability-centred partnerships. The findings from my research seek to assist researchers, policymakers, and businesses navigate this complex landscape as they attempt to resuscitate age-old practices of resource efficiency in the context of contemporary economic structures and scientific knowledge.

In the recent years, European public institutions have taken a keen interest in improving the food system's resilience to climate change. This has resulted in the proliferation of policy documents that aim to foster sustainable practices in the food industry, including better utilisation of surpluses and waste biomass. A key contribution of this dissertation lies in its investigation of private actors' perception of these policy goals as well as the instruments developed to achieve them. By drawing from the experiences and expertise of farmers, fishers, agri-food processors, traders, retail employees, business operators, and food bank volunteers, I have attempted to paint a vivid picture of what food waste valorisation looks like in practice. Data collected from these interactions indicate the numerous practical obstacles stakeholders face when working with food waste – lack of access to appropriate regulatory mechanisms, conflicts between economic goals and environmental or social aspirations, and concerns regarding the long-term viability of operations that use food waste as a resource to name a few. My analysis of this data highlights the urgent need for comprehensive and tailored support mechanisms that address the specific barriers faced by different actors in the food industry. Furthermore, the findings shed light on the importance of aligning economic incentives with environmental and social goals to

encourage widespread adoption of food waste valorisation practices. The dissertation also proposes recommendations for policy adjustments and collaborative efforts between public institutions and private actors to create a conducive environment for sustainable food waste management and resource recovery.

By bridging the gap between policy objectives and private sector perspectives, this research aims to enable the realisation of the circular bioeconomy and contribute to the development of an effective system for the safe and sustainable valorisation of food waste. It also urges public institutions to take cognisance of the skewed power dynamics in today's globalised food supply chains and their impact on food waste reduction efforts. Recognising the influence of dominant actors such as large multinational corporations, the dissertation emphasises the importance of ensuring the fair distribution of benefits and opportunities in the circular bioeconomy. By addressing these power imbalances, public institutions can help create an ecosystem where small and medium-sized enterprises, local initiatives, and socially responsible businesses can actively participate and contribute to a more sustainable food system.

To enhance accessibility and maximize the potential impact of this research, I have actively engaged in a range of public outreach initiatives throughout my tenure as a PhD candidate. By presenting various facets of my research at international academic conferences, facilitating workshops for industry stakeholders and public institutions, contributing to the development of academic curricula on the subject, and leveraging popular as well as social media platforms to communicate about food waste valorisation, I have successfully broadened the reach of my work. These efforts have not only disseminated knowledge but also fostered meaningful dialogue, facilitated knowledge exchange, and catalysed collaborations among academia, industry professionals, policymakers, and the wider public. Through the strategic dissemination of my research, I have aimed to ignite transformative conversations, raise awareness, and inspire actionable measures that pave the way towards a more sustainable and resilient food system.

Appendices

Nederlandse Samenvatting

Bederfelijkheid is een inherente eigenschap van alles wat eetbaar is, waardoor verspilling een intrinsiek onderdeel is van het voedselsysteem. Zonder effectieve verwerking, behandeling, transport en opslag kunnen voedselproducten oneetbaar worden, wat ervoor zorgt dat het geen onderdeel meer uitmaakt van onze voedselketen. Daarnaast kan voedsel ook buiten de voedselketen terecht komen vanwege milieufactoren die buiten menselijke controle liggen, zoals extreme temperaturen en plagen. Wanneer voedselverspilling in overmaat plaatsvindt, is het echter geen natuurlijk en intrinsiek aspect meer van het voedselsysteem.

Op het moment van het schrijven van dit proefschrift wordt geschat dat ongeveer één derde van al het voedsel dat op de planeet wordt geproduceerd, als afval eindigt. In het licht van een veranderend klimaat, afnemende natuurlijke hulpbronnen en een steeds groeiende bevolking, vormt dit een serieus probleem. In de afgelopen tien jaar is de noodzaak om voedselverspilling te verminderen erkend door zowel publieke instanties als particuliere bedrijven. Als reactie hierop hebben onderzoekers geprobeerd de grenzen van het probleem af te bakenen, manieren bediscussieerd om het aan te pakken en kaders gecreëerd om de impact van verschillende interventies te meten. In de praktijk maakt de buitengewoon ingewikkelde aard van het voedselverspillingsprobleem het echter moeilijk om concrete doelen vast te stellen, verantwoordelijkheden te verdelen en uiteindelijk verantwoording af te leggen. Gezien het feit dat de gezondheids- en veiligheidsrisico's voor consumenten een belangrijke drijfveer van voedselverspilling is, zouden veel manieren om voedselverspilling te verminderen mogelijk de gezondheid van de consument bovendien kunnen schaden.

Het onderzoek dat in dit proefschrift wordt beschreven, heeft als doel het begrip te vergroten van één specifiek aspect van het bredere voedselverspillingsprobleem. Het onderzoekt richt zich op de haalbaarheid van het veilig en duurzaam creëren van meerwaarde uit voedseloverschotten en afval, terwijl tegelijkertijd de economische belangen van bedrijfseigenaren in balans worden gebracht met de milieudoelstellingen van publieke instanties. Een dergelijke opgave sluit aan bij de ambitieuze doelstellingen die door de Europese Unie zijn gesteld met betrekking tot het verminderen van voedselverspilling en het bevorderen van een circulaire

economie. Het behalen van deze doelen vereist echter een grondig begrip van de complexe dynamiek tussen overheidsbeleid, bestuurmechanismen en juridische kaders die voedselverspillingspraktijken vormgeven. Daarnaast biedt de toenemende erkenning van de economische, milieu gerelateerde en sociale waarde van voedseloverschotten en afvalstromen een kans om innovatieve strategieën te ontwikkelen die ten goede kunnen komen aan zowel private belanghebbenden als de bredere samenleving. Door het delicate samenspel tussen overheidsbeleid, bestuur en wetgeving te onderzoeken, streeft dit onderzoek ernaar het begrip van het fenomeen van het meerwaarde geven aan voedselverspilling verder te vergroten. Daarbij worden waardevolle inzichten en aanbevelingen geboden voor beleidsmakers, bedrijven en maatschappelijke organisaties om een duurzame en efficiënte aanpak van voedselverspilling in de Europese Unie en daarbuiten te bevorderen.

Samenvatting van de hoofdstukken

De thesis begint met Hoofdstuk 1, dat een inleiding presenteert in belangrijke thema's en definities rondom dit onderwerp. Daarna volgt Hoofdstuk 2, welke de basis van het proefschrift legt door de meest relevante bijproducten van voedselverwerking in de EU in kaart te brengen en de verschillende manieren waarop deze meerwaarde kunnen krijgen. Dit hoofdstuk benadrukt het belang van het in evenwicht brengen van veiligheid, voedingswaarden en milieuoverwegingen bij het ontwikkelen van strategieën om voedselverspilling te valoriseren als menselijk voedsel en dier voedsel. Het bespreekt hoe tegenstellingen tussen verschillende beleidsdoelen, consumentenperceptie en wettelijke hindernissen barrières kunnen vormen voor verbeterd gebruik van voedselverspilling. Op basis van deze inzichten onderzoekt Hoofdstuk 3 een afvalstroom die voortkomt uit beleidsverandering. Het doel van deze studie was om de haalbaarheid te onderzoeken van het opnemen van meer vis in voedselpakketten die door Nederlandse voedselbanken worden verstrekt, door gebruik te maken van bijvangst in de visserij. Om dit doel te bereiken, hebben we eerst vastgesteld of voedselbankontvangers belang hebben bij het ontvangen van dergelijke vis. Vervolgens hebben we de standpunten van relevante belanghebbenden, zoals deskundigen in visserijbeheer, marine ecologen, zeevruchtenhandelaren, vertegenwoordigers van beroepsverenigingen en voedselveiligheidsdeskundigen geanalyseerd. Gegevens verzameld door het

interviewen van deze deelnemers gaven aan dat hoewel het valoriseren van dergelijke vis via liefdadige herverdeling wel degelijk sociaal en milieutechnisch gunstig was, de economische en wettelijke barrières, belanghebbendenrelaties en de stand van logistiek en infrastructuur zouden de donatie van bijvangst aan voedselbanken momenteel uitdagend maken.

Hoofdstuk 4 verlegt de focus van bijproducten en afvalstromen naar de actoren die betrokken zijn bij de valorisatie ervan. In dit hoofdstuk onderzoeken we de ambities en zorgen van relevante belanghebbenden om een beter begrip te krijgen van de huidige stand van voedselverspillingsvalorisatie in Nederland. Uit de bevindingen van deze studie blijkt dat actoren in de toeleveringsketen, die zich bezighouden met voedselverspillingsvalorisatie, lokale integratie als een cruciaal aspect van hun werk beschouwen. Ze nemen vaak persoonlijke verantwoordelijkheid voor het waarborgen van voedselveiligheid en worden geconfronteerd met verschillende ethische dilemma's in het omzetten van overtollig of afvalvoedsel in voedsel dat geschikt is voor menselijke consumptie. Bovendien stuiten ze op zorgen over hoe de maatschappij naar voedselverspillingsvalorisatie kijkt en worstelen ze vaak met de regelgeving en keten-gerelateerde onzekerheden die kenmerkend zijn voor hun werkzaamheden. Aangezien deze studie werd uitgevoerd toen de gevolgen van de Covid-19-crisis doorklonken in de voedselherverdelingssector, deelden verschillende deelnemers de beproevingen die ze tijdens de pandemie hebben doorgemaakt. Een aparte analyse van deze gegevens wordt gepresenteerd in Hoofdstuk 5, dat onderzoekt hoe voedselhulporganisaties die afhankelijk zijn van overtollig voedsel, werden beïnvloed door de verstoringen in de toeleveringsketen veroorzaakt door de Covid-19-crisis. De belangrijkste bevindingen van het artikel laten zien dat deze verstoringen onder meer leidden tot een toename van het overschot aan voedsel. Tegelijkertijd leidde werkloosheid als gevolg van de lockdown tot een sterke stijging van het aantal burgers dat voedselhulp zocht. Dit resulteerde echter niet noodzakelijk in overtollig voedsel dat degenen in nood bereikte. Uitdagingen op het gebied van veiligheid, logistiek en capaciteit belemmerden de effectieve werking van herverdelingsorganisaties, vooral in het geval van kleinere liefdadigheidsorganisaties. Via initiatieven op gemeenschapsniveau, innovatief gebruik van sociale media en ongewone samenwerkingen bleven voedselherverdelingssystemen actief.

Hoofdstuk 6 analyseert relevante wetgeving en beleidsdoelstellingen met betrekking tot het gebruik van voedselafval voor de productie van biobrandstof en biogas. Een belangrijke bijdrage van dit hoofdstuk ligt in de identificatie van hoe het model van de voedselafval hiërarchie dat ten grondslag ligt aan alle wettelijke veranderingen met betrekking tot de valorisatie van voedselafval, mogelijk onbedoeld concurrentie kan creëren tussen verschillende valorisatieopties. Ondanks dat energieterugwinning als de minst wenselijke optie wordt gerangschikt in deze hiërarchie, kan het aantrekkelijker zijn voor voedselbedrijfsoperators om producten via deze weg te valoriseren. Dit vanwege het potentieel om voedselafval uit stortplaatsen te houden en de veiligheidsrisico's en kosten te vermijden die gepaard gaan met het hergebruiken van afval als voedsel of diervoeder. Om dergelijke concurrentie te voorkomen, stellen we voor dat valorisatieopties voor voedsel moeten worden gebaseerd op hun veiligheid voor menselijke consumptie. Door economische en sociale welvaart te prioriteren wanneer voedsel geschikt is voor humane consumptie en milieuduurzaamheid wanneer dit niet het geval is, kunnen conflicten tussen de economische, sociale en milieuprioriteiten van voedselbedrijfsoperators grotendeels worden voorkomen.

Hoofdstuk 7 presenteert een casestudy die de omstandigheden en strategische beslissingen onderzoekt die een middelgroot bedrijf in Nederland in staat stelden om de valorisatie van citrusafval op commerciële schaal te bereiken. Onze analyse laat zien dat de regelgevende en politieke contexten in Nederland een cruciale rol hebben gespeeld in het succes van het bedrijf. De resultaten die in dit hoofdstuk worden gedeeld, geven aan dat de Nederlandse overheid in staat is geweest om aan de veeleisende en soms vage eisen van de algemene levensmiddelenverordening van de EU en de kaderrichtlijn afvalstoffen te voldoen om aan de behoeften van bedrijven te vervullen, terwijl de veiligheid van consumenten en het milieu behouden blijven. We hebben vastgesteld dat het vormen van partnerschappen op basis van wederzijds vertrouwen en economisch levensvatbare voorstellen cruciaal was voor het opzetten van functionele toeleveringsketens en het behalen van commerciële levensvatbaarheid. Samenwerking met grotere bedrijven en het betrekken van belanghebbenden door consistente en transparante communicatie hebben ook bijgedragen aan het succes van het bedrijf. Bovendien zijn de positieve perspectieven van werknemers ten aanzien van circulariteit, samen met hun bereidheid om nieuwe

vaardigheden te leren, drijvende krachten achter het groeitraject van het bedrijf geweest. De focus van de organisatie op circulariteit stelt het in staat te opereren binnen een kader van een circulaire economie, waarin het de waarde van afvalmaterialen maximaliseert door ze om te zetten in nieuwe producten of hulpbronnen.

Hoofdstuk 8 presenteert een commentaar op de rol van de detailhandel bij het verminderen van voedselverspilling. De talloze manieren waarop deze bedrijven direct en indirect hebben op de staat van voedselverspilling worden besproken, samen met de oppervlakkige invloed initiatieven die worden genomen om het probleem te verlichten. Gebaseerd op het wettelijk kader voor bedrijven, stellen we een verantwoordelijkheidssysteem voor om het probleem van voedselverspilling aan te pakken. We stellen voor dat de eerste stap naar verbeterde verantwoordelijkheid van detailhandels voor voedselverspilling het uitvoeren van *due diligence* is, gevolgd door het ontwikkelen van passend beleid, het monitoren van de voortgang, het uitvoeren van herstelacties en het rapporteren van het bedrijfseffect en lopende inspanningen op een transparante manier. Deze aanpak biedt de mogelijkheid om de pivotale positie van detailhandelsbedrijven in het voedselsysteem te gebruiken als een hefboom om hun immense macht in balans te brengen met verantwoording voor hun acties.

Hoofdstuk 9 vat de belangrijkste bevindingen van alle onderzoeks-hoofdstukken samen en zet de belangrijkste overwegingen uiteen voor het veilig en duurzaam valoriseren van voedselverspilling, en wordt ingegaan op de behoeften van alle betrokken belanghebbenden.

Conclusie

De bevindingen van dit onderzoek, gericht op het verkennen van de veilige en duurzame valorisatie van voedselverspilling met inachtneming van de belangen van verschillende belanghebbenden in het voedselsysteem, leveren enkele opmerkelijke conclusies op. Een prominent thema in dit proefschrift is het delicate balans tussen het waarborgen van voedselveiligheid en het realiseren van innovatieve processen voor het onttrekken van meerwaarde uit voedselverspilling. Om de uitdagingen hiervan het hoofd te bieden, is het belangrijk om te erkennen dat het voedselsysteem

voortdurend evolueert om aan de behoeften van consumenten te voldoen. Innovaties die eerder als onpraktisch en onveilig werden beschouwd, hebben grondige verfijning ondergaan en hebben uiteindelijk het voedselsysteem ten goede veranderd. Daarom kan voedselveiligheid, hoewel het een grote uitdaging lijkt, zorgvuldig worden aangepakt door gezamenlijke inspanningen in de hele toeleveringsketen en door te werken aan het veranderen van de maatschappelijke kijk op voedselverspilling.

Met uitzondering van herverdeling vanuit een liefdadigheidsoogpunt, wordt innovatie op het gebied van voedselverspillingsvalorisatie vaak gedreven door economische prikkels. Het is daarom van cruciaal belang dat publieke instanties de maatschappelijke en milieuvoordelen van deze initiatieven erkennen en de toegang tot regelgevende en economische mechanismen verbeteren, zodat de voedselindustrie haar maximale potentieel op dit gebied kan bereiken. Het creëren van mechanismen die wetgeving in lijn brengen met de wensen van bedrijven, het afstemmen van de doelen van verbonden beleidsdomeinen zoals landbouw, afvalbeheer en klimaatverandering, en het integreren van vaardigheden die nodig zijn om de circularisering van voedselsystemen te bereiken in curricula van hoger onderwijs kunnen aanzienlijk bijdragen aan het versterken van de capaciteit van een land om een veilig en duurzaam voedselsysteem te bevorderen. Private actoren moeten beseffen dat voedselverspillingsvalorisatie het meest succesvol kan worden uitgevoerd door samen te werken met andere belanghebbenden in het voedselsysteem. Door partnerschappen te vormen op basis van wederzijds vertrouwen en transparante communicatie, is het mogelijk om succesvolle symbiose op te zetten die leiden tot het delen van middelen, het verbeteren van technische kennis en het creëren van maatschappelijk bewustzijn over voedselverspilling en de valorisatie ervan.

Wat betreft liefdadige herverdeling van overtollig voedsel, is het met name voor welvaartsstaten belangrijk om te onderzoeken of private actoren – die gebruikmaken van overgebleven overtollig voedsel om de mensen die het nodig hebben te voeden – een lange termijn oplossing vormen voor het systemische probleem van voedselonzekerheid. Hoewel het inderdaad een vindingrijk gebruik is van overtollig voedsel, zullen door de vooruitgang van de circulaire bio-economie en verbeteringen in de vraagvoorspelling dergelijke liefdadigheidsinstellingen in de nabije toekomst

zonder voldoende voedsel zitten om te herverdelen. Bovendien hebben vrijwilligers die dergelijke operaties uitvoeren vaak niet voldoende kennis over voedselveiligheidseisen, wat de gezondheid van al kwetsbare ontvangers van voedselhulp in gevaar kan brengen.

Tot slot is het aanpakken van de machtsongelijkheid in het voedselsysteem van het grootste belang voor het bereiken van doelstellingen rondom het verminderen van voedselverspilling. Met name overheden moeten invloedrijke actoren zoals de detailhandel aansprakelijk houden voor hun bijdrage aan voedselverspilling en streven naar decentralisatie van macht in het voedselsysteem. Gezien de ernst van het voedselverspillingsprobleem is het duidelijk dat zelfgestuurd bedrijfsvrijwilligerswerk en filantropie voedselverspilling niet duurzaam kunnen verminderen.

Het onderzoek gepresenteerd in deze thesis benadrukt, hoewel er uitdagingen zijn, het potentieel voor een positieve transformatie van het voedselsysteem door gezamenlijke inspanningen, geïntegreerd beleid en een verschuiving in maatschappelijke percepties. Door manieren te omarmen die zijn geïntegreerd in innovatie, duurzaamheid en rechtvaardigheid, is het mogelijk om een toekomst te creëren waarin voedselverspilling wordt geminimaliseerd, voedselveiligheid wordt gegarandeerd en circulaire voedselproductieketens de norm zijn

Scientific and non-scientific outputs from this thesis

Published or accepted papers and book chapters

Rao, M., Bast, A., & de Boer, A. (Forthcoming). Food Waste to Biogas and Biofuel: Law & Policy. In J. van Zeben & L De Almeida (Eds.) *Law for the EU's Circular Energy System: Biofuel, Biowaste and Biogas*. Edward Elgar Publishing. [In press]

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Manuscripts under review

Rao, M., Bast, A., & de Boer, A. (Forthcoming). What does it take to close the loop? Lessons from a successful citrus waste valorisation business. [Manuscript under review].

Rao, M., Bernaz, N., & de Boer, A. (Forthcoming). Holding Retail Corporations Accountable for Food Waste: A Due Diligence Framework Informed by Business and Human Rights Principles. [Manuscript under review]

Conference presentations and invited talks

Rao, M. (Oct 2023). How regulatory processes impact innovation. *Presented as a guest lecture to MSc Health Food Innovation Management students at Maastricht University, The Netherlands.*

Rao, M. (May 2023). Valorising food waste in Europe and beyond: Can safety and sustainability go hand in hand in the circular bioeconomy? *Presented as a guest lecture to graduate students at the Federal University of Bahia, Brazil*.

Rao, M. (May 2023). Moving towards circularity or running around in circles? A critical evaluation of the regulatory framework for food waste valorisation in the European Union. *Oral presentation at the Future of Food Law Conference in Wageningen, The Netherlands.*

Rao, M., Bilić, L., de Boer, A. (Dec 2022). Transforming food waste into functional ingredients: Lessons from a Dutch case study. *Poster presentation at the 22nd IUNS-ICN conference in Tokyo, Japan.*

Rao, M., Bast, A., de Boer, A. (Oct 2022). Insights into the experiences of professionals engaged in food waste valorisation. *Oral presentation at the 2nd RETASTE Conference on Food Waste in Heraklion, Greece.*

Rao, M. (Sep 2022). Barriers and enablers of food waste valorisation in the Netherlands. *Workshop conducted at FoodValley NL's upcycling community event in Wageningen, the Netherlands.*

Rao, M. (May 2022). Finding the balance between safety and sustainability in a circular food system – The case of food processing by-products. *Presented as keynote lecture at the 13th annual conference of the World Mycotoxin Forum in Parma, Italy.*

Rao, M. Bast, A., de Boer, A. (Apr 2022). Exploring the possibility of utilising unwanted catch in food bank parcels in the Netherlands. *Oral presentation at the Circular@WUR conference in Wageningen, The Netherlands.*

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Curriculum Vitae

Madhura Rao was born on the 16th of March 1995 in Mumbai, India. In 2016, she graduated with a BSc in food, hospitality, and tourism studies from Indira Gandhi National Open University.

In 2016, Madhura moved to the Netherlands to study at Wageningen University where she followed an MSc in food safety, specialising in supply chain operations and food law. In 2018, she interned at the European Food Information Council in Brussels and developed public education material on the safety and quality aspects of organic food production.

Madhura started her PhD at Maastricht University's Food Claims Centre Venlo under the supervision of Prof. Dr. Aalt Bast and Dr. Alie de Boer in November 2019. She was also involved in teaching and curriculum development activities for the liberal arts and sciences undergraduate programme on Campus Venlo. In December 2022, she obtained her Dutch University Teaching Qualification through the Faculty of Science and Engineering. From June 2019 until May 2023, Madhura worked as a freelance science communicator for the European knowledge institute EIT Food.

Since August 2023, Madhura has been working with the Athena Institute at the Vrije Universiteit, Amsterdam as a postdoctoral fellow. At Athena, her work is connected to the EU-funded project CLEVERFOOD which seeks to empower citizens to participate in the transition to a sustainable food system through living labs and participatory action research. Madhura also advises UN Climate Change for their project 'Resilience Frontiers'.

Madhura is an enthusiastic cook, an avid reader of literary fiction, a lazy learner of the Dutch language, a keen watcher of Korean dramas, and a frequent user of twitter.com. She currently lives with her partner Rahul and their cat Pip in Rotterdam, The Netherlands.