Sustainable bread supply chains in Sweden

Examining scenarios for reducing or lowering the impact of surplus bread

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Degree project • 30 credits
Swedish University of Agricultural Sciences, SLU
Department of Energy and Technology
Master's Program in Sustainable Food Systems
Molecular Sciences, 2023:23
Uppsala, 2023

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Credits: 30 credits
Level: Advanced level, A2E
Course title: Master thesis in Food Science
Course code: EX0875
Programme/education: Sustainable Food Systems
Course coordinating dept: Department of Molecular Sciences
Place of publication: Uppsala
Year of publication: 2023
Title of Series: Molecular Sciences
Part Number: 2023:23
Cover picture: Ales Krivec (https://unsplash.com/photos/QnNqGoCnBg0)

Keywords: food waste quantification, bread take-back agreements (TBA), supply chain, food waste hierarchy, sustainable food system, food donations

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Abstract

Food waste has significant environmental, social, and economic implications, demanding actions toward a sustainable food system. In Sweden's bread supply chain, approximately 14% of produced bread is wasted, with 9% attributed to unsold bread in stores. Take-back agreements (TBAs), covering over 90% of pre-packaged bread, hold suppliers responsible for the entire chain, including surplus management. While prior studies have identified TBAs as potential waste generators, this paper examines four scenarios to address the bread supply chain from various perspectives. Prohibiting TBAs reveals the potential to reduce the retail-interface surplus by 50%, leading to a 30% overall reduction in waste annually. Improved stakeholder cooperation and inventory management can effectively decrease surplus at the production stage and the supplier-retail interface, resulting in a 33% reduction annually. By enforcing the Swedish Environmental Code and promoting the food waste hierarchy or adopting the French approach of mandatory surplus food donation by retailers, 30% to 64% of the surplus could be diverted from less desirable energy recovery to preferred reuse options every year. Additionally, this study highlights the underutilized potential for increasing donations of surplus bread.

In conclusion, this paper demonstrates that Sweden can enhance its bread supply chain through a combination of regulations and market-based mechanisms. By implementing these measures, Sweden can optimize surplus management, minimize waste, and progress toward a sustainable food system.

Keywords: food waste quantification, bread take-back agreements (TBAs), supply chain, food waste hierarchy, sustainable food system, food donations

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Abbreviations

AD	Anaerobic Digestion
EPA	Environmental Protection Agency
EU	European Union
GHG	Greenhouse Gases
LCA	Life-Cycle Analysis
NGO	Non-Governmental Organization
PL	Private-Label
POS	Point-of-Sale
RFID	Radio Frequency Identification
SDG	Sustainable Development Goal
TBA	Take-Back Agreement
UK	United Kingdom
UN	United Nations
US	United States

1. Introduction

Food waste has become an increasingly pressing issue on the global agenda. Although the proportion of global food production that is wasted is a subject of debate and varies between 20% to 60% depending on the study's system boundaries (Johansson 2021), it is clear that food waste is a critical problem that requires urgent attention. The United Nations (UN) Sustainable Development Goals (SDGs) from 2015 set a target of halving food waste at the consumer and retail level by 2030 (United Nations 2015), which is just a few years away. Given that food waste has significant environmental and social impacts, reducing it should be a priority for policymakers and stakeholders. In the European Union (EU), food waste is a topic with high priority as it is estimated that 20% of all food that is produced becomes either waste or is lost (European Commission 2020). The EU has directed several initiatives and policies dealing with this topic, such as the Waste Framework Directive 2008/98/EC, the EU Platform on Food Losses and Food Waste released in 2016, and the Farm to Fork Strategy released in 2019 (Grant & Rossi 2022).

The waste hierarchy, which establishes a priority for waste reduction activities and laws as well as waste management, is implemented as a framework in all EU member states, including Sweden (Papargyropoulou *et al.* 2014). The EU Directive 2008/98/EC establishes the waste hierarchy with prevention as the top priority, followed by reuse, recycling, recovery, and disposal as the last option. In Sweden, the priority is applied provided that it is environmentally justified and economically reasonable (Naturvårdsverket 2023).

In Sweden, households were responsible for 70% of the food waste generated in 2020, while the food industry and supermarkets accounted for 6% and 11%, respectively (Hultén *et al.* 2022). Despite the often edibility of surplus food, there is only a negligible proportion of such food being donated for human consumption in Sweden, despite an increasing number of people facing food insecurity (Johansson 2021). In 2021, only 0.4% of the overall food waste was donated for human consumption but the goal is to increase it by over 100% by 2025 (Sundin *et al.* 2023). In Sweden, surplus food is commonly viewed as a waste problem, primarily assessed from an environmental and economic standpoint. Consequently, existing policies and infrastructure have led to approximately 32% of the total collected food waste in 2018 being utilized for biogas production (Johansson 2021).

When considering volume, bread is one of the highest contributors to food waste generation in the retail sector along with fresh fruit and vegetables (Albizzati *et al.* 2019). Bakeries, together with dairies and the meat sector, account for over 50% of the total agricultural value of output in Sweden, thereby making it one of the most significant sectors in the food industry (Ghosh & Eriksson 2019). In Sweden, 90% of the bread sold is distributed under a take-back agreement (TBA), where the supplier takes back any surplus and deals with waste management (Weber *et al.* 2023). TBAs are a form of a reverse supply chain that operates under a cradle-to-cradle philosophy, which can serve a circular economy in the best practice (Ghosh & Eriksson 2019). However, previous studies have shown that for bread, TBAs can potentially be a hotspot for waste generation at the supplier-retail interface because of the lack of incentives for retailers to prevent waste (Eriksson *et al.* 2017).

The depletion of natural resources, greenhouse gas (GHG) emissions from production and transportation, and the environmental impacts associated with waste management are examples of the severe consequences resulting from food waste (Papargyropoulou *et al.* 2014). While some surplus food is necessary to ensure food security, the excessive levels of surplus and wasted food globally threaten that same issue and have significant environmental and social implications (Papargyropoulou *et al.* 2014). To effectively reduce food waste, policies are needed that encourage all stakeholders to act. These policies may take the form of market-based mechanisms that increase the cost of wasting food or binding regulations that mandate certain behaviors, or a combination of both. In this paper, four different scenarios will be explored to investigate their potential impact on the production and waste management of bread in Sweden. Each scenario is based on the aim of reducing the impact of the bread supply chain by either decreasing the surplus or utilizing it more efficiently, or both. Given that food waste is a global issue with both environmental and social impacts, any initiatives aimed at reducing it should be both efficient and substantial.

1.1 Research aims and questions

This paper aims to investigate the waste reduction potential of four scenarios on the bread supply chain in Sweden, with the objective of reducing the impact of food waste and bread production. These scenarios take the form of either market-based mechanisms or regulations, aimed at reducing the surplus or utilizing it more efficiently. The scenarios are grounded in real-world examples but are hypothetically applied to the existing structure of the dominant bread supply chain in Sweden. Accordingly, the research questions that this paper addresses are:

- How would the implementation of each scenario affect the current bread supply chain in Sweden?
- In what way can strategies to reduce food waste be adapted to address specific challenges posed by TBAs in the bread supply chain?
- What scenario could show the greatest potential in reducing bread waste and/or applying the waste hierarchy to the surplus?

2. Problem Background

This section focuses on understanding food waste by providing its definition, introducing the food waste hierarchy, and highlighting the environmental and social impacts food waste can bring. It also gives an overview of the bread supply chain in Sweden, along with background information on TBAs. Lastly, it explains the four scenarios that will be explored in this study.

2.1 Definition of food waste

The terminology associated with food waste comes with a set of different meanings depending on context. It is important to establish clear definitions as these shape the system boundaries and ultimately influence the outcomes of research on this subject (Johansson 2021). According to Papargyropoulou *et al.* (2014), surplus food refers to food that is produced in quantities exceeding our needs, while food waste is a consequence of this surplus. However, the same study emphasizes the importance of distinguishing between 'avoidable' food waste, which includes food that was initially considered edible but eventually discarded, and 'unavoidable' food waste, such as apple cores, meat bones, and coffee grounds. Additionally, there is a distinction between food waste and food loss. Hultén *et al.* (2022) define food waste as leftovers from households or food discarded by retailers and other stakeholders, while food loss refers to by-products that never reach the consumer, either because they are left in the field or used as animal feed or for ethanol production. Another more general perspective is viewing food waste as the portion of food lost at any stage of the supply chain, which could have been avoidable to some extent or simply refers to unsold products (Sedlmeier *et al.* 2019; Nikolicic *et al.* 2021).

In this paper, surplus food is defined as food that remains edible but may not reach its intended destination in the supply chain. It will remain classified as surplus food as long as it is donated, as its intended purpose, which is human consumption, is still achieved. Food waste is defined as the outcome of surplus food not being utilized for its intended purpose or, as framed by Teller *et al.* (2018), as products that are unsellable and thus need to be either recycled or discarded. In this paper,

any bread that is directed to any stage of the food waste hierarchy that is not reused will be considered wasted.

2.2 Food waste hierarchy

Discussions regarding the waste hierarchy began as early as the 1970s to establish guidelines for effective waste prevention and management practices (Teigiserova *et al.* 2020). The EU directive 2008/98/EC, implemented in 2015, prioritizes waste prevention strategies for all member states based on a shared hierarchy, with prevention as the primary focus, followed by preparing for reuse, recycling, recovery, and ultimately disposal (Giordano *et al.* 2020). The UN's SDGs mention actions aligned with the waste hierarchy, although without a specific order, and underscore the significant potential of prevention, reduction, recycling, and reuse in substantially reducing waste generation (United Nations 2015). In the context of food waste, Papargyropoulou *et al.* (2014) applied the waste hierarchy to identify and prioritize options for minimizing and managing food surplus and waste in the food supply chain. The same article highlights that the food waste hierarchy should not only guide waste management practices but also serve as guiding principles for avoiding food waste in the first place.

Various iterations of the waste hierarchy can be found worldwide, including the food recovery hierarchy in the US, the Moerman ladder in the Netherlands, and the French 4-level hierarchy (Redlingshofer et al., 2020). In the context of bread surplus and waste, the food waste hierarchy can be applied to prioritize strategies and management approaches, as illustrated in Figure 1. The most desirable approach is the prevention of surplus to even occur; however, it should be acknowledged that prevention can sometimes be more challenging to achieve (Papargyropoulou *et al.* 2014). Stakeholders responsible for waste management, who are also dependent on sales, often prioritize reuse and recycle-recovery methods over prevention due to the cost-effectiveness of these methods in relation to the potential loss of sales (Redlingshofer *et al.* 2020).

The second most preferred method in the food waste hierarchy is reusing. In the case of bread intended for human consumption, reusing involves redistributing the edible products through alternative distribution channels but still reaching people as the end consumer. An example of this could be donating bread to food assistance programs or selling it at a discounted price either at the retail stage or at alternative sale channels. Recycling is the next preferred option, where bread waste is repurposed for animal feed or ethanol production. Additionally, bread waste can be utilized for energy recovery through methods like incineration or anaerobic digestion (AD). It is important to note that disposal, the least preferred method in

the hierarchy, is not an option in the bread supply chain in Sweden as organic matter cannot be sent to landfills according to directive SFS 2001:512.

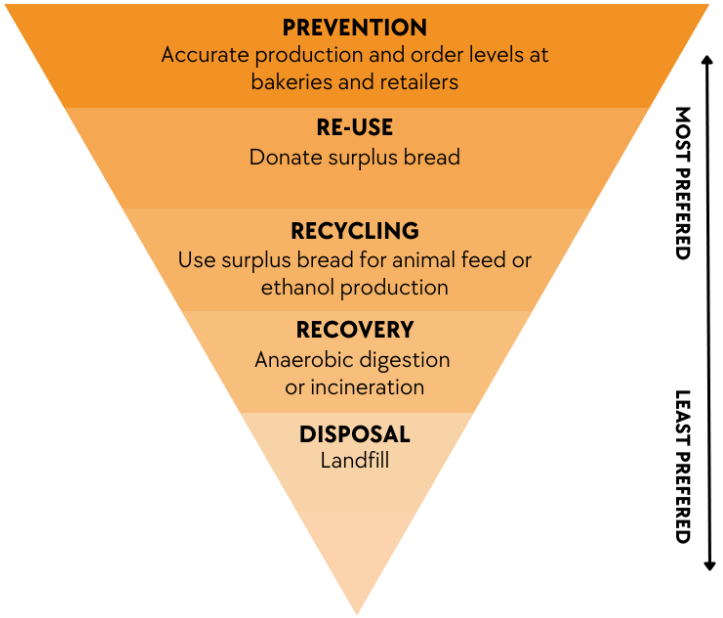

Figure 1. Food waste hierarchy applied to surplus and waste management strategies for bread. Own illustration based on Papargyropoulou et al. (2014) food waste hierarchy.

2.3 Implications of food waste

According to the latest IPCC report, global food waste was responsible for 8-10% of total GHG emissions annually between 2010 and 2016, which is why reducing food surplus and waste is a crucial climate change mitigation strategy (IPCC 2022). Food waste is not solely an issue of environmental or economic impact; it also contributes to increased food prices, leaving individuals living in food insecurity even more vulnerable (FAO 2011). The Food Waste Report by the United Nations Environment Programme (2021) emphasizes the numerous important benefits of waste reduction, including cost savings for stakeholders, improved food security, reduced environmental impacts, and the promotion of a circular economy that adds value to resources.

The circular economy, prioritized in both the EU and Sweden, places a strong emphasis on renewable energy. Consequently, in Sweden, political policies have led to the development of infrastructure that makes it more profitable and convenient to redirect surplus food for biogas production rather than donating it for human consumption or exploring alternative avenues (Johansson 2021). This is supported by Naturvårdsverket (2022), which states that Sweden achieved its

national goal in 2020 of treating at least 40% of food waste in a manner that recovers nutrients and energy. In Sweden, the cost of food waste is estimated to range between 1-2 billion € per year (Johansson 2021), with a total quantity exceeding one million tons (Naturvårdsverket 2022). It is important to note that food waste prevention methods do not offer universal solutions but instead vary across different regions. In developed countries like Sweden and other EU members, Papargyropoulou *et al.* (2014) suggest that food waste prevention efforts should focus on consumers, retailers, and the supply chain, whereas in developing countries, most of the food waste occurs at the production stage, such as farms.

2.4 Bread in Sweden

According to Jordbruksverket (2019), the consumption of bread in Sweden was in 2018 approximately 50 kilograms per person and year, accounting for 28% of the total energy intake. In terms of sales, bread ranked as the third-largest category in the Swedish food market in 2016, representing 16% of total food sales, following meat at 18% and dairy products at 17% (Konkurrensverket 2018). The market for bread in Sweden is dominated by three bakeries - Pågen, Fazer, and Polarbröd – which collectively hold over 80% of the market share (Brancoli *et al.* 2019). The remaining 20% of bread sold in Sweden is either baked at the retailer, also called bake-off bread, private labeled (PL) bread, the retailers' own brands, or bread from smaller bakeries that are often sold directly at the bakery (Brödinstitutet n.d.).

Bread and bakery products have a short shelf life compared to most of the other products in a supermarket and are sometimes called ultra-fresh products, which also results in them being some of the most discarded items (Riesenegger & Huebner 2022). Bread, along with fresh fruit and vegetables, has been identified as one of the main sources of surplus food in terms of mass (Albizzati *et al.* 2019). Additionally, a study conducted by Brancoli *et al.* (2017) revealed that bread, along with meat, has the highest environmental footprint among retailers. The trend of bread being one of the biggest contributors to food waste in terms of quantity is observed not only in Sweden but also in other countries, including New Zealand, Finland, and Austria (Nikolicic *et al.* 2021). In Sweden, the annual bread waste is estimated to exceed 80 000 tons, with households contributing the largest share at 37%, followed by the retail stage at 35%, and bakeries accounting for 15% (Brancoli *et al.* 2019). Preventing food waste, and in this case bread, has different implications for all stakeholders. Bakeries should avoid producing an excessive amount of bread that would later go to waste within the food supply chain, while retailers' focus should be on supplying the necessary quantity (Papargyropoulou *et al.* 2014). According to Albizzati *et al.* (2019), retail stores connect the sectors of

consumers and producers which is why incentives implemented at this stage can have positive effects both upstream and downstream in the supply chain.

This paper will primarily focus on the bread supply chain leading up to consumption, and therefore will not examine waste generation at the household level. The term 'retailers' throughout the paper specifically refers to food retailers, such as supermarkets or grocery shops. Bakeries, as suppliers of bread products to retailers, will be interchangeably referred to as bakeries or suppliers.

2.4.1 Reverse logistics of bread

In the retail industry of Sweden, three key stakeholders, namely Ica, Axfood, and Coop, hold a significant market share, accounting for 86% of the total market (Konkurrensverket 2018). The distribution of pre-packaged bread in Sweden predominantly involves full TBA agreements, with 90% of the products being distributed through such arrangements (Weber *et al.* 2023). The specific terms and extent of these agreements are often considered confidential corporate information and cannot be fully disclosed in detail. However, it is implied that under a full TBA, the responsibility for forecasting, ordering, placement, and removal of unsold products from supermarket shelves lies with the bakeries (Brancoli *et al.* 2019). According to Ungerth (2021), the distribution company Polfärskt, majority owned by Polarbröd, has been delivering products from both Polarbröd and Fazer to retail stores since 2021, while Pågen still manages their own deliveries. Ungerth also highlights that due to these TBAs, the bakeries supply fresh pre-packaged bread to approximately 3000 retail stores all over Sweden, between two and seven days a week, throughout the year. As a result of TBAs and its distribution system, the drivers also function as sellers, and their salary is dependent on both the quantity of bread sold and the amount of bread returned from the stores under TBA (Ghosh & Eriksson 2019).

Under TBAs, retailers lack incentives and the ability to manage shelf space, assortment, or discount bread nearing its best-before-date (Brancoli *et al.* 2019). Instead, suppliers are responsible for managing bread waste. However, there is a growing presence of PL bread at retailers (Ungerth 2021). In 2018, approximately 25% of all products sold in Swedish supermarkets were PL products, and this is expected to increase according to Konkurrensverket (2018). A study by Riesenegger and Huebner (2022) showed that if retailers can do their assortment planning with consideration of substitutions, this could potentially have the effect of lowering bread waste. With PL, retailers are also subjective to any cost of waste, including the cost of unsold products as well as managing the waste (Eriksson *et al.* 2017). As a potential result of this, the waste estimate for PL bread is estimated to be 4.5% (Bartek *et al.* n.d.).

Studies have indicated that more than 90% of pre-packaged bread sold in Sweden is subject to TBA arrangements (Weber et al., 2023). While there are no specific examples of a scenario without bread under TBA, there was a case in 2018 where the retail chain Lidl and the bakery Fazer decided to discontinue their TBA arrangement. According to Ungerth (2021), it was mentioned that bread waste decreased, although the extent of the reduction was not specified. However, Ungerth also states that Lidl resumed using TBAs in 2021, as they wanted to continue offering bread from other bakeries.

2.5 Scenario 1 - Unfair trading practices

In 2019, Directive 2019/633 on Unfair Trading Practices in business-to-business relationships in the agricultural and food supply chain was passed by the European Parliament and the Council of the EU. All member states were required to adopt and publish the necessary laws and regulations by November 2021. The directive aims to improve the functioning of the food supply system, recognizing the existence of significant imbalances in bargaining power between suppliers and buyers of agricultural and food products, as stated in the first paragraph (1) of Directive 2019/633. According to the directive, these imbalances often lead to unfair trading practices, particularly with larger and more powerful actors taking advantage of smaller ones, a situation that is increasingly common in the agricultural production sector. Deconinck (2021) describes the food supply chain as resembling an hourglass, where numerous smaller suppliers provide food to a limited number of market players who then distribute it to a large base of consumers.

Directive 2019/633, as stated in paragraph six (6), specifically targets the food supply chain, recognizing that agricultural production is uniquely susceptible to uncertainties arising from biological processes and weather conditions. Consequently, the directive aims to provide support to all small stakeholders in the food supply chain, whether they are farmers, producer organizations, or companies, by implementing a set of regulations that apply to larger operators. The goal is to address the imbalances in bargaining power and unfair trading practices, ultimately fostering a more equitable and sustainable food supply system.

In Sweden, the EU Directive 2019/633 has been transposed into national law SFS 2021:579, known as the ”Lag om förbud mot otillbörliga handelsmetoder vid köp av jordbruks- och livsmedelsprodukter”. Under the Swedish implementation, the regulations on unfair trading practices apply to stakeholders with an annual turnover of at least two million SEK (Mannheimer Swartling 2021).

Following the directive, member states are required to establish a 'black list' that clearly outlines the prohibited practices and a 'grey list' that includes conditional prohibitions (European Commission 2021). The grey list includes practices that are allowed if they, according to Article 3 in Directive 2019/633, "have been previously agreed in clear and ambiguous terms in the supply agreement or in a subsequent agreement between the supplier and the buyer". In Sweden, the implementation of the directive has led to the identification of nine practices prohibited on the black list, and six conditional practices on the grey list (see Table 1).

Table 1. Sweden's implementation of EU Directive 2019/633 and the 'grey' and 'black' list. Own table but with translation by Mannheimer Swartling (2021).

'Black list' in Sweden *Prohibited trading practices*	'Grey list' in Sweden *Prohibited unless agreed in clear and unambiguous terms*
1. The buyer pays the supplier for agricultural and food products later than 30 days after the supplier's payment request.	1. The buyer returns unsold products to the supplier without paying for those products.
2. The buyer cancels orders of agricultural and food products with notice of less than 30 days.	2. The buyer returns unsold products without paying for the disposal of those products.
3. The buyer unilaterally changes the terms of a supply agreement that concern frequency, method, place, timing, volume, quality standards, terms of payment or prices.	3. The buyer requires payment as a condition for stocking, displaying or listing its agricultural and food products, or of making such products available on the market.
4. The buyer unilaterally changes the terms of the supple agreement that concern the provision of certain specified services.	4. The buyer requires the supplier to pay for the advertising or marketing by the buyer of agricultural and food products.
5. The buyer requires payments from the supplier that are not related to the sale of the agricultural and food products of the supplier.	5. The buyer charges the supplier for staff for fitting-out premises used for the sale of the supplier's products.
6. The buyer requires the supplier to pay for deterioration or loss that occurs on the buyer's premises or after ownership has been transferred to the buyer, where such deterioration or loss is not caused by negligence or fault of the supplier.	6. The buyer requires the supplier to bear all or part of the cost of any discounts on agricultural and food products that are sold by the buyer as part of a promotion. Regardless of the agreement, the buyer must prior to its requirement specify the period of the promotion and the expected quantity of the agricultural and food products to be ordered at the discounted price.
7. The buyer refuses to confirm in writing the terms of a supply agreement (with certain exceptions regarding producer organizations).	
8. The buyer threatens to carry out, or carries out, acts of commercial retaliation against the supplier if the supplier exercises its contractual or legal rights.	

9. The buyer requires compensation from the supplier for the cost of examining customers' complaints relating to the sale of the supplier's products, despite the absence of negligence or fault on the part of the supplier.	

The Directive 2019/633 emphasizes that the listed unfair trading practices are the minimum approach member states need to adopt, allowing them to go beyond the directive if desired. Most member states have utilized the black and grey lists to differentiate between prohibited practices, and some have even reclassified certain practices from the grey list to the black list (European Commission 2021). In Sweden, the trading practice of returning unsold products to the supplier without payment for the products or disposal of the same has been retained on the grey list, as shown in Table 1. Consequently, TBAs are still permitted in Sweden if mutually agreed upon by the supplier and the buyer. However, other member states, such as Germany, France, Latvia, and Slovakia, have moved this practice to the black list, making it prohibited even under mutual agreements (European Commission 2021). Although the EU Directive 2019/633 acknowledges in its introduction that certain practices may still be unfair even if agreed upon by both parties it does not provide detailed guidance on how to determine or address such situations.

2.6 Scenario 2 - The French example

In the EU, several directives are in place to address food waste but member states are encouraged to implement their separate national plans and regulations, resulting in variations such as municipal waste management plans, action plans for food waste reduction, or laws specifically targeting waste issues within the food supply chain (Giordano *et al.* 2020). Italy and France were the first two EU member states to introduce national laws specifically addressing food waste, employing different approaches through regulatory or incentivized initiatives (Franco & Cicatiello 2021).

In 2016, France passed Law 2016-138, which specifically targets food waste reduction, with a particular focus on the retail sector (Giordano *et al.* 2020). This law was enacted at a time when food waste in France was estimated to exceed ten million tons annually, with 14% of the waste occurring at the retail stage (Albizzati *et al.* 2019). The law introduced three main measures: establishing a waste hierarchy for surplus food, imposing penalties on businesses that intentionally render safe food inedible, and requiring supermarkets above a certain size to have a contract with a food assistance organization (Vaqué 2017).

While the French law sets a clear objective on following the waste hierarchy adopted at the EU level, it appears to place greater emphasis on food redistribution rather than waste prevention (Giordano *et al.* 2020). According to the law, all supermarkets with a sales area exceeding 400m^2 are required to establish agreements with charity organizations to receive surplus food (Giordano *et al.* 2020). While these agreements have been referred to as mandatory donations in some media reports, the law does not specify the quantities or frequency of these donations (Mourad & Finn 2019). According to the article by Mourad and Finn (2019), food assistance organizations were the ones who advocated for the provision in the law that focuses on establishing contracts rather than specifying the quantity of food to be donated. Their concern was that they did not want to become the recipients of non-quality products and be seen as merely a dumping ground for supermarkets. However, the same article highlights that even three years after the implementation of the law, several food assistance organizations in France still faced challenges in effectively managing donated food, primarily due to issues related to storage capacity and sporadic donations.

In 2016, Italy passed a similar law, No. 166/2016, against food waste, commonly referred to as the 'Gadda law,' named after Maria Chiara Gadda, a member of parliament who played a significant role in its enactment (Arcuri 2019). In Italy, like France, the laws enforce the food waste hierarchy but the main difference is that in Italy food donations are only encouraged through tax exemptions and incentives established by municipalities, whereas in France it is posed as mandatory (Giordano *et al.* 2020). It is worth mentioning that France has also introduced incentives, such as tax incentives or credits, to increase food donations (Albizzati *et al.* 2019). Although tax incentives for food donations have the potential to significantly reduce food waste in Italy, their implementation has been limited to only a few municipalities (Franco & Cicatiello 2021).

In essence, there are two approaches to reusing food surplus: monetary and non-monetary (Sedlmeier *et al.* 2019). Donations fall under the non-monetary approach as the agreement does not rely on monetary transactions at its core, whereas monetary approaches involve identifying potential business models to develop a secondary market for surplus food, such as repurposing the food or selling it at a discounted price (Sedlmeier *et al.* 2019). Therefore, economic incentives play a crucial role in increasing food donations. It is important to note that what stakeholders may consider to be food waste, even if it is still edible, represents an economic loss. Additionally, donating food often requires additional costs for storing, handling, and logistics (Lebersorger & Schneider 2014). In this regard, economic incentives and penalties, such as increased waste management costs or tax incentives for donations, can be pivotal in driving the necessary shift. Donating food, however, comes with uncertainties regarding liabilities and to address this

concern, several EU countries have implemented regulations to limit these uncertainties and encourage more food donations (Johansson 2021).

2.7 Scenario 3 – The Swedish Environmental Code

Minimizing food waste is essential for sustainable food supply chains, as methods like incineration cannot fully recover the energy and resources invested in production. Policy measures can be a cost-effective option to drive joint efforts in reducing food surplus and waste, as investing in new technology or infrastructure can be expensive (Eriksson *et al.* 2017). Policy instruments can take the form of market-based or non-market-based approaches, or a combination of both, as economic and regulatory instruments (Eriksson *et al.* 2020). These instruments can serve different purposes and have varying impacts on stakeholders.

The Swedish Environmental Code, comprising 15 acts, 33 chapters, and almost 500 sections, was enacted in 1999 (Ministry of Climate and Enterprise 2015). This comprehensive legislation applies to all activities and measures in Sweden, including food businesses, making it the primary environmental legislation in the country. The Environmental Code serves the purpose of promoting sustainable development by providing a general framework for environmental protection (Naturvårdsverket n.d.). The waste hierarchy adopted by the EU, as mentioned earlier, is enforced in Chapter 2 §5 of the Environmental Code SFS 1998:808, prioritizing waste reduction, minimizing hazardous substances, mitigating negative waste effects, and emphasizing waste recycling. Chapter 15 §10 reiterates the waste hierarchy but specifically addresses already generated waste, prioritizing preparation for reuse, recycling of materials, alternative recycling methods if necessary, and ultimately disposal.

According to Eriksson *et al.* (2023), the Swedish Environmental Code theoretically implies that wasting food is illegal in Sweden. However, the article highlights that the Code lacks clear definitions regarding what constitutes normal and acceptable food waste, and it has not been applied to reduce waste in the food supply chain specifically.

2.7.1 Food donations in Sweden

In comparison to some other European countries, Sweden has placed greater emphasis on developing infrastructure and providing incentives for AD rather than focusing on food donations (Johansson 2021). In 2021, less than 0.4% of the overall surplus food in Sweden was donated, whereas the figures were 4% in the US and 3% in the UK (Sundin *et al.* 2023). Instead, Sweden has set a national goal to collect

food waste for biogas production, aiming for at least 75% of all food waste to be biologically treated by 2023 (Johansson 2021). According to the food waste hierarchy depicted in Figure 1, AD treatment of food waste is categorized as a form of recovery, which is considered the second least preferred option before disposal.

When evaluating the sustainability of redistributing surplus food, various parameters need to be considered, and different perspectives may yield different results. From an economic standpoint, donating food can sometimes be more costly than sending it for AD. Johansson (2021) states that selling food at a reduced price can potentially generate an income of 1.7€/kg, while donating food may cost grocery stores up to 0.3€/kg. However, it is important to note that the social perspective is often not taken into account in these calculations, which could yield different outcomes. Another study examining the sustainability performance of food redistribution in Sweden found that social supermarkets and food bag centers demonstrated the best environmental performance, while transport to charity scored higher from a social perspective (Bergstrom *et al.* 2020).

In the UK, the non-governmental organization (NGO) WRAP has played a significant role in providing insights and frameworks for reducing waste and establishing partnerships for food redistribution. Since 2017, WRAP has been collecting data on the amount of redistributed food from various sectors such as retail, manufacturing, hospitality, and food service. The data indicates a nearly 300% increase in redistributed food from 2015 to 2021 and notes the potential for further improvement (WRAP 2022). The report also highlights that during this period, over £1.3 billion worth of surplus food, equivalent to more than a billion meals, has been redistributed. This remarkable increase can be attributed to various factors, including grants for project ideas, expanded stakeholder networks, increased public awareness, and other initiatives. The findings demonstrate that both commercial redistributions, where businesses redistribute surplus food for profit, and charitable and social redistribution, involving non-profit organizations collecting surplus food, can be successful when clear objectives and goals are established (WRAP 2022).

According to a study by Arcuri (2019), redistributing food is often viewed as an effective approach to addressing both food waste and food insecurity. However, this solution primarily tackles the symptoms rather than addressing the root causes of these issues. The study emphasizes that improving one of these issues without addressing the underlying causes may lead to the re-emergence of the other. Additionally, practical challenges such as local demand for donated food and logistical issues can hinder the implementation of food donations (Lebersorger & Schneider 2014).

In the case of the TBA bread supply chain, approximately 830 tons of bread is donated annually, representing 2% of all surplus bread (Bartek *et al.* n.d.). Several studies indicate that the current amount of bread wasted exceeds the capacity of food assistance organizations in Sweden (Ungerth 2021; Weber *et al.* 2023), suggesting that redistributing bread alone would not solve the issue of bread surplus (Brancoli *et al.* 2020). However, it is important to note that 1-5% of the population in Sweden experiences food insecurity and relies to some extent on social charities and food donations (Johansson 2021). The demand for accessing food at reduced prices or for free is continuously increasing (Larsson 2023), as evidenced by a 67% rise in food donations and sales of discounted food reported by the food assistance organization Stadsmissionen (Sveriges Stadsmissioner 2023).

2.8 Scenario 4 – Sharing of sales data

In the reversed supply chain of TBA bread, each supplier is responsible for forecasting, stocking shelves, and removing unsold bread from retailers (Eriksson *et al.* 2017). As retailers only pay for sold bread, they lack incentives and influence over the supply chain. Consequently, each driver supplying bread independently forecasts demand based on their separate historical data, with no data sharing or collaboration among suppliers (Ghosh & Eriksson, 2019). While retailers possess combined data on sold bread through their point-of-sale (POS) system, several studies imply that this is not shared with the suppliers (Brancoli *et al.* 2019; Ungerth 2021; Bartek *et al.* n.d.). Instead, suppliers continue to rely on their own data, even though they express a desire to access retailer data, as retailers' demand for full shelves compels them to stock up, potentially leading to increased waste (Ungerth 2021).

In the current state of TBAs, retailers also lack incentives to limit the assortment of bread as it carries no risk and research suggests that full shelves drive sales (Riesenegger & Huebner 2022). However, studies have also shown that reducing product assortment has the potential to decrease bread waste (Brancoli *et al.* 2019). According to Ungerth (2021), some of the larger supermarkets in Sweden offer up to 107 different types of bread on their shelves. Consumers tend to expect fully stocked shelves at supermarkets, but they are also willing to substitute products within the same category when their desired item is unavailable (Riesenegger & Huebner 2022). As a result of customers' willingness to adapt and substitute products within the same category, supermarket shelves do not need to remain fully stocked until closing time with a full assortment, which could potentially lead to fewer returns of unsold bread (Riesenegger & Huebner 2022).

As a result, retailers have the potential to minimize food waste by opting to reduce the variety of products in highly perishable food categories, like bread, and instead prioritize stocking the most popular items (Teller *et al.* 2018). However, while this measure could benefit retailers that want to decrease waste, it may create competition issues among bakeries and limit consumer options. More important, the current system of TBAs places the responsibility for reducing surplus bread on the suppliers, rather than the retailers. In this system, retailers lack the authority and influence to actively address the issue of surplus bread or available assortment. Therefore, any efforts to minimize food waste in this context would require collaboration and coordination between retailers and suppliers to find effective solutions throughout the supply chain.

Riesenegger and Huebner (2022) found that implementing machine-learning-based forecasting systems can lead to improved sales and decreased surplus food in the retail sector. Their study revealed that one of the participants was able to increase revenues by 10% while simultaneously reducing food waste. This highlights the potential benefits of utilizing advanced forecasting technologies to optimize inventory management and minimize waste. Furthermore, de Moraes *et al.* (2020) conducted a study on food waste in the retail sector and identified a lack of information sharing and integrated inventory systems between suppliers and retailers as contributing factors to avoidable food waste. The study emphasized the importance of collaboration between suppliers and retailers as one of the most effective practices for reducing waste at the retail stage. Improving the sharing of data and implementing integrated forecasting systems have also been identified by Canali *et al.* (2017) as essential solutions for reducing food waste. According to the NGO WRAP, effective collaboration among key suppliers is a critical step for manufacturers to tackle food waste, encompassing the sharing of data, including forecasts (WRAP 2023).

Nikolicic *et al.* (2021) conducted a study on reducing the waste of dairy products for retailers using the Radio Frequency Identification (RFID) label system. This technology enables improved tracking of products, pallets, or other types of parcels, allowing for better supply and demand matching through the real-time exchange of accurate information. The study found that implementing RFID resulted in a significant reduction in waste of dairy products for both retailers and producers. Specifically, a waste reduction of 29.4% was observed for retailers, while producers experienced a waste reduction of 38.5% (Nikolicic *et al.* 2021). Milk is, according to Eriksson *et al.* (2017), a good product comparison to bread since they both are highly perishable with a short shelf-life and sold in large volumes with high turnover. However, the same study points out that milk generally has much lower waste levels than bread and does not have TBA, so any waste is at the retailers' expense and thus can serve as an incentive for waste reduction activities.

3. Methods

The primary method used in this paper is the quantification of potential changes to the bread supply chain under the TBA system in Sweden. These quantifications draw upon previous studies, including research on the impact of TBAs and the bread supply chain in Sweden, as well as other case studies that may offer insights applicable to the bread supply chain. The objective of quantification studies, as stated by Gonzalez *et al.* (2017), is "to obtain an aggregate estimate for a test set without requiring predictions for its individual instances" (p.1). As this study aggregates data from different inputs, each set of data is not analyzed but rather used to make hypothetical predictions. It is important to note that if the aim were to obtain an optimal model, more advanced methods would need to be developed (Gonzalez *et al.* 2017).

According to Kafa and Jaegler (2021), the quantification of food surplus and waste serves as an initial step in identifying areas and hotspots that require further evaluation and guiding the implementation of effective strategies to control and reduce these impacts. A quantification process enables a potential further assessment of economic, environmental, and social consequences associated with food waste. While the calculated scenarios in this study are informed by previous research on the TBA bread supply chain in Sweden, it is important to note that the scenarios in this paper are hypothetical. Consequently, they have not been extensively examined nor are they based on implementations in the current context.

Complementing the data collected from reports and other literature, a digital semi-structured interview was conducted on 27 April 2023 with a stakeholder involved in food donations. Semi-structured interviews are a common method for data collection and enable a dynamic conversation during the interview, meanwhile letting the interviewer improvise with follow-up questions (Kallio *et al.* 2016). The interviewed stakeholder is Simon Stegrud, who is the manager of partnerships and warehouse for Matmissionen in Sweden, which is a social supermarket established by the organization Stadsmissionen. All food sold at Matmissionen has been donated by their partners from the food industry and is sold with a 70% price reduction to members that need financial support (Stadsmissionen n.d.). A summary of the interview, including the questions and quotes, can be found in Appendix 1, which has been approved by the interviewee for use in this report.

3.1 Application of the scenarios

All four scenarios examined in this paper emphasize the potential for reducing or utilizing surplus bread on a broad scale. These scenarios are built upon the base case, which is presented in the results section, and exhibit the current supply chain of TBA bread in Sweden.

Scenario 1 examines the potential outcomes of prohibiting TBAs for bread in Sweden, in alignment with the EU Directive 2019/633 on Unfair Trading Practices. While Sweden has retained the practice of buyers returning unsold products to suppliers without incurring costs or responsibility for disposal, some other European countries have classified such practices as prohibited even under mutual agreements (European Commission 2021). In Scenario 1, where TBAs are disallowed even under mutual agreements, retailers would assume full responsibilities for bread including forecasting, ordering, assortment planning, and stock management of bread in their stores. They would also be accountable for the proper management of surplus bread and waste. To simulate this scenario, the waste estimate for PL bread is utilized in Scenario 1, offering insights into the potential outcomes when retailers assume full responsibility for the bread supply chain.

The focus of Scenario 1 will not be on retailers' waste management practices, although it can be assumed that a significant portion of the waste may be directed towards AD or incineration, depending on the local waste management infrastructure (Johansson 2021). Instead, the primary emphasis will be on exploring the potential waste reduction that could be achieved if retailers take on the responsibility of managing the supply chain of bread after ordering it from the bakeries.

Scenario 2, called the French example in this study, examines two changes to the TBA bread supply chain in Sweden. Firstly, TBA practices would be prohibited even under mutual agreements, as indicated by France's decision to shift practices related to TBA to the black list (European Commission 2021). Consequently, retailers would assume full responsibility for supplying their stores with bread, and the waste estimate for PL bread is applied. Secondly, Scenario 2 considers the implementation of the French law 2016-138, which enforces the waste hierarchy and requires larger supermarkets to have a contract with a food assistance organization (Vaqué 2017).

Even though the French law does not specify the exact extent of donations, it has had a considerable impact on food donation quantities in France. Within a year, there was a 30% increase in donation quantities, and between 2016 and 2018, the percentage of supermarkets donating food rose from 66% to 90% (Mourad & Finn

2019). As a result, Scenario 2 entails a situation where TBAs are prohibited and all surplus bread from retailers is donated, rather than sent for AD and incineration.

In Scenario 3, the assumption is made that all surplus bread is directed toward the two most preferred priorities in the waste hierarchy following prevention, which are reuse and recycle. This would be the result of stricter enforcement of the Swedish Environmental Code and the waste hierarchy. The same amount as in the base case would be allocated for animal feed and ethanol production, which are considered recycling. However, the surplus bread that would have been incinerated or used for AD in the base case would instead be donated. It is important to note that the potential application of donating all surplus bread at each stage of the supply chain may face practical limitations and might not be possible to the same extent as presented in the results. However, this scenario wants to illustrate the potential benefits of utilizing surplus more according to the waste hierarchy.

Scenario 4 explores the potential benefits of enhanced collaboration between suppliers and retailers in the context of TBA bread. Building on previous research highlighting the positive impact of effective forecasting systems on sales and food waste reduction (Riesenegger & Huebner 2022), this scenario emphasizes the sharing of detailed POS data between retailers and suppliers. By facilitating better coordination and optimization of demand and supply, the aim is to improve the overall efficiency of the TBA bread system, which remains under this scenario. In the absence of practical examples of data sharing specifically related to the TBA bread supply chain, the potential impact of improved information sharing between retailers and bakeries is estimated based on a study conducted on milk. The study by Nikolicic *et al.* (2021) utilized RFID labeling to track and share inventory data, resulting in a 38.5% reduction in surplus milk at the supplier level and a 29.4% reduction at the retailer level, without affecting sales. As a result, these reductions are applied to the base case.

4. Results

This result section includes a quantification process involving four scenarios applied to the bread supply chain. Each scenario is evaluated alongside a base case representing the current TBA bread supply chain in Sweden, simplified in Figure 2. Some surplus bread occurs already at production, which is managed through five streams: donation for human consumption, animal feed, ethanol production, AD, and incineration. The bread is then delivered to retailers, and under the TBA system, suppliers are responsible for taking back any unsold bread. Surplus bread is collected at a distribution center and is then either directed for ethanol production or sent for incineration or AD.

Figure 2. The current supply chain of TBA bread in Sweden, illustrating the flow of bread from production to final waste management.

Table 2 presents the current annual weight and percentage breakdown of the supply chain of TBA bread in Sweden, which is essential for quantifying the scenarios. The data in the table is sourced from Bartek *et al.* (n.d.). As presented in Table 2, the total annual production of TBA bread in Sweden amounts to 242 744 tons. At the production stage alone, there is already a surplus of 6%, equivalent to 13 836 tons. This surplus is further categorized into five streams: 42% is utilized as animal feed, 30% is directed for incineration, 14% is used for ethanol production, 8% is sent to AD, and 6% is donated to undisclosed food assistance organizations.

Out of the bread delivered to retail, 9% is taken back under the TBAs, which equals 20 530 tons of bread every year. Out of the returned bread, approximately 18% is directed for ethanol production, amounting to 3 695 tons. The remaining bread is divided between AD, accounting for 41%, and incineration, also accounting for 41%.

Table 2. The base case for the annual supply chain of TBA bread in Sweden, including current surplus and waste management streams. All numbers from Bartek et al. (n.d.).

BASE CASE	Number, in weight (ton)	%	Comment
Total TBA bread produced	**242744**	**100%**	
Total bread delivered to retail	228106	94%	
Surplus bread from bakeries	**13836**	**6%**	*% of total bread produced*
Surplus bread from bakeries donated	830	6%	
Surplus bread from bakeries to animal feed	5811	42%	
Surplus bread from bakeries to ethanol	1937	14%	
Surplus bread from bakeries to AD	1107	8%	
Surplus bread from bakeries to incineration	4151	30%	
Bread returned with TBA	**20530**	**9%**	*% of total delivered to retail*
TBA bread to ethanol production	3695	18%	
TBA bread to incineration	8417	41%	
TBA bread to AD	8417	41%	

Table 3 provides an overview of the waste management streams for all surplus bread in the TBA supply chain in Sweden, combining both the production stage and the supplier-retail interface. Out of the total surplus of 34 366 tons, 37% is sent for incineration, followed by AD. Additionally, approximately 17% and 16% of the bread waste are utilized as animal feed and for ethanol production, respectively. 2% of the overall surplus bread in the TBA supply chain is donated for human consumption.

Table 3. The combined waste management of all annual surplus bread in the supply chain of TBA.

MANAGEMENT OF ALL SURPLUS TBA BREAD	Number, in weight (ton)	%
Incineration	12568	37%
AD	9524	28%
Animal feed	5811	17%
Ethanol production	5632	16%
Donated for human consumption	830	2%
Total TBA bread waste out of total production	**34366**	**14%**

4.1 Scenario 1 – Unfair trading practices

Examining the potential outcomes of prohibiting TBAs for bread in Sweden, in alignment with the EU Directive 2019/633 on Unfair Trading Practices, Figure 3 illustrates the supply chain of bread if TBAs are not allowed. It is demonstrated that while some surplus may still occur at the production stage, once the bread is delivered to the retailer, the responsibility for any surplus bread would lie with the stores.

Figure 3. The supply chain of bread under Scenario 1, where TBAs would not be allowed.

Table 4 presents the results of applying the scenario of no TBA to the base case of TBA bread. In this scenario, it is assumed that the same quantity of bread is delivered to retailers, but without the use of TBAs, and instead, the waste rate of 4.5% for PL bread is applied. The findings show a significant reduction of 50% in surplus bread at the retail stage, amounting to a decrease of 10 265 tons annually.

Furthermore, the scenario demonstrates that even if retailers would utilize incineration and AD for waste management, there is a significant reduction in the total amount of bread destined for these processes, with a 39% decrease compared to the base case.

Table 4. Scenario 1, no TBA allowed, applied to the base case of TBA bread.

SCENARIO 1 APPLIED	Number, in weight (ton)	%
PL bread waste estimate applied to bread delivered to retail	10265	4.5%
Bread waste reduction as a result	**10265**	**50%**
Bread waste to incineration	5132	50%
Bread waste to AD	5132	50%
Decreased amount of bread to incineration	3285	39%
Decreased amount of bread to AD	3285	39%

4.2 Scenario 2 – The French example

Scenario 2 examines a supply chain of bread where TBAs would be prohibited and retailers would be required to donate surplus food to a food assistance organization. The supply chain of Scenario 2 is depicted in Figure 4, which illustrates that surplus bread would still occur at the production stage, followed by its delivery to retailers. In this scenario, retailers would redirect any surplus to food assistance organizations, aligning with the requirements of the French law.

Figure 4. The supply chain under Scenario 2, with no TBAs allowed and compulsory donations from retailers.

Table 5 presents the quantification results for Scenario 2. In this scenario, TBAs are not allowed, and the waste estimate for PL bread is applied to the base case of TBA. The result shows a 50% reduction in surplus bread at the supplier-retail interface. Furthermore, it is assumed that retailers would donate all surplus bread to food assistance programs, leading to a substantial increase in donations. Specifically, 32% of all surplus bread would be donated, compared to only 2% in the base case. This implies that 30% of all surplus bread would move up in the waste hierarchy, transitioning from recycling or recovery to reuse for human consumption.

Table 5. Scenario 2, no TBA allowed and retailers donating surplus bread.

SCENARIO 2 APPLIED	Number, in weight (ton)	%
PL bread waste estimate applied to bread delivered to retail	10265	4.5%
Decrease in bread surplus	**10265**	**50%**
Bread donations in base case, of total surplus	830	2%
Bread moved up in hierarchy (to reuse), of total surplus	10265	30%
Bread donations in supply chain, total of all surplus	**11095**	**32%**

4.3 Scenario 3 – The Swedish Environmental Code

Scenario 3 investigates the potential outcome of stricter enforcement of the Swedish Environmental Code and the waste hierarchy in the bread supply chain. In Figure 5, the proposed supply chain of Scenario 3 is shown. In this supply chain, surplus bread from the production stage would be used for animal feed and ethanol production, as well as donated for human consumption. No surplus would go to incineration or AD. As TBAs would still be applied in this scenario, the suppliers would still remove any unsold bread from the retailers. However, this would then be either donated or sent for ethanol production.

Figure 5. The supply chain under Scenario 2, with a stronger emphasis on the waste hierarchy for any surplus bread.

The results in Table 6 show that at the production stage, a total of 6 088 tons of bread would be donated instead of being sent for incineration or AD. The surplus bread from bakeries that are allocated for ethanol production or animal feed remains the same as in the base case. At the retail stage, where bakeries take back any surplus bread due to the existence of TBAs, the same amount would still be sent for ethanol production as in the base case. However, rather than sending the remaining surplus for AD or incineration, it would be donated for human consumption. Consequently, a total of 67% of all TBA bread surplus would be donated, compared to only 2% in the base case.

Table 6. Scenario 3, the waste hierarchy enforced to a greater extent and no surplus bread is sent to AD or incineration.

SCENARIO 3 APPLIED	Number, in weight (ton)	%
Surplus bread at bakeries	13836	100%
Total bread donated, instead of AD and incineration	6088	44%
Surplus bread to animal feed	5811	42%
Surplus bread to ethanol production	1937	14%
Surplus bread at retail stage with TBA	20530	100%
Donation instead of AD and incineration	16834	82%

Surplus bread to ethanol production	3695	18%
Total bread donated *instead* of AD and incineration, of total surplus	22092	64%
Bread donated in base case, of total surplus	830	2%
Total bread donated in supply chain, of total surplus	**22922**	**67%**

4.4 Scenario 4 – Sharing of sales data

Scenario 4 explores the potential benefits of enhanced collaboration between suppliers and retailers in the context of TBA bread, which would continue to exist. While Figure 6 highlights the specific aspect of POS data sharing, it is important to note that the scenario animates broader collaboration between suppliers and retailers for enhanced forecasting and inventory management.

Figure 6. Scenario 4 applied to the supply chain of TBA bread, with sharing of POS data from retailers to suppliers.

Applying the waste reductions from a case study on milk, the results in Table 7 demonstrate the potential reductions to the TBA bread supply chain. It indicates a decrease of 5 327 tons of bread surplus at the bakeries and a decrease of 6 036 tons of bread waste at the retail stage. Consequently, the overall bread waste in the TBA bread supply chain would decrease from 14% to 9%, representing a 33% reduction and preventing the waste of 11 363 tons of bread annually.

Table 7. Scenario 4, with better inventory management and information sharing applied to the base case of TBA bread.

SCENARIO 4 APPLIED	Number, in weight (ton)	%
Waste reduction at bakeries	5327	38,5%
Waste reduction at retail stage	6036	29,4%
Total bread waste in base case	34366	14%

Total bread waste with scenario	23003	9%
Total waste reduction in supply chain of TBA bread	**11363**	**33%**

4.5 Summary of results

When considering the prevention of waste, Scenario 4 demonstrates the greatest potential by aiming to decrease any excess production. According to the summary of results in Table 8, a significant 33% prevention of waste can be achieved with Scenario 4. Similarly, both Scenario 1 and Scenario 2 also show substantial waste reductions of 30% but as these scenarios mainly focus on the prohibition of TBAs, the reduction mainly occurs at the supplier-retailer interface. Although this analysis does not explicitly measure the impact on the production stage, it can be inferred that implementing Scenario 1 or Scenario 2 would likely result in waste reduction by potentially adjusting production levels upstream, leading to a greater decrease in waste overall. Scenario 4 optimizes inventory levels and data sharing to minimize waste, resulting in reductions at both the supplier-retailer interface and the production stage.

Table 8. Summary of potential results of all four scenarios.

SUMMARY	Waste reduction, tons	Waste reduction, %	Hierarchy effect, tons	Hierarchy effect, %
Scenario 1	10 265	30%		
Scenario 2	10 265	30%	10 265	30%
Scenario 3			22 092	64%
Scenario 4	11 363	33%		

When considering the potential for applying the waste hierarchy to the bread supply chain, Table 8 highlights that Scenario 3 demonstrates the greatest effect, resulting in 22 092 tons of bread being donated instead of being recycled. This represents a significant shift in waste management, as 64% of the surplus bread in the TBA bread supply chain would be redirected for donations rather than being sent for incineration or AD. Similarly, Scenario 2 also shows a positive hierarchy effect, with an additional 10 265 tons of bread being donated, equivalent to 30% of the total surplus. These scenarios illustrate the potential for increasing the reuse of bread through donations, thereby aligning with the food waste hierarchy.

5. Discussion

Previous studies have provided valuable insights into various aspects of the TBA bread supply chain in Sweden, as well as food waste generation in general. This study contributes to the existing research by highlighting the underutilized potential to decrease waste and improve the utilization of surplus within the bread supply chain in Sweden. Table 8 summarizes the results, revealing a general waste reduction potential and the impact of the hierarchical approach across all scenarios. While Scenarios 1 and 2 demonstrate waste reduction, Scenario 2 also showcases a surplus hierarchy effect. However, the potential hierarchy effect in Scenario 3 is even more significant. On the other hand, Scenario 4 exhibits the greatest waste reduction potential among all scenarios. Additionally, as this scenario is based on market-based mechanisms, it may be more favorable for stakeholders compared to forced regulations, which the other three scenarios explore to varying extents.

The following chapters will further discuss these results with regard to the research questions, examine the study's limitations, and provide recommendations for future research.

5.1 Effect of implementing the scenarios

All four scenarios presented in this study have the potential to bring about changes in the current bread supply chain in Sweden, although to varying degrees. When it comes to addressing challenges in the food system, Giordano *et al.* (2020) distinguish between "weak actions" that aim to improve the efficiency of the existing system and "strong actions" that strive for a more comprehensive transformation of the system, including both production and consumption. Since the four scenarios mainly focus on improving the efficiency of the current supply chain, they can be considered weak actions according to this framework. However, it could be argued that completely prohibiting TBAs could potentially lead to a significant system change. However, since the exact outcome of such a regulation is unclear, it is too uncertain to classify it as a strong action.

In addressing the question of how the implementation of each scenario would impact the current bread supply chain in Sweden, the findings indicate variability. However, what can be implied is that all four scenarios highlight weaknesses in the existing system and present potential strategies to decrease waste, improve utilization, or potentially achieve both objectives.

In Scenario 1, the prohibition of TBAs is based on the EU Directive on Unfair Trading Practices. Despite attempts to supply bread without TBAs, it is worth noting that the TBA arrangement provides economic advantages for retailers, as they only pay for the sold bread without bearing the risk of surplus. Hence, there are currently no strong incentives to prohibit TBAs, which can also be related to concentrated market power. The concentration of the retail market, with three stakeholders controlling over 86% of the total market (Konkurrensverket 2018), can be considered an oligopolistic market. An oligopoly refers to a market structure where a small number of actors control a significant portion of the market (OECD 2015). This concentration of power is evident not only in the retail market but also on the supply side, where the three major suppliers collectively hold over 80% of the pre-packaged bread market (Brancoli et al. 2019). According to the OECD (2015), actors in an oligopoly can become interdependent and set marketing and pricing strategies in response to their rivals, which over time can be a disadvantage for consumers and other stakeholders in the market. In Sweden, one of the outcomes of TBAs is that a bakery must be able to absorb the cost of unsold returned bread including the handling of it, which has proven to be difficult for a new producer who wants to enter the market (Ghosh & Eriksson 2019). As a result, TBAs have been identified as a potential barrier to competition, limiting the entry of new bakeries into the market (Eriksson et al. 2017). The concentrated market power held by TBA bread suppliers and retailers in Sweden can also serve as a barrier to the voluntary development of new supply chains without TBAs, unless a simultaneous prohibition is implemented for all stakeholders.

The responsibility for bread surplus and waste is currently under suppliers with the existing TBAs, but as shown in the results section (Table 4-5), shifting this to retailers can provide new opportunities for waste reduction. This is also supported by Lebersorger and Schneider (2014), who found that shifting the responsibility, and the economic burden, for unsold bread from bakeries to retailers would provide incentives to reduce waste by optimizing ordering and end-of-day sales. Teller *et al.* (2018) identified that any actions on food waste occurring at store levels are highly effective since it usually does not require additional skills or knowledge and can also be less costly. In Scenario 1, the waste estimation for PL bread serves as the basis. By applying the waste estimation for PL bread to the existing supply chain of TBA bread, a notable reduction of 50% in waste is observed at the supplier-retail interface (Table 4-5). Even in a scenario where it is assumed that retailers are

directing all surplus bread to incineration and AD, this example still demonstrates a substantial reduction in waste streams for both. If TBAs were to be prohibited, retailers would assume the responsibility not only for forecasting but also for the financial consequences of unsold products and waste disposal, as they do with PL bread. Importantly, when retailers become accountable for surplus bread, they are more likely to engage in in-store activities aimed at waste prevention, such as offering discounts or donating the surplus to food assistance organizations. Similar reasoning was also presented by (Brancoli *et al.* 2019).

Given the continued presence of TBAs in the Swedish bread supply chain, there are still alternative approaches to consider to effectively reduce the surplus and align more closely with the principles of the food waste hierarchy. In Scenario 2, the focus shifts to the exploration of the French Law 2016-138 on food waste, which emphasizes the obligations of retailers to donate surplus food. However, under TBAs, it is the suppliers who are responsible for any surplus management, which is why the French law in its current form would not affect the supply chain of TBA bread. Therefore, for the French law to be effective in Sweden, TBAs would need to be prohibited, or the law would need to include other stakeholders beyond retailers, such as suppliers.

It is important to acknowledge that the assumption in Scenario 2, where retailers donate 100% of their surplus bread to food assistance programs, may not be entirely realistic. Practical constraints such as logistical challenges and local needs can limit the feasibility of donating all surplus food. However, there are both local and regional capacities to receive surplus bread in Sweden to a much greater extent than today, which Stegrud confirms (Appendix 1). It should be noted though, that the French law does not specify the exact percentage of surplus food that supermarkets must donate, and in reality, 1% of all surplus food would still be according to the law. It is also worth mentioning that France offers tax exemptions and incentives for food donations, which can be assumed to further encourage supermarkets to increase their donation quantities. As a result, Scenario 2 shows that there is a potential for both reducing surplus bread and utilizing it better in Sweden, but to realize this further, incentives are needed.

The financial outcome of any kind of food waste management seems to be important for the relevant stakeholders. In the interview with Stegrud (Appendix 1), it was concluded that donating food can be financially beneficial for the suppliers, but it also depends on the municipality since the cost of transporting and disposing of food waste is dependent on local taxes. Franco and Cicatiello (2021) also found that in municipalities in Italy where the waste tax was very low, there were fewer financial incentives for retailers to donate food. According to Johansson (2021), The Swedish Environmental Protection Agency (EPA) states that energy

recovery through AD or incineration is considered a preferred central solution for managing food waste, as the need for donated food is perceived to be insufficient. However, the results from the interview with Stegrud (Appendix 1) challenge this notion. The expanding social supermarket, Matmissionen, is set to open several new stores in 2023, indicating an increased capacity to receive donated food. Stegrud also highlights the existing need for more donations in certain product categories such as bread, but also fruit and vegetables. While the EPA may argue that food donations are not a sustainable long-term solution, it is important to acknowledge that approximately 2% of the Swedish population faces food insecurity and that recent inflation and rising food prices have further intensified the demand for food donations (Sundin *et al.* 2023).

In Sweden, the waste hierarchy is applied when it is environmentally justified and economically reasonable (Naturvårdsverket 2023), but the lack of a clear definition of what is reasonable and justified can make it into a subjective decision. It is estimated that approximately 1.3 million tons of food waste are collected annually in Sweden, with about 38% of that being subjected to biological treatment, while only 2 400 tons are donated (Johansson 2021). If the aim is to reduce the environmental impact of food waste, which arguably should be the goal of the EPA, the food waste hierarchy is the most effective system to accomplish this. This is also supported by Albizzati *et al.* (2019), who found that neither AD nor incineration can match the benefits of donating food for human consumption or using it as animal feed.

The focus on AD for biogas production, commonly seen in countries like Sweden, may not be as environmentally justified as prioritizing food redistribution at a national level. Albizzati *et al.* (2019) also support this perspective, suggesting that prioritizing food redistribution would be a more reasonable approach for countries to adopt. Scenarios 2 and 3 demonstrate the potential for increasing annual donations by 10 265 tons or 22 092 tons, respectively. This can be achieved by stricter enforcement of the waste hierarchy through the Swedish Environmental Code or by following the example set by France. Research has shown that implementing the food waste hierarchy through country-specific legislation, as observed in France, can result in significant environmental benefits and savings while also reducing costs for retailers (Albizzati *et al.* 2019).

However, donating food presents a set of challenges. In the current Swedish system, it is more convenient and cost-effective to dispose of food through incineration or AD, as it requires less effort and does not involve assessing safety or health regulations (Johansson 2021). During the interview (Appendix 1), Stegrud mentions that while Sweden is lagging in implementing laws that encourage food donations, Matmissionen has built the necessary infrastructure to receive large

donations, making them better prepared compared to other countries. This is an important finding in this study since, without a well-functioning infrastructure, food donations can lead to food assistance organizations having to bear the costs of disposal because they are not ready to receive and distribute it before it expires.

Redistribution of edible food is a concrete measure for retailers to reduce the negative impacts of food waste, especially since most of the food removed from the shelves is still consumable. However, it should be up to the central organization of retail stores to encourage cooperation with charitable organizations, as well as support from public policies to encourage such behavior even further. Stegrud (Appendix 1) confirms this by stating *"If we are to have a structure that facilitates donations to a larger extent, it must come centrally from the organization, and corporate leadership will not make such a decision unless it is economically justifiable. And for this, we need political decisions that give long-term incentives"* (quote 2).

5.2 Specific challenges of TBAs

In addressing the question of how strategies to reduce food waste can be adapted to tackle the challenges posed by TBAs in the bread supply chain, all four scenarios are theoretically applicable. However, Scenarios 1 and 2 assume that TBAs are not allowed, which would significantly alter the supply structure of pre-packaged bread in Sweden. While they present alternative approaches that may be relevant for the overall bread supply chain, they are not directly applicable to the existing TBA model. Given the concentrated market structure of both retailers and bakeries, it is unlikely that the prohibition of TBAs would occur without legal intervention. Presently, the major stakeholders in the supply chain appear to favor maintaining the existing structure, making it challenging, if not impossible, for smaller stakeholders to explore alternative arrangements. However, in Scenarios 3 and 4, TBAs are retained and the focus shifts towards improving the existing supply model.

Scenario 3 presents an opportunity to promote increased donations of surplus bread at every stage of the supply chain. It is important to acknowledge that there may be practical constraints and challenges associated with donating all surplus bread, such as local infrastructure and needs, and it might not be possible to the same extent as presented in Table 6. Yet, there are both central and local organizations available to receive surplus bread and currently, there is a need for more donations of specifically pre-packaged bread. These insights further underscore the potential impact and significance of enhancing the donation process within the bread supply

chain, and by aligning with the waste hierarchy, it is possible to reduce waste and maximize the utilization of resources.

Despite previous research suggesting that current bread waste exceeds the needs of charitable organizations (Weber *et al.* 2023) and that donation systems can be complex (Brancoli *et al.* 2019), this study reveals a different perspective. Scenario 2 and 3 (Table 5-6) highlight the untapped potential for increased bread donations instead of prioritizing lower-level waste management methods. The interview with Stegrud (Appendix 1) confirms the existing demand for more bread donations and Matmissionen's readiness to handle substantial surplus food. Stegrud (Appendix 1) says that *"Once politicians decide to make it easier to donate food, we will be ready to receive large amounts of surplus food because we have built up the logistics and routines necessary to receive it"* (quote 1). However, Scenario 3 assumes the enforcement of the Swedish Environmental Code, which has previously shown potential for waste reduction (Eriksson *et al.* 2023) but may face challenges due to limited resources and ambiguities in stakeholder requirements. Furthermore, other political instruments may prioritize alternative waste management strategies like AD, even if the Code is enforced. Regardless of the chosen strategy, the findings of this study demonstrate that both Scenario 2 and Scenario 3 would lead to a decrease in bread waste through increased donations.

Scenario 4 explores enhanced collaboration among stakeholders in the supply chain without any major changes to the existing TBA supply chain, resulting in significant waste reduction, as demonstrated in Table 7. As society becomes increasingly digitalized, improving data sharing for forecasting and inventory management should be a relatively achievable effort. Even the central organization for Swedish bakeries and confectionery recognizes that accessing retailers' POS data could decrease bread surplus (Ungerth 2021). However, research indicates that this practice is not widely implemented (Brancoli *et al.* 2019; Bartek *et al.* n.d.). Despite the challenges highlighted by previous studies, this study underscores the potential of data sharing as a valuable measure in addressing bread waste. This market-based mechanism, as opposed to a regulatory measure, could potentially be favored by stakeholders, further supporting its implementation.

5.3 The scenario with the greatest potential

It is challenging to determine which of the four scenarios could have the greatest potential since they focus on different parts of the supply chain. To make a comprehensive evaluation, an LCA study could be conducted to also assess the scenario with the greatest environmental impact reduction. However, it is worth noting that such studies often overlook the social aspects of food surplus and waste

(Johansson 2021), which downplays the significance of increasing food donations. Nevertheless, considering the implementation of the waste hierarchy at both the EU and Swedish levels, it can guide in identifying the scenario with the highest potential.

Research has shown that following the food waste hierarchy is most advantageous from an environmental perspective when considering a general food mix, but it is uncertain whether this applies to bread exclusively (Albizzati *et al.* 2019). Nonetheless, it is important to highlight that prioritizing the prevention step of the hierarchy consistently yields the most favorable environmental outcomes, regardless of the following steps. In the context of the Swedish TBA bread supply chain, focusing on prevention measures would lead to a reduction in surplus both during production and through the retrieval of unsold bread from retailers.

When interpreting these findings, it is important to consider the desired outcome. If the primary objective is to prevent any waste from being generated, Scenario 4 with data sharing demonstrates the highest potential. On the other hand, if the focus is on maximizing the reuse of bread instead of recycling it for energy, Scenario 3 and the application of the Swedish Environmental Code show the greatest potential. However, it is worth noting that Scenario 2, the French example, presents a combined effect by simultaneously preventing waste and reusing surplus that has already occurred. Scenario 1, on the other hand, prohibiting TBAs with the EU Directive on Unfair Trading Practices, only shows a waste reduction at the supplier-retail interface. Thus, the choice of the most suitable scenario depends on the specific goals and priorities of the bread supply chain in Sweden.

In practical implementation, a combination of multiple scenarios may be possible and preferable. Ideally, by following the food waste hierarchy, the most favorable outcome would involve both preventing waste and reusing any surplus bread. Enforcing the Swedish Environmental Code does not necessarily exclude the possibility of prohibiting TBAs, or vice versa. Similarly, optimizing inventory management and fostering collaboration between suppliers and retailers does not hinder efforts to redirect more surplus towards donation. In an optimistic scenario, it is possible to simultaneously implement all four scenarios to some extent since they do not overlap. This would establish a system that integrates legislation and economic instruments, which could provide the best approach to steer the food system toward reduced resource consumption and a sustainable bread supply chain in Sweden.

5.4 Limitations and future recommendations

This study focuses on the potential impacts on the bread supply chain by considering hypothetical cases that have not yet been implemented in the Swedish context of TBA bread. Thus, there is yet no concrete data on which to base the quantification of the scenarios. Instead, the results of this study should be seen as indicators for hotspots of reduction and potential pathways to utilize bread waste better. Two of the scenarios explore a situation where TBAs would not be allowed, making it difficult to predict the full implications in a practical setting. Furthermore, a significant portion of pre-packaged bread in Sweden is supplied under TBAs, but there are no existing examples to illustrate the exact effects if retailers were to take on full responsibility for ordering and managing bread. The application of these scenarios is instead based on waste statistics for PL bread, which currently is distributed under a different type of supply chain system. However, it is important to note that while PL bread is increasing, managing this specific product category might not necessarily apply to the entire assortment of bread in supermarkets. The true extent of the impact of prohibiting TBAs would likely only be fully understood once the policy is implemented, and even then, it would likely require some time for the supply chain to adjust to the new structures. A future recommendation is to conduct further research to investigate stakeholders' motivations for keeping TBAs in the bread supply chain and understand Sweden's decision to include these practices on the grey list while implementing the EU directive for Unfair Trading Practices. This research is especially important considering the directive's objective of addressing concentrated power in the food industry.

Enforcing the Swedish Environmental Code has previously demonstrated the potential for significant reductions in food waste (Eriksson *et al.* 2023). However, in this study, the Code was primarily utilized to enforce the waste hierarchy. Instead of focusing on prevention, which is the most preferred approach, this paper emphasizes the repositioning of the current surplus within the hierarchy. The extent to which this repositioning is achievable is challenging to predict, especially since the current waste management practices for surplus bread are only based on modeling from previous studies rather than direct information from bakeries. Additionally, it is difficult to anticipate the condition of bread that is currently not designated for donations and how the corresponding supply chain would be structured. Therefore, it is recommended for future research to investigate this further, as it can contribute to the ongoing discussion on waste management in Sweden and shed light on why donations are not prioritized.

Scenario 4 presented challenges in terms of prediction due to the limited availability of studies focusing on improved cooperation and shared sales data between suppliers and retailers, specifically within the context of waste prevention in the

bread supply chain. While a study on milk was used as a reference, it should be noted that the supply chain dynamics of bread may differ, and the utilization of RFID technology is not yet extensively implemented. As a result, estimating the potential impact of such measures on the bread supply chain proved challenging. Future research could focus on exploring the optimization of food supply chains through data sharing and assessing the impact on waste generation for various food items, including bread.

Even though there are several studies available on the bread supply chain under TBAs, most of these studies primarily focus on the Swedish context. While there are indications that TBAs may exist in other regions, there is a lack of direct evidence and scientific literature specifically addressing this (Eriksson *et al.* 2017). Therefore, a recommendation for future research would be to investigate the prevalence and extent of TBAs in the food supply chains across Europe, not limited to bread but also encompassing other food products. This research could also explore the implications of TBAs on market power, particularly concerning the EU's regulations on Unfair Trading Practices. Studying these aspects has the potential to improve policies and practices directed toward a more sustainable, and fair, food system.

Finally, to assess the environmental impact of redirecting food surplus and reducing food waste in the scenarios, conducting an LCA study could prove to be valuable. Although such a study would need to establish system boundaries based on potential scenarios, it could provide insights for guiding future research and informing policy recommendations.

6. Conclusion

Efforts to mitigate food waste play a vital role in aligning with global sustainable development objectives. In Sweden, addressing the specific issue of bread waste has the potential to encourage a more sustainable food system. This study examines four scenarios aimed at reducing bread waste and improving the utilization of surplus within the bread supply chain of take-back agreements (TBAs).

The implementation of each scenario has different impacts on the current bread supply chain. In Scenarios 1 and 2, where TBAs are prohibited, there is a reduction in waste at the supplier-retail interface, resulting in a total 30% waste reduction. Scenario 2, which aligns with the French law on food waste, also introduces a potential hierarchy effect by redirecting surplus from the recovery stage to reuse. Scenarios 3 and 4 address the challenges associated with TBAs by allowing their continued practice. Scenario 4 examines the potential benefits of better data sharing and achieves the highest waste reduction of 33%. Meanwhile, Scenario 3, which focuses on enforcing the Swedish Environmental Code, shows the greatest potential for improving the utilization of surplus in line with the food waste hierarchy.

Determining the definitive optimal scenario was found challenging as it depends on the desired outcome and practical feasibility. However, the results underscore the potential of combining legislation and economic instruments to optimize the TBA bread supply chain in Sweden, reducing waste, and improving surplus utilization. This study further emphasizes the importance of enhanced stakeholder cooperation and the need for political action to promote a more sustainable food system.

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Popular science summary

Food waste has significant environmental, social, and economic implications, demanding actions toward a sustainable food system. In the EU, over 20% of the produced food is said to be either wasted or lost. This is also a problem in Sweden and this paper looks at the waste streams of the supply chain of bread and particularly at the supplier-retail interface. 90% of the pre-packed bread sold in Sweden is under a take-back agreement (TBA), where the bakeries control the full supply chain of bread, including production, transportation, stocking shelves, and removing any unsold bread including waste management of the same bread. The retailers only pay for the sold bread and thus have no financial objective to decrease the bread waste. Out of 242 744 tons of TBA bread produced yearly, 14% is wasted at the production stage or the supplier-retail interface. Simultaneously, the bread waste management currently practiced does not follow the Swedish and EU-adopted waste hierarchy, where after prevention, reuse is the most preferred method, followed by recycling and recovery.

This paper evaluates four scenarios that could potentially affect the supply chain of TBA bread. These scenarios are either market-based mechanisms, such as promoting preferred methods, or legislation that would force stakeholders into certain practices. Prohibiting TBAs reveals the potential to reduce the retail-interface surplus by 50%, leading to a 30% overall reduction in waste. Improved stakeholder cooperation and inventory management can effectively decrease surplus at the production stage and the supplier-retail interface, resulting in a 33% reduction. By enforcing the Swedish Environmental Code and promoting the food waste hierarchy or adopting the French approach of mandatory surplus food donation by retailers, 30% to 69% of the surplus could be diverted from less desirable energy recovery to preferred reuse options. This paper does not answer which of these scenarios is the best but rather highlights that there is an underutilized potential for increasing donations of surplus bread as well as practices that could prevent surplus bread from occurring at all. Finally, this paper underscores that enhanced stakeholder cooperation and the need for political action are needed to decrease bread waste in Sweden and as a result, promote a more sustainable food system.

Acknowledgments

I want to thank Louise Bartek, my supervisor for this process. Her support, and research, have been crucial for making this paper come together. I also want to thank my examinator Mattias Eriksson who seems to have an endless number of ideas when it comes to food waste research and has the quickest response rate on an email I have experienced. An extended thank you is also directed to Simon Stegrud at Matmissionen for taking the time for our interview and providing my paper with insights that previous research could not. Lastly, I want to thank the non-profit organization Reformaten for letting me spend endless hours at their office for my writing process, as well as the energy to keep on making suggestions on how to improve our food system.

Appendix 1

Summary of interview with Simon Stegrud
Manager of partnerships and warehouse for Matmissionen, Jakobsberg.

The interview was conducted and recorded on Zoom on 27 April 2023, in Swedish. All content in this summary, including translation and citations, has been approved by the interviewee via email on 9 May 2023. Certain names of companies have been anonymized.

MATMISSIONEN - GENERAL INFORMATION

What is your role at Matmissionen?
I'm a partner manager and unit manager for the warehouse, but partner management takes up most of the time. My main mission is to get more surplus food into Matmissionen and other social operations that fall under Stockholms Stadsmission but also other organizations such as Frälsningsarmén, Convictus, etc. I make sure to maintain partner relations but also try to increase their donations by looking at solutions on logistics. This also includes explaining the process of donating food and trying to make it as easy as possible for everyone involved.

What is the relationship between Matmissionen and Stadsmissionen?
Matmissionen's warehouse operations function as a central warehouse for surplus food that is redirected to several different facilities. Since this is a central warehouse, Matmissionen almost functions as a wholesaler. This means that companies that want to donate food do not have to break pallets, etc. but can donate their surplus food more easily. Additionally, Matmissionen manages the "last mile" of the donation.

There are currently eight Matmissionen in Sweden. Stockholms Stadsmission is the overarching organization, but Matmissionen is like a franchise where the idea is that the stores should support themselves. But since we currently are in an expansion phase, we receive support from Stockholms Stadsmission. Matmissionen will expand during the year with new stores in Helsingborg, Malmö, Norrtälje,

Södertälje, a fifth store in another city in Sweden (medium-sized city), and an additional one in Gothenburg.

Are the operations national, regional, or local?
There are local Stadsmissionen all over Sweden but you can as of now only find Matmissionen in the larger cities. We have a monthly meeting for all local Stadsmissionen where we all update each other on the local work of receiving surplus food and we at Matmissionen try to give support in terms of the general terms of food donations. In cities where Matmissionen does not exist, the logistics and partners are local. The central warehouse in Jakobsberg does some deliveries to other Matmissionen in the country, which helps us distribute large volumes nationally.

FOOD DONATIONS IN SWEDEN

How do direct donations from retailers work?
Currently, we do not pick up directly from stores because it is too much logistics and time-consuming in relation to the amount of food a store can donate. Additionally, the shelf life of food from stores is usually shorter. However, we will now explore a collaboration with a larger retail store to coordinate donations from nearby actors. So that means this retail store will work as a hub that then makes deliveries to our central warehouse and the nearest Matmissionen. Local Stadsmissionen does work more with smaller retail stores as they usually require fewer volumes.

Which actors do you work with for food donations?
We work broadly with the entire industry. There is a central warehouse in Jakobsberg where we receive all donations, regardless of whether we pick it up ourselves or the supplier delivers it to us. We have contracts with all the largest grocery chains.

Why do suppliers donate food today?
In some cases, it’s financially beneficial, especially when Matmissionen collects surplus food. This way, the supplier avoids the logistics and costs of disposing of the surplus food. However, this varies from municipality to municipality as prices for waste and transportation of waste differ. In addition, from an HR perspective, donating food can create an attractive workplace and a positive company image. Matmissionen always tries to share the story of these collaborations with the entire company so that it becomes a source of pride and not just the initiative of individuals.

What is the process for food donations in places where Matmissionen does not operate?
See the answer above.

What does Matmissionen do with the unsold food? How is it sorted?
Matmissionen has a food waste rate of about 3%, which is a good number, especially considering that some of the products sold in our stores are not always easy to sell to consumers. Some of the surplus food goes to biogas, and the rest is sent for incineration. This depends on the local handling of food waste. For example, in Jakobsberg, there is no collection for biogas. There is also a smaller collaboration with a 4H farm that comes and takes as much surplus food as they want to feed their animals.

What are the challenges in Sweden today regarding food donation? What are the opportunities?
In terms of politics, Sweden is partly lagging when it comes to food waste and mainly food donation, compared to other Nordic countries. The politics have yet not supported the expansion of this network or logistics. But this also means that when they eventually do choose to support these measures, there will already be logistics in place to receive larger amounts of food. In contrast, in other countries, where the willingness to donate is forced without having developed a concept, routine for distributing food, and logistics, it leads to a France-like situation. Matmissionen's structure makes us well-prepared for expanded donations.

Quote 1:
"Once politicians decide to make it easier to donate food, we will be ready to receive large amounts of surplus food because we have built up the logistics and routines necessary to receive it."

Several aspects complicate the expansion of food donations. For non-temperature-controlled grocery products, such as Producer 1 [company name anonymized], there is a big competitor in Company 1 [company name anonymized], which is the only surplus actor that handles larger volumes than Matmissionen. However, they do not handle fresh produce. Additionally, many companies believe that it is complicated to donate food, especially concerning moms (VAT), and that they may have to pay additional tax for donated food. However, Skatteverket (the Swedish tax authorities) has clarified that if the routine for registering donated food is clear, there is no need to pay tax on it. Another aspect is traceability. Matmissionen has the same requirements as other players in the food industry to have documentation on traceability for all products we sell. Currently, much of the logistics for food donations happen manually between actors donating to Matmissionen. This creates

a manual process for partners. There are also existing logistics that could be better utilized, and Matmissionen sees the challenge mainly with empty transports that could be optimized to be filled and improve the situation for all players. As of now, all logistics are done manually and are tied to the engagement of individuals, which is a risk factor.

Quote 2:
"If we are to have a structure that facilitates donations to a larger extent, it must come centrally from the organization, and corporate leadership will not make such a decision unless it is economically justifiable. And for this, we need political decisions that give long-term incentives."

DONATED BREAD

How would it work with donations directly from the store? Would the short shelf life be a problem?
Donation from the store is not possible |see previous answer] but it is possible to pick up reclaimed bread from the bakeries' own warehouses.

What is your requirement when it comes to date stamps for bread? What is the requirement on your end? In what condition can the bread be?
Matmissionen has no problem accepting bread that only has a few days left on the date. One day after the best-before date is the general routine. Matmissionen can also further reduce the price of products. Matmissionen members currently only pay 30% of the price, but this can be reduced even further if the products have a short date or are difficult to sell for other reasons.

How much bread do you currently accept and how much more could you accept? According to our figures, about 940 tons of bread are donated per year, with Stadsmissionen receiving about 639 tons, could that be correct? About how much of this is soft bread, sweet pastries, and crispbread?
This sounds high. I have not been able to come up with an entirely accurate figure yet, but based on my estimate, I believe that Matmissionen currently receives 400-450 tons of bread per year at the current rate. This includes all kinds of bread, even sweet bread [fikabröd]. In Stockholm, we've handled 50 tons of bread in the first three months, which gives an average of 200 tons of bread this year. The local Stadsmissionen organizations receive much lower volumes.

What is the annual need? Are there regional differences?
It's currently relevant for Matmissionen to find new collaborations regarding bread. We see an increased need to receive surplus bread, especially factory-baked bread,

i.e. bread in plastic bags. Freshly baked bread that is not packed is not relevant as it is often mixed with other products which can create problems with allergies.

Bakery 1 [company name anonymized] has no production in the Stockholm area, so they work with Stadsmissionen and Matmissionen in Gothenburg and Malmö. Matmissionen has tried to establish a routine where they can pick up bread returns (TBA) from stores, e.g. Bakery 1's terminals in Stockholm, but they have encountered resistance and no willingness to donate this. This may have to do with budgeting for biogas and ethanol but that's just speculation. Bakery 2 [company name anonymized] is easier to work with, but Matmissionen has recently seen a dramatic decrease in the amount of bread they receive from their factory. This is primarily because Bakery 2 has found routines and methods to reduce bread waste already in production.

FOOD WASTE

How do you see the relationship between food donation and food waste?
There are no clear figures on how much edible surplus food there is in Sweden today and what is thrown away. However, Matmissionen has seen that when we expand and become a more attractive logistics solution for companies that want to donate their surplus, volumes increase significantly. Even though Matmissionen is the largest actor in receiving surplus, we sometimes cannot even accept 10% of the food that companies offer. So even if the supply would decrease overall and at the same time Matmissionen's needs increase, we still see that there will be enough food to receive. Of course, this is just a feeling and not an actual calculation, which is a risk. However, we already see that certain categories are decreasing, such as manageable volumes of fruits and vegetables. There is already not a lot to work with, and Matmissionen sees that it is decreasing from suppliers. Matmissionen still hopes that we will be able to supply their new stores with these products, but it is not entirely certain. It is a difficult product category to work with since it has a shorter shelf life than other products and Matmissionen needs sufficient volumes and good quality for it to be usable in stores.

Currently, the largest volumes of fruits and vegetables come from Retailer 1's [company name anonymized] central warehouse. These products work perfectly for Matmissionen because it is a shorter distance from the warehouse to the customer, but for Retailer 1's own chain, which is often longer where the products should be held in the central warehouse (6-7 days) and then on the store shelf (2-3 days) and then at the consumer's home (a couple of days), it's not always possible. Matmissionen cuts about two weeks off the lead time for goods.

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