Jordbruks verket

Food loss in Sweden

National follow-up methods for increased knowledge about losses and resources in food production






- Few countries in the world follow-up the food losses that arises at the beginning of the food chain on a national basis. Now there are methods to do this in Sweden.
- The methods can mainly be used for eight production flows: beef, pork, milk, fish, wheat, potatoes, carrots and strawberries, and will be used to follow-up national and global targets for reducing food loss and waste.
- Increased knowledge about the amount of food losses and its causes will lead to initiatives to ensure that more from the food production goes on to become food.

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Food loss in Sweden

The report presents follow-up methods on a national level, focusing primarily on food losses, but may also include food waste, in the early stages of the food chain. The methods will be used to gain increased knowledge so that stakeholders throughout the entire food chain can contribute to measures and initiatives to ensure that more from the food production goes on to become food. They will also be used to follow-up goals and targets for reducing food loss within the Swedish environmental objectives system and the Agenda 2030.

The report has been produced within the scope of the Swedish governmental assignment and associated strategy for reducing food loss and waste, in which setting a national target for food loss and waste reduction and the development of follow-up methods, are a crucial part. An important element in the development of the methods has been the dialogue with farmer- and industry representatives and with the Swedish Environmental Protection Agency, Statistics Sweden (SCB), the Swedish Food Agency, the Swedish University of Agricultural Sciences and Research Institutes of Sweden.

By translating this report into English, we hope to be able to share our insights and reasoning as one way to establish a national follow-up on food losses. Just as we want to learn and keep being inspired by other countries and actors working in this area. Please note that the original version was published in Swedish in March 2021 and that there may be linguistic differences and terminology that does not exactly correspond in the translation to English. If questions please contact the Swedish Board of Agriculture fraga@jordbruksverket.se.

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Summary

There is a lack of knowledge about the quantities and causes of food loss and waste, especially in the early stages of the food chain. The studies that have been performed show significant losses already in the primary production, which leads to economic losses for producers and unnecessary environmental and climate impact. Not all food loss can be avoided, but being aware of and optimizing the flows of food production contribute to a more robust food chain. When work and resources have been used to produce the quality that consumers demand, it is more resource efficient that raw materials and products reach the consumer and are consumed. By-products from the food industry can also, with additional processing or handling, to a greater extent be utilized in food products alternatively be used as feed instead of becoming waste.

New methods will increase knowledge about quantities and causes

In this report, we propose methods for the national follow-up of food loss in the production chains for pork, beef, milk, fish, wheat, potatoes, carrots and strawberries. They are now used in the work on following up food losses in 2021–2022. Sweden will be one of the first countries to take a holistic approach to measure food losses at the national level.

The methods are based on using existing statistics to the extent available, in combination with data from advisory programmes, interviews, questionnaires and field investigations. For **meat**, the methods are based on using animal registers and industry programmes to calculate the proportion of meat that is lost when animals die or are euthanized at the farm or slaughter plant and sent to waste, and to follow-up how by-products from different parts of the animal are used following slaughter. In **milk** production, the losses can be assessed by calculating how much is lost when dairy cows are treated with antibiotics, and by following how by-products, such as whey and buttermilk, are utilized.

Damaged or too small **fish** , as well as discarded but edible parts in the preparation can be monitored using existing statistics as well as through interviews and company surveys. Losses in **wheat** production can be monitored using official statistics on unharvested acreage and studies on wildlife damage, interviews with growers, and through surveys/data collection of mills and bakeries. For **potatoes and carrots** food losses can be monitored in field studies, but also by measurements of how much is sorted out at packing plants, or is damaged during storage. For **strawberries**, the focus is primarily on different harvesting strategies.

The approach is dynamic and can be expanded depending on funding and access to data. More data may be provided from the food industry using surveys, as well as from investigations of factors that lead to food loss, such as studying

food losses caused by unfair trading practices. Cooperation with farmers and industry actors and other authorities remains very important.

The entire food chain can contribute

Food production is governed by biological factors and variations in which it is possible to be better or worse prepared. It is a matter of knowledge but also of access to technology, product development and innovations, which requires financial resources.

Market demand is an important factor, and retailers and consumers often require higher exterior quality in fruit, vegetables, berries and potatoes, than required by legislation and marketing standards. In addition, there are order cancellations and returns that also lead to food loss and waste. Actors throughout the food system, such as companies, organisations, authorities and researchers, need to work actively and together to ensure that more of what is produced for food actually becomes food. New technology, innovation and collaboration can pave the way for a positive development.

Monitoring the Swedish food loss target and the SDG 12.3

Since 2020, there are two national targets for food loss and waste reduction:

Food losses

- By 2025, an increased share of the food production should reach retailers and consumers, and

Food waste

- From 2020 to 2025, the total amount of food waste should be reduced by at least 20 percent by weight per capita.

The methods presented in this report will be used to follow-up the milestone target for reducing food losses as well as for follow-up of the sustainability goal SDG 12.3 in the Agenda 2030. By measuring and following up, both challenges and potential opportunities can become more apparent and make it possible to implement measures and initiatives both at the societal level and at companies in the food chain.

Innehåll

1 Introduction

Food loss and waste leads to unnecessary use of resources that leads to both environmental impact and unnecessary costs for producers as well as consumers. The Food and Agriculture Organization of the United Nations, FAO, has estimated that about one third of all food produced is not consumed by humans[1], and that global food loss and waste after harvest, slaughter and catch is about 14 percent in terms of economic value[2] and that pre-harvest losses are of significant magnitude[3]. Reduced food loss and waste can result in a triple gain – reducing hunger, better economic conditions and reduced impact on the environment and climate.

There is currently no comprehensive and sufficiently detailed data on the total amount of food loss and waste in Sweden. In order for both companies and authorities to be able to work more efficiently to reduce food loss and waste, we must have an accurate picture of where food loss and waste arises, what the extent of it is at different levels and where the challenges lie. In particular, it is food loss and waste in the early stages primarily in primary production, including by-products from the food industry, that have been insufficiently investigated. Furthermore, very small quantities of food loss and waste from primary production and the food industry will, with the EU's new classification, be referred to as food waste and be included in the annual national statistics for food waste.

In the work that is underway to achieve the environmental and climate goals,[4] resource efficiency and reduced food loss and waste are important factors. Resource efficiency means that we use our limited resources in an efficient and sustainable way with minimal environmental impact. The new Swedish milestone targets for reduced food loss and waste, within the Swedish environmental objectives system, will justify a change in behaviour of all stakeholders relating to food. To be able to follow the development towards the goals and targets, follow-up is required.

The overall goal in the Swedish food strategy[5] is a competitive food chain where total food production increases while the relevant environmental goals are achieved. It is also clear that there must be sustainable development in the food chain, as well as sustainable production growth and reduced vulnerability in the food chain. Reduced food loss and waste and increased resource efficiency align well with the goals of the food strategy, as it can lead to both reduced environmental and climate impact, reduced costs, increased profitability and a more robust food chain.

1 FAO 2011.

2 FAO 2019.

3 FAO 2011 and Flanagan et al. 2019.

4 Sweden's sixteen environmental quality objectives, the Generational Goal, Sweden's climate goal of having no net emissions into the atmosphere by 2045 and thereafter achieving negative emissions, the EU's food strategy From Farm to Fork and 2030 Agenda Sustainable Development Target 12.3.

5 Bill 2016/17:104 En livsmedelsstrategi för Sverige – fler jobb och hållbar tillväxt i hela landet (A food strategy for Sweden – more jobs and sustainable growth throughout the country).

Since 2018, there has been an action plan in place for reducing food loss and waste that extends as far as 2030 – Fler gör mer[6], which was developed within the scope of a government mandate that was given to the Swedish Food Agency, the Swedish Board of Agriculture and the Swedish Environmental Protection Agency in collaboration with stakeholders in the food chain. The action plan states how Sweden will work with food loss and waste reduction measures in the long term. One of four crucial points for the work on national food loss and waste was to bring forward a national target and also to develop follow-up methods.[7]

1.1 Aim and target group

The aim of the report is to present methods for the national follow-up on food loss and waste with a focus on primary production and up to, but not including, the retail level. The methods are used during 2021-2022 for following up the Swedish food loss target and the SDG 12.3, and are supposed to be repeated regularly.

The target group for the report is farmers- and industry organisations, companies, authorities, the Swedish government and organisations that can contribute with expertise about the quantities and causes of food loss and waste, but also be part of the efforts to both follow-up and reduce them. By translating the report into English, it is also possible that organisations, governments and stakeholders in other countries can benefit from it in their work to set goals, measure and reduce food loss and waste.

Development of the methods and this report is an initiative within the food strategy's mandate for reducing food loss and waste, which is implemented by the Swedish Food Agency together with the Swedish Board of Agriculture and the Swedish Environmental Protection Agency. In 2021, the follow-up of food losses will be financed with funds from the government assignment for reducing food loss and waste. In order to be able to complete the follow-up with 2021 as the base year, additional funding is required in 2022 as well as at least for target year 2025 (target year refers to the milestone target for reducing food loss and waste). Resources are needed to continue to follow-up food losses over time and to obtain sufficient statistical quality and scope. Therefore, other funding might also be needed in addition to what will be provided within the scope of government mandates for reducing food loss and waste.

6 Fler gör mer – Nationella handlingsplanen för minskat matsvinn 2030. (More people are doing more – National action plan for reduced food waste 2030).

7 Fler gör mer – Handlingsplan för minskat matsvinn 2030.

1.2 How did we develop the methods?

The choice of the eight products on which the method is primarily based was determined after several discussions within the project's reference group. Christina Anderzén from the Swedish Environmental Protection Agency and Louise Sörme from Statistics Sweden participated in the reference group. At the Swedish Board of Agriculture, Lis Eriksson and Caroline Sandberg participated in Greppa Näringen, Sara Ragnarsson Växtrådgivning Syd, Jörgen Persson the Statistics Unit, Kristina Mattsson and Amanda Karltorp as well as project manager Karin Lindow at the Food Chain and Export Unit. Karin Östergren from Research Institutes of Sweden, RISE and Marie Olsson and Ingrid Strid from The Swedish University of Agricultural Sciences, SLU also participated in these discussions. Subsequently, there was some consultation with farmers stakeholders and finally the project's steering committee decided which products to choose.

There are a number of products that would have been interesting to study but for resource reasons it was decided to focus on pork, beef, milk, fish, wheat, potatoes, carrots and strawberries. The products were selected according to a number of different criteria:

- The production value of the raw material.
- The production volume of the raw material.
- Distribution across different categories of raw material.[8]
- Climate impact per kilogram.
- Results from previous studies of food waste and food loss at the beginning of the food chain.
- Potential for processing/valorization.

The products importance for the Swedish food supply and health was also discussed, as well as the wish to measure the production of both storable and fresh -vegetables. In the final selection, the various aspects were combined. Hopefully, in the future, the method could include more product flows than the eight that were selected. This would require more financing, or having more data available in line with increased digitalization or investments in resource efficiency.

The Swedish Board of Agriculture then commissioned Karin Östergren at RISE to produce a background study showing how other countries follow-up on food loss and what tools, frameworks and studies are available and should be considered.[9] This study was used as a knowledge base in the development of the method, and parts of it are presented in Chapter 4. This study was carried out during the first half of 2020.

8 The FAO's five categories; cereals and legumes/fruit and vegetables/root vegetables, tubers and oil-seeds/animal-based products/fish and fish products.

9 Consultation report doc. no.: 4.5.17-03596/2020.

Next step was for researchers at the Swedish University of Agricultural Sciences to develop eight proposals for follow-up methods for different product flows. The starting point was to first review the existing statistics in order to make use of what is already available in records, official statistics, farmers- and industry programmes, and so on. From there, the researchers proposed the need of additional studies. Further description of the method can be found in Chapter 5.

The method proposals were then discussed and modified based on the farmers- and industry's stakeholders views over the course of several meetings. Their views have been important and have in many instances guided the work, as it is the companies and their representatives who have the expertise regarding what the production flows look like and how to proceed. Furthermore, they are the main target group for the efforts and measures that the new knowledge from the follow-up will generate.

The farmers- and industry organisations that have participated in discussions and provided valuable views on the method proposals are primarily: the Swedish beef producers, The Swedish pig producers, Swedish meat industries, The federation of Swedish farmers, Norrmejerier, Swedish Pelagic Federation PO, The Swedish fishery producer organization, The fish processing organization, Swedish grain producers, The organization for feed and grain, The Swedish Mills, The potato growers organization and the Swedish Food federation.

1.3 Definitions

The Swedish term **matsvinn (eng. food loss and waste)** is described by the Swedish authorities[10] as food[11] that has been produced with the intention of becoming food but which for various reasons does not progress in the food chain and is not consumed by humans.

Food loss and waste can occur throughout the food chain and has many different designations. Figure 1 illustrates the terms that are primarily used in this report.

10 The Swedish Board of Agriculture, The Swedish Food Agency and The Swedish Environmental Protection Agency.

11 Article 2 of Regulation (EC) No. 178/2002.

Figure 1. *Key terms used to follow-up food loss and waste in the various stages of the food chain. Food waste refers in this report to what is defined as food waste according to the EU legislation and food loss refers in this report to any other food intended for human consumption that does not progress to human consumption.*

The method presented in this report has a main focus on food losses in the primary production and food industry. However, the method also has an open approach to the extent that it follows the production flows that was intended to be consumed by humans but did not continue the food chain, with the purpose to also track the food waste flows in the early stages of the food chain. The different amounts of food loss versus food waste (food waste according to EU waste directive) will then when possible, be presented separately.

Pre-harvest and pre-slaughter losses such as food producing animals that die or are put down on the farm and are not consumed in the producer's own household, as well as food crops plants that have not been harvested and thus do not progress in the food chain, are a loss from a resource perspective. Although these losses arise before the raw material is classified as food (at least not in the EU legislation) and thus by EU definition may not be seen as a food loss, it is still important for environmental/climate and financial reasons to include them in the efforts to increase resource efficiency.

In this report, **Food loss** is defined as the losses that arise from primary production up to, but not including, the retail stage, and is also separate from what is classified as food waste according to the EU waste directive. The term food loss is not defined in legislation but the FAO defines food loss and waste as follows:[12] "Food loss is the decrease in the quantity or quality of food resulting from decisions and actions by food suppliers in the chain, excluding retailers, food service providers and consumers. Food waste refers to the decrease in the

12 FAO 2019.

quantity or quality of food resulting from decisions and actions by retailers, food service providers[13] and consumers."

Food loss has also been defined in the Swedish food loss and waste context in the development of Swedish targets for reduced food loss and waste.[14,15] For example, food loss includes potatoes or bread that becomes animal feed instead of food. It can also include vegetables that are harvested and left in the field, become animal feed, or are converted into biogas on a person's own farm.

Planned feed production, when animal producers grow grain as feed for their animals, or for other purposes where food was never the ultimate purpose, is not considered as either a food loss or waste. However, these flows can be interesting to note and monitor in a follow-up from a resource point of view. With different technology, demand, price, legislation or the need for food supply, it can be interesting to monitor how these volumes change over time.

Food waste is regulated in the EU waste legislation[16] and includes all food both solid and liquid that has become waste. Waste[17] includes all items or substances that the owner wants to dispose of or is obliged to dispose of. There are probably only small flows arising from the primary production and the food industry that, according to the EU definition are classified as food waste, but rather it falls under the term *food loss*.

Food waste includes both edible and inedible food parts of food defined by the EU food legislation. From 2020, the Swedish follow-up of food waste will be based on the EU definition of food waste. More information about the follow-up of food waste can be found in Chapter 4.1.

Food waste can occur at all stages of the food chain and is usually digested, composted or incinerated. In Sweden it is prohibited by national law to deposit combustible and organic waste to landfill, which also includes food waste. From primary production, food waste can arise when food is sold or brought to a waste facility that is not the primary producer's own, but these flows are probably minor. By-products from the food industry that are not treated as waste are also not included in the waste statistics.

Due to the revision of the EU waste legislation the term food waste has been given a clearer scope and has also got another Swedish translation into *livsmedelsavfall* (former translation: *matavfall*).

By-products are substances or items that have arisen in a production process where the main purpose is not to produce the substance or item. They must be able to be used directly without any other processing than that which is normal in industrial practice, and they must continue to be used in a way that

13 *The catering industry* refers to food stakeholders within the public sector, restaurants and the like.

14 The Swedish Environmental Agency's website.

15 Miljömålsportalen's website.

16 Directive 2008/98/EC.

17 Waste is defined in Article 3 of Directive 2008/98/EC of the European Parliament and of the Council.

is acceptable to health and the environment and that does not contravene legislation.[18] By-products can be used more or less resource efficiently. Through processing, they can instead become food, alternatively they can be used as animal feed, used for fuel production, as fertilizers or technical products. It is therefore relevant to include the by-products in the work for reduced food waste and increased resource efficiency, even if they do not automatically fall under the EU-definition of food waste.

Examples of by-products are rapeseed meal, molasses and whey. Some by-products such as whey, milk, whole or parts of animals are classified as animal by-products and, for safety reasons, fall under specific legislation that regulates how these shall be handled.[19]

Food is defined in EU food legislation[20] as any substance or product, whether processed, partially processed or unprocessed, that is intended for or can reasonably be expected to be intended for human consumption. Food includes beverages, chewing gum and all substances, including water, intentionally added to the food during manufacture. Food does not include animal feed, live animals, with the exception of those that have been processed for putting on the market as food, pre-harvest plants, medicines, cosmetics, tobacco and tobacco products, drugs or psychotropic substances, residues and contaminants.

1.4 How definitions and demarcations are handled in this report

Side flows, secondary flows, residual streams, residual flows, bio-streams, spillage and waste

There are many different terms for what is generated from the food production that does not ultimately go on to become food. In this report, the terms *food loss* including pre harvest and pre slaughter losses, and food waste are mainly used, this is illustrated in figure 1. In chapter five, on the other hand, there may be other terms that are appropriate for the specific raw material/product, such as guts in fish processing, harvest waste of vegetables, white water from dairy production and so on.

18 Environmental Code 1998:808 Chapter 15, Section 1.

19 Regulation (EC) No. 1069/2009.

20 Article 3 of Regulation (EC) No 178/2002.

The text box below clarifies how the method presented in this report relates to the various terms and definitions in the field.

> The method presented in this report is focusing on food losses. But in order to get a complete picture that provides the greatest knowledge about the resources within food production, the method also include following up the food waste in the beginning of the food chain. The purpose is not primarily about evaluating and excluding different flows, but about quantifying and describing what was intended to be food but does not continue the food chain, and how it is being used instead. This is regardless of whether it is to be classified as food waste or food loss, as the application areas (so-called destinations) can vary over time from the same activity.

The methods include food production, which extends from primary production to, but not including, retail, food service and consumers.

Thus, the method presented has an open approach to the extent that it follows the flows that under other circumstances, such as different refinement, processing, innovation, or different demand, could have been consumed by humans. If not today, perhaps in the future based on reasonable efforts. This is regardless of destination and what it should be classified as or called because the allocation to different categories can vary. One and the same flow at the same company can, for example, for a time result in waste, but when the demand change, it can be used as animal feed, or lead to a commercial transaction that results in an export product for human consumption.

In order to get a complete picture that provides the greatest information about losses and resources in food production, the choice therefore resulted in the method not primarily evaluating and excluding the different flows, but describing and quantifying them regardless of destination. The Swedish Environmental Protection Agency's participation has been very valuable and this method is also expected to contribute to improved food waste statistics, as the national waste statistics are not based on raw material flows, but compile data from e.g. environmental reports and waste facilities at an aggregate level.

The method is primarily about the parts of the product that can reasonably be expected to be consumed by people in Sweden or in other markets via export, or where processing could lead to human consumption. This does not primarily include bones, fruit and vegetable peel, vegetable tops and the like, although from a broader resource perspective it would have been interesting to make better use of these resources for food consumption as well. What the market demands and what we consumers want to eat can change over time and be different on different markets.

The method refers to Swedish primary production, but the food processors and distribution stages often use both Swedish and imported raw materials, and

therefore the imported products are also affected by the measures and insights that the work is expected to lead to.

What has already become animal feed and is then lost, because the feed is trampled by the animals during feeding for instance or when the feed goes bad during storage, is not included. Nor are losses of other inputs that are stored or spilled, such as seeds, plant protection products, fertilizers, water or the like.

2 Why is more knowledge about food losses and resources needed?

The fact that more of the food produced progresses in the food chain has several advantages. Both reduced environmental- and climate impact and increased profitability for food producers. Consequently, food loss and waste must be prevented. However, food production is a biological process and will never be 100 percent marketable as food. The resources that cannot go on to become food should therefore be used as resource-efficiently as possible.

Below is a description of why it is important that more food production resources go to food, how to prioritize and who should do the job.

2.1 Reduced environmental and climate impact, increased profitability and a more robust food production

When inputs such as seed, manure, inorganic fertilizer, plant protection products, animal feed, veterinary medicine, energy, personnel, water and land have been used for food production, it is most resource efficient if the raw material or product reaches the intended target.

The environmental and resource perspective

All food production can involve various forms of environmental impact such as greenhouse gas emissions that lead to an impact on the climate, leakage of plant nutrients that may contribute to eutrophication, access to and use of land that contributes to increased or decreased biodiversity, excessive use of plant production products, etc. Approximately 14 percent of the world's climate-affecting emissions originate from agriculture and its land usage,[21] and the agricultural sector accounts for approximately 13 percent of the total greenhouse gas emissions in Sweden.[22] Emissions from the agricultural sector do not include all emissions or removals (such as agricultural energy use, emissions from imported inputs and animal feed, as well as the leakage or storage of carbon on agricultural land). If these emissions are also included, the proportion of emissions from agriculture would be greater.[23] Food production also contributes to around half of the total eutrophication in Sweden.[24] Depending on whether the food waste consists of animal products or vegetables, the difference in

21 IPCC AR 5 Synthesis Report, 2014.

22 SCB 2020.

23 Ibid.

24 Havs- och vattenmyndigheten 2019:20. (Excluding discharges via municipal sewage treatment plants and individual sewers).

environmental and climate impact is considerable and it involves different environmental factors. Reducing food loss and waste can mean that the same production levels as before are maintained, with a constant environmental impact from production, at the same time as the food produced is used more efficiently and feeds more people.[25] Or that less food needs to be produced to feed the same amount of population.

Plant protection products are needed in many instances to prevent food loss, but are used unnecessarily if the crops are not subsequently consumed. The fact that vegetables or other vegetable products are left in the field constitutes a lost business opportunity. It probably does not either contribute much to increasing the level of humus content in the soil, but instead leads to nitrogen loss. To increase the humus content, it is more efficient to grow perennial crops, intermediate crops and catch crops or to leave the crop residues from cereals.[26] Seas and lakes are not a finite resource and even in fishing it is important to use as much as possible of the catch in a resource-efficient way. Similarly, meat and milk that do not become food have a considerable climate impact and thus it is important to use as much as possible of the animals in a resource-efficient way. A study of the German meat production chain showed that its climate impact can be significantly reduced if edible organs are used to a greater extent. If we had consumed half of the intestines that today do not become food, the meat chain's contribution to climate impact would decrease by as much as 14 percent.[27] In order to complete the picture, we should also state that grazing animals keep the land clear and thus contribute to biodiversity and to maintaining our cultural landscapes. However, this does not contradict what has already been stated, as it is important that the animals are used in a resource-efficient way.

Reduced costs and increased profitability

In addition to unnecessary costs, food loss also leads to lost revenue. It is almost always more profitable to have the raw material sold for food, when food use was the intention. In a major international study with stakeholders from the entire food chain, it was revealed that 99 percent of the businesses that invested in reduced food waste saw a positive return. According to the study, companies in the food chain had a median return of 14 times the amount they had invested to reduce food waste.[28]

Studies in North Carolina, USA, have shown that the vegetable harvest can increase by up to 20 percent and that more than half of what is left in the

25 The Swedish Environmental Protection Agency 2020a.

26 Personal statement Thomas Kätterer, Swedish University of Agriculture Sciences.

27 Xue et al. 2019.

28 WRI and WRAP, 2017. The study included 700 food companies with close to 1,200 production plants in 17 countries.

field after harvest could be sold.[29] The British organisation WRAP has in turn studied the financial values that can be saved in the potato chain from farm to supermarket shelf. They found that a small adjustment of the regular size requirement for ware potatoes, from 45 mm to 43 mm, allowed 5 percent more potatoes to be used, which resulted in an increased income of GBP 100,000 per 1,000 tonnes of potatoes, while having minimal effect on consumers.[30]

Several studies have calculated the cost for health problems, diseases and injuries in animal production. The fact that Sweden has a good standard of animal health entails, in addition to animal welfare and low antibiotic usage, reduced losses and costs. Sweden considers itself to be free of several diseases, such as the porcine disease PRRS and bovine viral diarrhoea BVD. PRRS can cost between SEK 644 to 860 per sow and year in terms of piglet mortality.[31] BVD costs SEK 200,000 per year for a herd of 100 cattle in the form of deteriorating calf health but also in reduced milk production and extended calving intervals.[32] A study of costs in milk production showed that cows that cannot be sent for slaughter or slaughtered on the farm, the carcasses of which are instead sent for waste disposal, on average cost SEK 9,000 in lost slaughter revenue with an additional SEK 1,560 for carcass handling. In summary it entailed a total cost of SEK 10,500 for the producer.[33]

Preparedness

From the perspective of preparedness, it is also important to have good knowledge of the various flows in the food chain and the areas of use that exist for the various resources. A robust food chain should reasonably be aware of and optimize its flows. It is also important to consider that in a crisis, consumer behaviour may change, market channels may be closed and the supply of inputs and labour may be limited. This can cause losses in both the quantity and the quality of the food produced. Flows that by definition are not described as food losses, such as by-catches of fish that become animal feed, potatoes for starch or milling cereals that are reclassified as animal feed, should also be important to know about in instances where these resources need to be used for food.

2.2 Can we achieve zero food loss?

Linguistically, the term matsvinn (food loss and waste) brings to mind thoughts of negligence, waste and carelessness. But food producers are also affected by a variety of biological factors. Early losses are governed by a number of natural factors such as weather, pests, wildlife damage and disease. The level

29 Johnson et al. 2018.

30 WRAP 2015.

31 The Swedish Board of Agriculture 2009:4

32 SVA 2013.

33 Växa Sverige 2010, 2015.

of preparedness for this varies among producers, but it is often self-regulating and a business owner, not least from a financial point of view, would want to optimize their production and protect their business from losses.

It may involve having the right expertise but also having access to the right technology. In a dry year, those who have access to irrigation can protect themselves against losses in the field, but it might also entail having a potato harvester, combine harvester, or machines for filleting fish or meat processing that provide minimal loss and waste, or having the capacity to cool and store fresh produce. Harvest staff also need to be well informed about how quality can be ensured and that livestock buildings and systems are well designed with staff that ensure good hygiene and animal welfare.

Comparatively little money is invested in research and innovation in the food chain. Studies of the degree of innovation show that Sweden ranks highly in Europe in several sectors (e.g. second place in the steel, forestry and automotive industries), but only in 14th place for food research out of a total of 31 countries. The degree of innovation is lower in the early stages of the food chain, and only every third agricultural company has introduced a new or improved product or process between the years 2016 and 2018, which is a significantly lower proportion than in other sectors. However, the proportion of innovative companies in the last three stages of the food chain is on par with other businesses. A problem in primary production and the food industry is the low profitability that can result in fewer opportunities to invest in sustainable technology, which would have meant that more food could have been utilized or that a higher quality could have been ensured.[34]

In many instances, it is also about market channels and business opportunities. When it comes to fruit, vegetables and potatoes, the market demand for appearance, varieties, size, degree of ripeness all have an effect. The market consists of wholesalers, retailers and consumers, who all have demands on the products. But with a reduced supply, prices rise and tolerance for defects increases at all levels.[35] When supply is high and the demand from one customer is declining, it is important to be able to find another customer who wants to buy at a price that makes it worthwhile to harvest, or that contacts exist with the processing industry that can take the raw material. Having this type of plan B drawn up in advance may help eliminating waste from occurring in the first place. Examples of solutions are when restaurants, commercial kitchens and the food industry can process and prepare the raw material that does not meet the demands for appearance in order to sell it as an intact product. Similarly, direct sales to consumers, such as farm shops, REKO rings (where farmers and food producers reach consumers in Facebook-groups and arrange meet-ups) and picking your own fruit and vegetables, can provide more sales alternatives. It is also important that business models prevent food waste, so that they manage the sale of any surplus that arises as food or animal feed, instead of it being

34 The Swedish Board of Agriculture 2020:3.

35 The Swedish Board of Agriculture 2014:5.

left in the field. One example is contracts where joint responsibility is taken for yield fluctuations, or belonging to a common sales channel such as a producer organisation.

2.3 The entire chain is responsible for early food loss

There is an increased interest in society concerning the issue of food waste, and this is an area in which many major food stakeholders want to gain a reputation. However, the food loss and waste problem is complex and in order to take genuine responsibility, it is not enough to just focus on your own business. One and the same stakeholder can contribute to food loss and waste at suppliers and producers further back in the chain as well as further down the chain. It is therefore positive that a voluntary agreement for reduced food loss and waste – SAMS, see Chapter 4.3) has been initiated within the food chain.

Further back in the chain, it can involve collaborating with suppliers on quality criteria, or on new products that utilize more of the raw materials, as well as using fair business practices. Further down the chain, it might involve ensuring good quality right from the farm all the way to the consumer's dinner plate, and not about enticing consumers with product offers to buy more than they can consume, especially when it comes to products with limited shelf life. The government and authorities also need to have food waste and resource issues high on their agenda so that rules do not risk leading to increased waste, and that more and increased investments are made in innovation, technology and knowledge that lead to reduced food loss and waste.

In order to be able to collaborate on these issues, it is necessary to have information on which quantities could be used more resource-efficiently, but also the reasons why losses arise. With this information, measures and efforts can be taken both by food producers, but also at the wholesalers-, retailers- and food service level, and all the way up to the demand from consumers. New food products that take advantage of residual flows from the food industry is one example, as is collaboration between stakeholders in the food chain so that appearance requirements can be adjusted, and joint efforts to influence consumer preferences can be promoted. Studies have shown that the quality criteria set by retailers on cosmetic reasons (size, colour and shape, etc.) can affect the sorting of products more than the EU marketing standards or UN trade standards.[36]

Unfair trading practices leading to food waste

A particularly concerning cause of food loss and waste as well as financial losses, is unfair trading practices. These are also covered by the term *Unfair*

36 The Swedish Board of Agriculture 2014:5.

Trading Practices (UTP). This may involve suppliers not being paid within a reasonable time frame, agreements being broken, late cancellation of orders, unreasonable returns or unfounded demands that suppliers bear the cost of products that have been returned or discarded. If an order cancellation occurs close to the delivery date, there is no guarantee that the supplier will have time to find a buyer for the product before it goes off. This can result in the producer being forced to sell it as animal feed, or that all or part of the cancelled delivery must be discarded. Similarly, returns of fruit, vegetables and bread can reduce the incentive for supermarkets to reduce the price and thereby have a product sold as food if instead they can send it back to the supplier at the supplier's expense.[37] Producers of fresh seasonal products such as strawberries and new potatoes are in a particularly vulnerable position as demand is high for a very short period of time and as the products cannot be stored.[38] Unfair trading practices can occur at all stages of the supply chain, and the problems have been raised by industry representatives within both primary production and the food industry.[39]

Legislation to combat UTP has been introduced in the EU. The Swedish regulations will come into force in november 2021 and include a ban on e.g. late cancellations of orders, late payments and commercial retaliations.[40] The Swedish Competition Authority has been appointed as the supervisory body and will pursue cases against buyers who use unfair trading practices.[41]

2.4 Resource hierarchy for food

In order to use our resources as efficiently as possible, food should be used for the purpose for which it was produced. If this is not possible, we should take advantage of it in the most environmentally and resource-efficient way possible. Food loss can be perceived as food that has not been utilized at all. But working circularly, using a cycle, reusing and recycling is something that food producers, not least farmers, have always done. Much of what in food production does not go on to become food, such as potatoes or whey, is still used as animal feed, which is a relatively good alternative in terms of resources. What is produced can, for example, also become biogas or be composted. But according to studies, it can be up to 15 times more climate-efficient to prevent food from becoming waste than to produce biogas from it.[42] However, this depends on which energy system the biogas replaces, for example if it replaces hydroelectric power or

37 Eriksson et al. 2012.

38 Ektander et al. 2018.

39 Livsmedelsföretagen and LRF 2019.

40 Directive (EU) 2019/633.

41 The Swedish Government 2020.

42 Personal statement Aina Stensgård, NORSUS. As calculated on food waste throughout the value chain in Norway, based on specific composition, and analyses of climate benefits for biogas production for fuel in Norway. The calculations are based on what is actually discarded in Norway so that the composition and climate impact of the discarded food is taken into account.

fossil fuels.[43] Further, the higher the environmental impacts are for producing a food product the more important it becomes to take measures to reduce food loss and waste.

Figure 2 shows a resource hierarchy for food that can be used at a general level as a basis for priorities. Primarily, food loss and waste must be prevented. At the same time, we must have a secure supply of food and animal feed. Dead animals that for various reasons do not progress in the food chain are often incinerated, which according to the resource hierarchy is the worst option. But, in many instances, it is also the only option available to safely deal with animal carcasses and risk material from slaughter.[44] Preventing animals from being injured or becoming sick is therefore also very important from a resource perspective. In this resource hierarchy, there are no products other than food and animal feed, such as bioplastics, biodiesel, building materials, etc. This recycling, when the material leaves the food chain, is suggested to be equated with biogas in the hierarchy, which is the case in the US Environmental Protection Agency's resource hierarchy, for example.[45]

Resource hierarchy for food

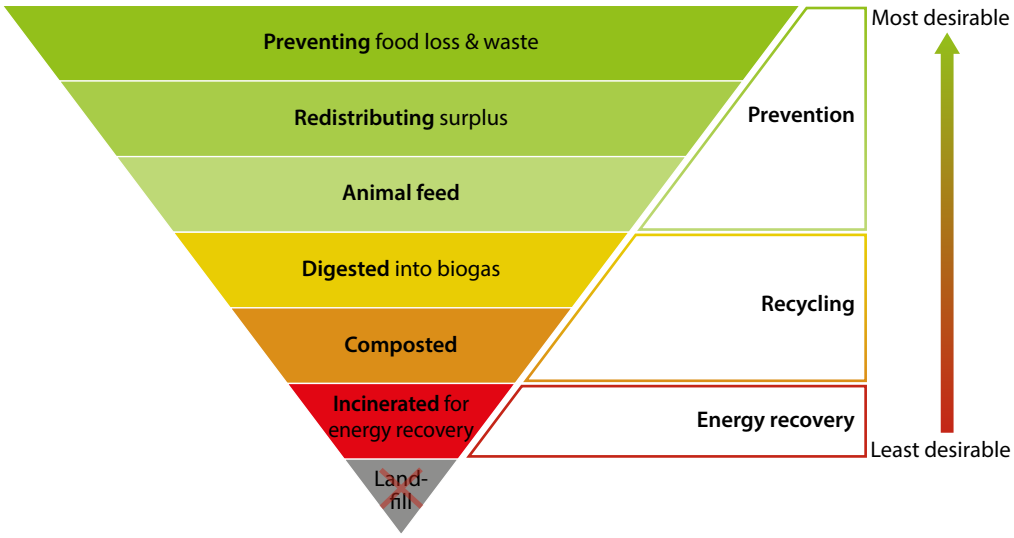


Figure 2. *Resource hierarchy for food based on WRAP (2018). Landfill is prohibited by the Swedish law.*

The ability to utilize raw materials or products in a resource-efficient way varies. Larger companies may find it easier to set aside time and resources to develop new products that make the most of raw materials or to invest in equipment that utilizes residual flows in new products. They may also have better conditions and quantities for exporting to markets with different demand. It is also about geographical and logistical conditions such as proximity to the processing industry, alternative customers, or charities or animal producers who require

43 Scherhaufer et al. 2020.

44 Regulation (EC) No. 1069/2009.

45 EPA 2021.

feed. If the distance is too great to transport a product to be processed into food, it defeats the purpose from both an environmental and financial perspective.

One of the research teams that may have come the furthest in measuring, evaluating and calculating food loss in the field can be found in North Carolina, USA. Their research showed that the harvest of vegetables could increase by up to 20 percent and that more than half of what was left in the field following harvest could be sold, which was significantly more than what the growers themselves had estimated.[46] They have also studied growers' harvesting strategies and the driving forces that affect food loss during field cultivation. Figure 3 shows their developed hierarchy based on interviews with 17 different outdoor farmers. Promoting markets for products that are rejected for reasons of appearance, changing consumer preferences and donating to the needy are some examples that were listed to reduce food losses. But most important for growers was that the market is stable and predictable in terms of high prices.

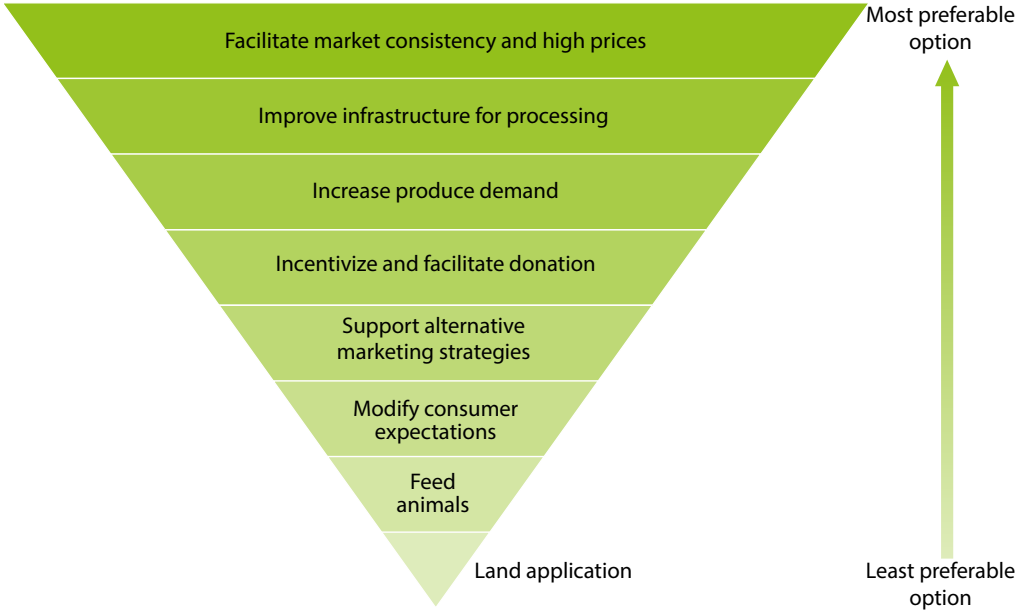


Figure 3. *The hierarchy shows the most and least desirable strategies for reducing food loss in the field according to fruit and vegetable growers in the USA according to Lisa Johnsson et al. 2019.*[47]

It is natural that food loss and waste decreases with higher prices, but higher prices are also associated with a reduced demand, which also reduces waste, so the two factors can be difficult to distinguish from one another. But striving for high prices to reduce waste may not be appropriate in a free market, and for fruit and vegetables we also want to increase consumption to promote public health. On the other hand, one strategy might be to strive for more stable pricing and more stable and predictable supply. However, the question is not an easy one because sometimes, during a period of hot weather for example, larger quantities than are normal and that are planned for will ripen, and

46 Johnson 2018.

47 Johnson et al. 2019.

consequently there will be, in the case of products with a short shelf life, the need to sell more during a period in order to reduce waste.

When a supermarket chain decides to have a campaign with low prices on apples, for example, consumers who buy more apples than normal will often buy less of other types of fruit. As a result, demand will change for the apples with a lower than normal price, as well as for other types of fruit. This makes it difficult for the supermarket to predict demand, which can thus lead to increased waste. One form of promotion which is common, such as for cucumbers, is "2 for the price of 1". This model risks increasing waste because it affects demand in the same way as a lower price, but also because, to an even greater extent than a price reduction, it entices the consumer to buy more than they could possibly consume. In the event of unexpected surpluses, it might therefore be preferable to lower prices than to offer a quantity discount. However, some campaigns are planned in advance and may involve a planned increase in production of, for example, iceberg lettuce, a certain week, on behalf of a supermarket chain, or that a supermarket chain orders a larger quantity of peaches for example. These planned campaigns can also contribute to waste by making demand more difficult to predict. A more consistent supply with fewer planned campaigns for products with a short shelf life could therefore reduce waste.

One question in this context is also who should bear the loss, which in many instances unfortunately is the producer. Another aspect is that a certain amount of overproduction is difficult to avoid as producers have to secure deliveries to their customers, even if they try to be as accurate as possible with their cultivation planning. Here, business models may need to be modified so that joint responsibility is taken for yield fluctuations, see also Chapter 2.2.

3 Follow-up of national and global goals

The method presented in this report shall contribute to the follow-up of both the national milestone target for reduced food loss and waste and the sdg 12.3. Furthermore, food loss could also be added to the recurring evaluation and follow-up of the Swedish food strategy. Today, food waste is used as an indicator of sustainable production and consumption.[48] With national statistics on food loss, a more comprehensive picture can be provided.

3.1 Milestone targets for reduced food loss and waste

The environmental objectives system consists of a generational goal[49], sixteen environmental quality objectives and a number of milestone targets in the areas of waste, biodiversity, hazardous substances, sustainable urban development, air pollution, climate and now also food waste. Sweden's environmental objectives include the national implementation of the ecological dimension of the Sustainable Development Goals. The milestone targets will make it easier to achieve the generational goal and the Swedish environmental objectives, and identify a desired change in society.

In June 2020, the government decided on two new milestone targets linked to the Swedish environmental objectives:

- From 2020 to 2025, the total amount of food waste should be reduced by at least 20 percent by weight per capita.
- By 2025, an increased share of the food production should reach retailers and consumers.

The follow-up method presented in this report will be used to follow-up the milestone target stating that an increased share of the food production should reach the retailers and consumers by 2025. The milestone targets are supposed to lead to an increased pace of measures from all stakeholders involved. In order to reduce food loss and waste already at the food production, efforts need to be made by stakeholders throughout the entire food chain right up to consumers. The proportional increase for food reaching retailers and consumers has not been stipulated, and this is due to that the follow-up for food losses was not in place when the milestone target was adopted. Nevertheless, the target year 2025 sets a higher pace to reduce the losses, compared to the sdg 12.3 that aims for 2030.[50]

48 The Swedish Board of Agriculture 2020:3.

49 The generational goal states: The overall goal of environmental policy is to pass on to the next generation a society where the major environmental problems have been solved, without causing increased environmental and health problems beyond Sweden's borders.

50 Government decision 20200625.

3.2 2030 Agenda

The UN Global Goals, which are part of the 2030 Agenda for Sustainable Development, consist of 17 global goals that aim to eradicate poverty and hunger, realize human rights for all, achieve equality and ensure lasting protection for the planet and its natural resources. The Global Goals balance the three dimensions of sustainable development: the economic, the social and the environmental. Goal 12 Responsible Consumption and Production aims to ensure sustainable consumption and production patterns. Target 12.3 states:

> By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses.

The Food and Agriculture Organization of the United Nations, FAO, defines *food loss and waste* as the reduced quantity or quality of food in the food chain. They delineate it based on where in the food chain it occurs, of which *food losses* occur from harvest up to, but not including, the retail level. Food waste is in turn what arises at retailers and consumer level.[51]

Food losses according to Target 12.3 shall be measured and followed up with an indicator, a so-called Food Loss Index (FLI). The recommendation from the FAO, which is responsible for compiling a global food loss index, is that each country selects ten of the most important raw materials and reports losses in their production flow from primary production up to, but not including, the retail level. Even if losses during harvest and slaughter are not included as part of the Food Loss Index that is reported globally, the FAO recommends that the national level also monitors losses that occur at harvest/slaughter/catch. The explanation for why the FAO has chosen not to collect data for these losses is that they cannot be obtained from the FAO's Food Balance Sheets[52], which are the FAO's main data source for calculating FLI globally today[53].

There is also an indicator for food waste in supermarkets, restaurants and at the retail level – the Food Waste Index (FWI). The demarcations between the FLI and FWI from a value-chain perspective are illustrated in Figure 4.

51 FAO 2019.

52 Food balance sheets show data on different countries' food systems, primarily concerning production and food supply.

53 Fabi 2020.

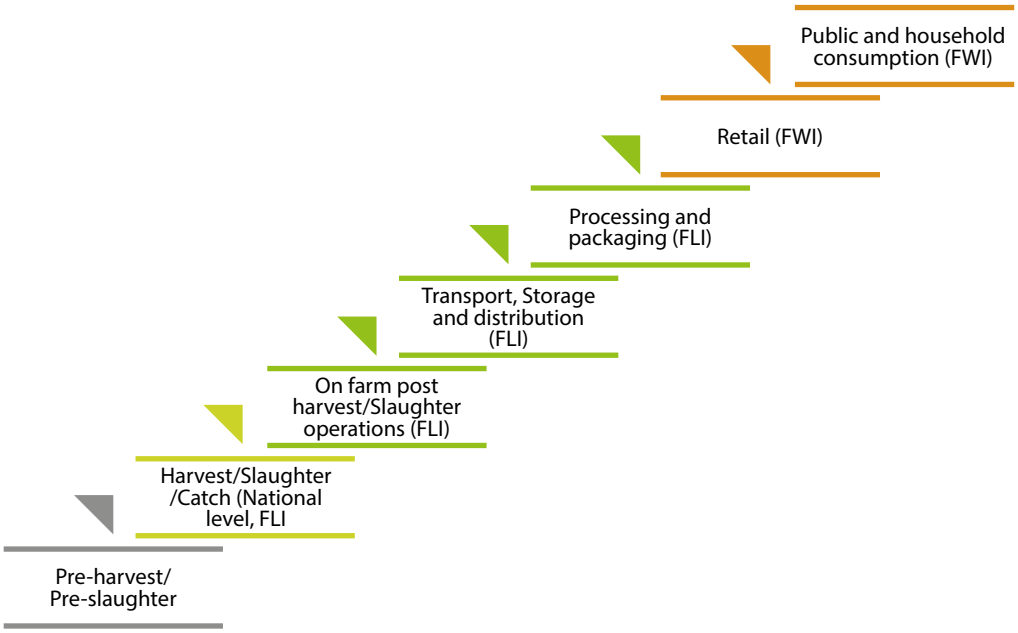


Figure 4. *Demarcations for the Food Loss Index (FLI) and the Food Waste Index (FWI). Grey= falls outside target 12.3, Green FLI, (Light green, only followed up nationally, not globally), Orange =FWI. Source: FAO.*

The Food Loss Index, FLI, includes all quantities of crops, livestock and fish intended for food that directly or indirectly leaves the food chain following harvest/slaughter/catch by being incinerated or otherwise discarded (for example, left in the field) and does not enter other product chains (such as animal feed, other industrial uses), up to but not including retail.[54] Losses that occur during production, storage, transport and processing, as well as imported products, are therefore all included.

Examples of industrial use include biofuels, fibres for packaging materials, bioplastics, materials such as leather or feathers, fats, oil, raw materials for making soap, biodiesel or cosmetics. Usage such as soil improvement and fertilizer is also excluded from the FLI and the FLW. Biogas production, on the other hand, is included in the FLI. The FLI is based on the ten most important raw materials in a country, based on production value, and must be selected at the national level within five product categories. These categories have also served as a guide when raw materials have been selected for the Swedish method presented in this report, see method in Chapter 1. The FAO further recommends that information on destinations (what is done with the losses that arise) and prices be collected in order to be able to obtain information on the qualitative losses at a later stage.

54 FAO 2019.

4 Background study – what we currently know

Measurements of food waste and food loss are an important part of creating a change at different levels in the food system, but the purpose of the measurements may be different, which affects the choice of method. There are a number of methods for measuring food loss and waste in the food chain. From weighing or determining the number and volume, which is a more time-consuming, costly but also more specific method, to calculating mass flows and the difference in inflows and outflows. The latter is a simpler approach but at the same time not as specific. Different methods have their advantages and disadvantages.

Examples of the aims of the measurements are:

- To increase resource efficiency and profitability in a company
- To increase resource efficiency in the value chain
- To reduce environmental impact
- To monitor trends over time and benchmark your own company against other companies
- To gather information on what measures are needed to reduce food loss and waste in a sector, regionally nationally, or globally
- To increase a country's degree of self-sufficiency/increase the supply of food
- To create an evidence-based underpinning for political decisions
- To reduce the amount of waste and the pressure on facilities that handle waste
- To improve the financial situation of stakeholders in the food chain.

While at a company level it is important to be able to follow-up a change in real time, it is important at national level to have access to representative data that is of good quality.

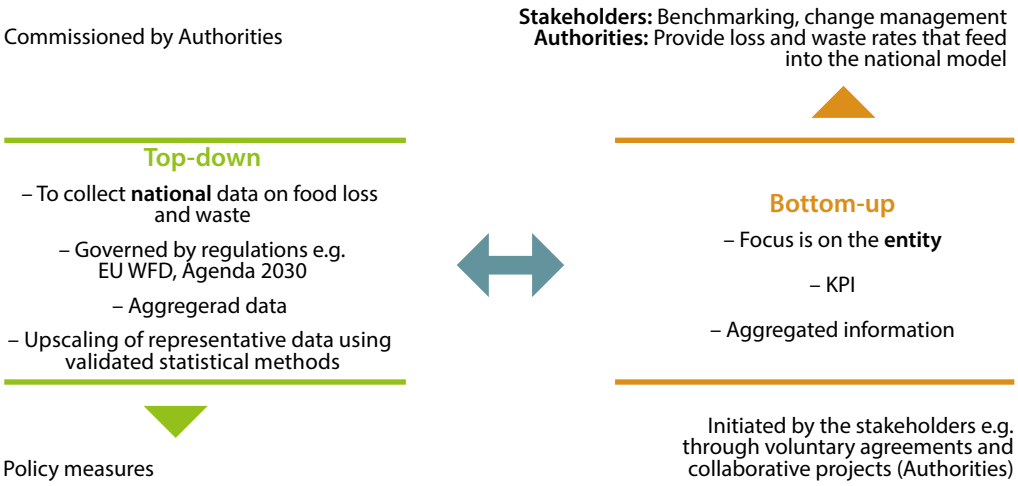


Figure 5. *The aim of the follow-up governs the choice of method. The different approaches complement each other for increased knowledge. Source: Karin Östergren, RISE.*

A method that describes national data should be based on a top-down perspective and, as far as possible, use existing data to be financially sustainable. However, local bottom-up studies may be necessary to supplement data gaps and to validate assumptions that have been made.

> *A large portion of humility and patience is an important ingredient in the work of following up losses in the food chain. It is always better to have approximations to begin with than no information at all. After that, it is always possible to gradually improve the data with regard to precision and accuracy.*

Quote from the background study conducted by Karin Östergren, Senior Researcher with many years of experience researching international food waste.[55]

Direct methods such as weighing, determining the number and volume are more expensive and more resource-intensive. For industries, packing plants and wholesalers, if equipment is in place in the form of sensors and scanners, these costs can still be affordable. Measuring crop losses in the field manually, on the other hand, is extremely resource-intensive. Experience also shows that self-reported data via surveys and interviews often give a lower value than when the measurements in the field have been carried out by an external expert. In primary production, there may be differences up to a factor of two[56] between self-estimated and actual data. The direct measurements give significantly higher values of the losses in the field compared with existing agricultural statistics. [57] An additional perspective on measurement methods is to measure losses before they arise, or with the recipient of the resource such as animal producers or animal feed manufacturers.

The choice of method for quantifying food loss and/or food waste depends on the aim of the measurements, what data is available and the resources available to produce new data[58, 59] . Table 1 below provides an overview of the recommended methods for following up stakeholders within food production.

55 Consultation report 2020.

56 WRAP 2019.

57 Johnson 2018.

58 FUSIONS 2014.

59 FUSIONS 2016.

Table 1. *Overview of methods for quantifying food loss and waste*[60, 61, 62]

	Method	Description
Direct methods	Weighing	The mass of food loss is determined directly.
	Determination of number	The amount of product is calculated based on quantity, and based on this, the mass is calculated. The quantity can be determined by counting the number, by scanning or by using visual scales. Visual scales for estimating the amount of damaged product in the field are included in this group.
	Determination of volume	The volume of the losses is determined, after which the weight is calculated
	Analysis of composition	Separate the desired category from a given mixed waste stream/ side flow to determine the composition. Usually referred to as "pick analysis".
	Verifications	Data that has been routinely collected and saved, often for other purposes (e.g. receipts, stock status, receipts for the disposal of waste).
	Diaries	Daily log of food losses and food waste and other information.
	Surveys	Collection of data on quantities including other information, e.g. about attitudes (motivation to reduce losses, why this particular product was rejected, etc.) as well as organisational and socio-economic aspects, etc.
Indirect methods	Mass balances	The amount of food loss is obtained by calculating the difference between inflows (e.g. ingredients, grain to a silo) and outflows, corrected with stock balances and weight changes due to processing (e.g. water content).
	Modelling	Using a mathematical model to study how the losses vary depending on different factors.
	Proxy data	Use of data from other facilities (e.g. data from other countries, other similar facilities to estimate the amount of waste at your own facility).

4.1 National follow-up provides an overall picture of the volume of food waste

Compared with many other countries, Sweden started keeping statistics on waste from the food chain quite early on.

The Swedish Environmental Protection Agency[63] has mapped the amount of food waste in Sweden every two years since 2010 and most recently in 2018.[64] In that work, the definition of food waste includes both avoidable food waste that could have been consumed and unavoidable food waste from the inedible parts of food that is expected to be discarded, such as fruit and vegetable peel, vegetables tops, bones and coffee grounds. As the definition of food waste has not been unambiguous in the past, it has been a challenge to produce data. The definition used for food waste has a major impact on how much of the

60 FLW Accounting standard.

61 FUSIONS 2014.

62 Stensgård 2017.

63 Measurements and compilations have been carried out by Svenska MiljöEmissions Data (SMED), which is a consortium within which the organisations the Swedish Environmental Institute (IVL), Statistics Sweden, the Swedish University of Agricultural Sciences, and Sveriges Meteorologiska och Hydrologiska Institute (SMHI) collaborate.

64 The Swedish Environmental Protection Agency 2020.

food waste and loss can be considered to be included in the national waste statistics. With a broader approach that covers all food loss and waste along the entire food chain, waste statistics need to be supplemented with additional information, such as on food loss at the beginning of the food chain and certain by-products from the food industry.

With the new interpretation of *food waste*[65], only small flows of food waste from primary production and the food industry are classified as food waste. One example is that the food loss that a primary producer sends to another stakeholder's biogas plant can be classified as food waste. But if it instead ends up in the producer's own biogas plant, compost, manure container, is left in the field or used as animal feed, it is not counted as food waste by the legislation, but can instead be considered a food loss.

By-products from the food industry that are not treated as waste (for example because they are disposed of as animal feed) are also not classified as food waste and are therefore not included in the statistics for food waste. It is estimated that large quantities of by-products are generated in the food industry, these are often used as animal feed, which is a resource-efficient market, but it would be better if, following processing or handling, they were included in food products. Improved statistics on by-products could lead to increased knowledge and efforts for both increased utilization for food purposes and increased animal feed use.[66]

To date, statistics on food waste have presented data for primary production from a Nordic study based on annual averages and estimates of food waste during the years 2010–2013. The Nordic study found that the losses in weight post harvest and slaughter were greatest in the production of vegetables, root vegetables and potatoes, followed by wheat and milk.[67] The statistics for primary production are starting to become outdated, are not recurrent and are partly based on enumerations and comparisons with other Nordic countries. Only losses after harvest and slaughter have been included in the food waste statistics. If data on losses before harvest and slaughter are included, according to the study, the losses in primary production are three times greater (295,000 tonnes compared to 98,000 tonnes).[68] A lot of work has been carried out over a number of years both nationally and internationally on food waste definitions and there is therefore reason to review how food loss and waste in the various stages of the food chain should be followed up.

The reporting that all Member States must carry out to the EU from the 2020 reference year only requires data on the amount of food waste. Furthermore, additional data on food donated or used for animal feed can be reported voluntarily to the EU. One development of the food waste statistics prior to the

65 Directive 2008/98/EC.

66 The Swedish Board of Agriculture 2020:4.

67 Franke et al. 2013.

68 Franke et al., 2016.

first reporting is ongoing and is being carried out by the Swedish Environmental Protection Agency and SMED, which has also been involved in developing the method presented in this report.

The Swedish statistics on food waste do not yet provide a complete picture of food loss and waste and what could have been used for food. Boundaries and definitions are of considerable importance for how the statistics are presented. A more comprehensive picture of food loss and waste also requires data on food loss, including losses prior to harvest and slaughter, by-products from the food industry as well as specific studies on the part of food waste that consists of edible items.

Depending on several different factors such as market demand, logistics, processing opportunities, a resource flow can in one instance become food as was intended, on another become animal feed and on a third become waste. The follow-up of food waste and food loss can therefore complement each other for a better overall picture of the quantities and causes of food loss and waste. The follow-up of food loss with the method presented in this report thus becomes an independent statistical follow-up from the food waste statistics. Together, the two statistical areas food waste and food loss complement each other for a more comprehensive picture of food waste in Sweden.

4.2 Studies show significant losses and resources as early as on the farm

The Swedish Board of Agriculture has also, within the framework of previous government assignments for reducing food loss and waste together with the Swedish Food Agency and the Swedish Environmental Protection Agency, produced studies with the following main conclusions:

- Of the Swedish beef production, both from dairy and beef cattle, nine percent of the meat (calculated by weight) does not go into food production. The losses are mainly due to animals that are over six months old dying or being put down on the farm. If we can reduce the losses in beef production, the climate impact of agriculture would be reduced.[69]
- Of the hens that are taken out of production, 33 percent do not become food. 5.6 million cockerel chicks are separated out, euthanized and turned into waste.[70]
- Trading standards have a limited impact on food waste in Sweden. Rather, it is the high demands of the trade and consumers that cause the greatest

69 The Swedish Board of Agriculture 2014:07.

70 The Swedish Board of Agriculture's report 2016.

waste. The waste in primary production varies between zero and about 30 percent.[71]

- One study of iceberg lettuce showed that 65 percent of the cultivated lettuce remains in the field at harvest. Growers feel that the demands for "perfect" products are becoming ever higher[72].
- Trading standards do not cause any major food waste from the Swedish fishing industry. The development of selective equipment, together with other measures, is expected in the long term to reduce the amount of fish and shellfish that cannot be sold as food because they are smaller than the established minimum size.[73]
- Nordic studies have estimated that around 300,000 tonnes from primary production (so called side-flows) do not go on to become food.[74]
- There is a need for better follow-up of food waste and residual products and what they are used for. When food loss and waste cannot be prevented, animal feed use is a resource-efficient alternative[75].

4.3 Measurements at the company level within the Swedish voluntary agreement for reduced food loss and waste - SAMS

Voluntary agreements between companies in the food chain with the aim of measuring and reducing food waste have proven to be a success factor when it comes to collecting data. There are good examples including Norway and Bransjeavtalet (The Industry Agreement)[76] and in the United Kingdom the Courtauld Commitment[77]. Stakeholders throughout the food chain work together to reduce food waste, and measurements at company level of both food waste and food losses, are central to being able to demonstrate and provide incentives for change. The aggregated data of voluntary agreements, or equivalent national research projects, are in many instances an important contribution to the authorities' following up and reporting on food waste. In several countries, the voluntary agreements give rise to their own national reports. Voluntary agreements are therefore an important source of data and method development when it comes to food loss as well.

In Sweden, a voluntary agreement for reduced food loss and waste, SAMS, was established in the spring of 2020. About twenty companies and organisations

71 The Swedish Board of Agriculture 2014:5.

72 The Swedish Board of Agriculture 2014:06.

73 The Swedish Board of Agriculture 2014:3.

74 Franke et al. 2016.

75 The Swedish Board of Agriculture 2020:04.

76 www.matvett.no.

77 www.wrap.org.uk.

are currently involved.[78] SAMS is run by the industry and the aim is to follow-up on the amount of food waste and food loss at participating companies. In 2020, measurement methods in the form of a so-called industry guide were developed for dairies, wholesalers and fish processing plants, respectively.[79] Data for food waste in the dairy and fish processing industries will therefore be compiled for 2020 and also made available for the authorities' national follow-up at the beginning of 2021. Subsequently, the intention is that measurements and compilations shall be made annually.

The hope is that more companies will join the voluntary agreement, but it is also possible that some of the companies that are not part of the agreement at least will start using the guide and may consider reporting data to the follow-up carried out by the authorities. The disadvantage of this, however, is that the companies that are not part of SAMS lose out on the industry-wide partnership, which is intended to accelerate the reduction of food waste for the participating companies. Working across industries and along the entire food chain reduces the risk of food waste being moved forward and backward between stakeholders in the chain.

So far, no companies in primary production have joined the voluntary agreement SAMS, but their perspectives and challenges are rather represented by their industry organisations such as the Federation of Swedish Farmers and Potatisodlarna (the Potato Growers). Thus, it is not possible to retrieve data on food loss in primary production from SAMS. The national follow-up with the method presented in this report will therefore be important for industry organisations and authorities that want to illustrate food loss in the discussions with stakeholders at a later stage.

4.4 How do other countries follow-up food loss?

In general, it can be said that knowledge about the quantity of food loss is limited in all countries, and especially in primary production. FAOs latest major report on food waste laso describes the need for more data.[80] Sweden has set a quite high ambition in terms of the aim of the authorities to measure food loss on a national level. This is shown by the consultation report carried out by RISE spring 2020 on behalf of the Swedish Board of Agriculture[81].

Finland has followed up on food loss in 2020 and also plans to carry out a survey study in 2021 aimed at primary production, which will also capture what goes on to be further processed as animal feed and for other uses.[82] The products they will be monitoring include wheat, oats, rye, potatoes, sugar beet, tomatoes,

78 www.ivl.se.

79 Östergren et al. 2020.

80 FAO 2019.

81 Consultation report doc. no.: 4.5.17-03596/2020.

82 Hartikainen et al. 2020.

cucumbers, carrots, and strawberries, as well as beef, pork, poultry, chicken, eggs, fish (wild-caught and farmed). Data for cereals, fruit and vegetables, and milk have been collected through surveys, while data for meat, eggs and fish are followed up using agricultural statistics. Finland monitors both the inedible and edible proportion as well as what is left in the field.

The food industry in Finland is followed up through a survey conducted by industry associations. They collect data for fourteen products in seven categories: meat and convenience foods, flour and starch products, bread, fruit and vegetables (processed), dairy products, beverages and the category other (sweets, coffee, ready meals and sugar, with a focus on both the inedible and edible proportion).

To date of the review, Norway has not collected data on food loss systematically in primary production, however, there is a proposal for a method developed in collaboration with the authorities and the industry. Their voluntary agreement for reduced food loss and waste, Matvett (Food Sense), has carried out a pilot project with the aim of developing a proposal for a method within Bransje-avtalet[83] (the Industry Agreement), which is then intended to also be used for reporting national data. A first proposal for methods based on the pilot project was published in 2019[84]. Matvett collects data from the food industry for the edible proportion of food waste and food loss (animal feed and further processing). However, food loss is not reported separately. The product categories that are followed up include: Bread, Fruit and vegetables (processed, frozen) and vegetables (fresh), Meat, Seafood, Eggs, Dairy products, Staples, Canned food, Beverages. In wholesale operations, statistics are collected for cakes and pastries, liquid dairy products, packaged fish, beer and mineral water.

In Denmark, there has been a voluntary agreement for reduced food loss and waste since 2019.[85] In 2020, a programme was planned in Denmark to follow-up food loss in agriculture and the fishing industry through interviews. The methodology was developed by PlanMiljö.

Germany has published national data for 2015: including method descriptions.[86] In primary production, there are studies on lettuce, carrots and strawberries as well as apples[87]. The methods that have been used are[88]:

- Primary production: Direct measurements, agricultural statistics
- Industry: Direct measurements, surveys, statistics
- Trade, wholesale, and distribution: Direct measurement methods, scanning

83 Ostfoldforskning 2018.

84 Ostfoldforskning 2019.

85 Website for Denmark's voluntary agreement.

86 Thuenen 2019a.

87 Thuenen 2019b.

88 Thuenen 2019a.

The United Kingdom WRAP[89], which leads the United Kingdom's voluntary agreement, has based its work on food losses in primary production on a mixture of its own data and proxy data[90]. The products that were studied in detail were for example iceberg lettuce and strawberries.

Within research and in the voluntary agreement, WRAP works within the industry collaboration the Courtauld Commitment 2025 with all parts of the sector, including agriculture, but also quantifies the amount of food losses. WRAP works actively to get more companies such as industries and supermarkets to send surplus food to become animal feed as an alternative to waste management. For example, bread that is approaching its best-before date.

The Netherlands has been quantifying food loss since 2018 as part of their national partnership project[91]. It involves questionnaires, but funds have also been sought to carry out farm surveys. For the industry, the loss for the different types of handling, such as for animal feed or biogas, has already been registered for the participants in the project. Animal feed data are obtained primarily from the feed statistics of the animal feed manufacturers' organisations[92]. In terms of methods, the researchers' recommendation for primary production is to use surveys in combination with measurements in the field for the most important products. In other respects, it is believed that it is important to use adapted data formats for different value chains and to focus on measuring at the stakeholder level and less on collecting national data.

89 The Waste and Resources Action Programme (WRAP).

90 WRAP 2019.

91 Website for the Netherlands partnership project.

92 Wageningen 2013.

5 National method for following up food losses

The methods comprise a description of the eight different product flows for *pork, beef, milk, fish, wheat, potatoes, carrots and strawberries*, and how they should be followed up from primary production up to, but not including, the retail level. In order to get a complete picture that provides the greatest knowledge about the losses and resources within food production, the method is not primarily about evaluating and excluding different flows, but about quantifying and describing what was intended to be food but which is not, and how it is being used instead. Chapter 1.3 describes how the products were selected, as well as definitions and demarcations for the methods. The methods are also presented in table format in Appendix 1.

The assignment for the researchers at SLU was partly to examine existing statistics but also, if necessary, to propose methods at a more advanced level that involve further investigations. Examples of existing statistics are animal registers, official statistics, industry programmes that the authorities have or are given access to. Following the examination of the statistics, it turned out that there are more existing statistics on animal production than for vegetable cultivation. The methods therefore also include the collection of new data such as via interviews, surveys and measurements in the field/on the farm. For companies that provide data, it can be important to anonymize data and that data are presented at an aggregate level.

The starting point for the methods was to be able to convert the data into national data as far as possible. It would have been easier and probably cheaper to send out surveys to a random sample of producers, which would have provided a sufficiently large statistical basis. At the same time, this was weighed against being able to obtain data of sufficiently good quality that also say something about the causes of food loss so that it is possible to remedy them. Studies conducted by the food waste organisation WRAP in the United Kingdom also show that there is a risk of using surveys as self-reporting can lead to an underestimation of food loss. Another important condition is not to burden the companies unnecessarily with the submission of data, and surveys can be perceived as burdensome as the companies already answer a lot of questions in different surveys. Measurements carried out at the companies provide more reliable values but on the other hand they are costly. At the same time it can have a greater effect and provide an increased incentive for implementing the measures for the companies that conduct the measurements.

For several product categories, the proposed methods are based on data from industry and advisory programmes, but also newly collected data. This presupposes continued good collaboration, where authorities and industry organisations work together to increase knowledge in this field. Better statistics are not an end in themselves but a basis for change. Continued work and

collaboration is required throughout the food chain so that measures and efforts result in more raw materials from food production becoming food. The method must be able to be used for follow-up starting in 2021 and at least for the milestone's final year 2025. The aim has been to present methods that utilize resources at a reasonable level within both companies and authorities, while at the same time providing sufficient knowledge and quality of the data produced.

5.1 A dynamic method that can be developed over time

Figure 6 shows that the methods are based on both simple and advanced data and that the method can be adjusted and changed over time. There is a lot of ongoing work and initiatives in the field, such as research and innovation, new technology, and digitalization as well as various investments in sustainable food and food supply. This could generate more accessible data for future follow-ups. Industry stakeholders are also working on the issue, such as several in the newly started voluntary agreement for reduced food loss and waste - SAMS see Chapter 4.3), which, among other things, deals with measurements at the company level. As SAMS expands with more members, more data on at least the food industry can be retrieved from this.

The method presented below should be seen as a dynamic tool to start with and over time adjust, improve and, if possible, expand to include more products. In addition to the method for the eight selected products, additional products can be added if there are resources to follow them up and if there are additional statistics that are easy to add. In addition to following specific products, the method can also be supplemented with data that show the development of various factors that cause food loss, or that show the development towards greater utilization of food.

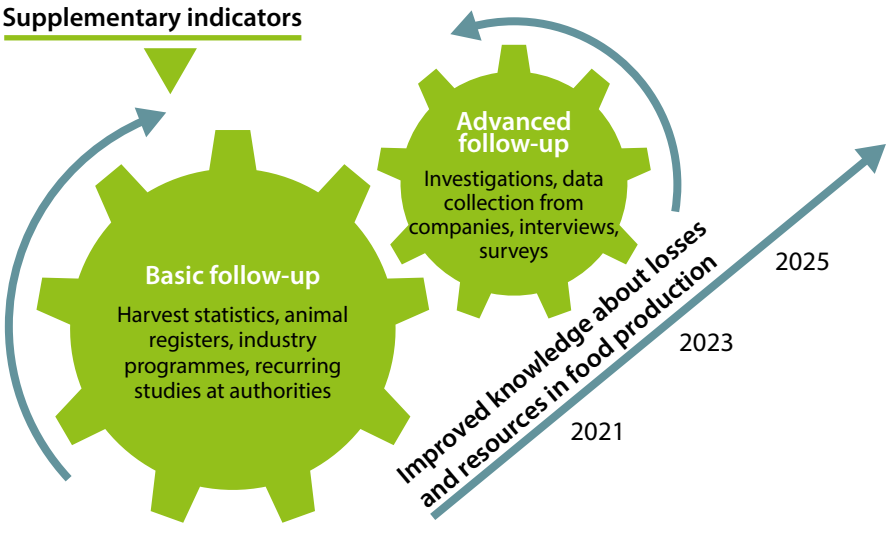


Figure 6. *The method is dynamic and can be adjusted and changed over time for better quality. Source: The Swedish Board of Agriculture.*

5.2 Beef and pork

Beef production

About two thirds of Swedish beef production comes from dairy cattle from milk production, and one third of beef comes from beef cattle from suckling calf production. From milk production, it is cows but also bull calves that are bred as bulls or steers in the dairy herds, or sold to specialized breeders of young cattle. Most of the heifers go into milk production. From the suckling calf production, bulls, steers and heifers are raised for slaughter. It is common for them to be kept in the calf herd for further rearing for slaughter or to be sold to a specialized breeder of young cattle.

The dairy farms slaughter different categories of animals, where the largest group consists of cull cows, i.e. cows that no longer produce the desired amount of milk or that cannot become pregnant again. The second largest group consists of bull calves that are slaughtered at about 18 months of age.

From suckling calf breeding, bulls, steers and any heifers that do not go to renewal of the herd are bred for slaughter. Older cows are also slaughtered in this type of production, especially when they cannot become with calf again.

Home slaughter means that animals are killed on the farm and that the meat is used within the household. On dairy farms, home slaughter amounts to just over 3 percent of commercial slaughter, while on beef farms it is slightly more common at around 5 percent. It is mainly older female animals aged over 24 months and younger male animals that are slaughtered on the farm.

Losses in beef production arise when animals die or have to be put down on the farm, and the producer is not able to benefit from the meat through home slaughter. Animals can also die during transportation to the abattoir, but this is very unusual. An earlier study of Swedish beef production with data for 2012 showed that 22 percent of the animals were lost at the farm level when they were stillborn, died a natural death or were put down, if the number of slaughtered animals is used as a reference value. The largest group of animals that did not progress in the food chain were those over six months of age. In summary, the losses amounted to nine percent, related to the carcass weight. The climate value of the lost meat was 220,000 tonnes of CO2e/year, which is about twice as much as the climate impact from soy feed for Swedish dairy and beef cattle.[93]

Pork production

Primary production of pigs can be divided into slaughter pig and piglet production, respectively, or into the suckling phase (during suckling), the growth phase (approximately 10–30 kg) and the fattening phase (approximately 30–115 kg). Mortality in piglets is around 18 percent during the suckling phase, 2 percent

93 The Swedish Board of Agriculture 2014:07.

during the growth phase and 1.5 percent during the fattening phase. From the primary producer, the pigs are transported to the abattoir and pigs can die during transportation, but this is unusual.

In Sweden, approximately 2.5 million pigs are bred annually for slaughter and in 2018, 2,646,040 pigs were slaughtered, corresponding to 249,790 tonnes of meat. These statistics only include meat that is approved for human consumption at the abattoir. Animals that do not go to the abattoir, or animals/carcasses that are not approved for slaughter at the abattoir are therefore not included in these statistics. When the conversion from animals to kilograms of meat takes place, inspected slaughter animals are converted to quantity of meat (including bones) approved for human consumption.

The slaughter of beef and pork

Upon arrival at the abattoir, the animals are inspected, so-called live animal inspection. If the inspection shows that an animal does not meet the requirements, it is put down and destroyed. In order to be approved for slaughter, the animals must be healthy and correctly identified.[94]

After slaughter, the carcass and organs are also inspected, and animals may be completely or partially rejected. According to calculations of pig slaughter from 2000–2009, the losses in the form of completely rejected animals accounted for about 0.5 percent of the total carcass weight. Of all slaughtered pigs, 25 percent were partially rejected. A large proportion of cases of partially rejected animals concerned only the lungs and other internal organs. Even if there had not been any remarks by the veterinarians performing the inspections, the lungs and other internal organs would still not have had any great potential to be sold as food, at least not at present. The carcasses of partially rejected pigs weigh, on average, one percent less than the equivalent for healthy pigs.[95]

For beef cattle, the carcass constitutes about 50 percent of the weight of the live animal, while for pigs the equivalent is about 70 percent. Of the parts that do not constitute the carcass, however, several are usually used for food, such as certain organs, the tail, fat, etc. But there are more parts of both cattle and pigs that could be used for food, at least for export to markets with other types of demand. What cannot be sold as food can often be used as animal feed or sent for further processing as technical products. Other areas of use are the production of biofertilizer and biogas, as well as biodiesel. Many of these products are classified as animal by-products and must be handled according to specific rules.[96] For so-called specified risk material such as skulls, brains, eyes and spinal cords from cattle over 12 months, due to the risk of transmission of infections that can cause TSE diseases (such as mad cow disease), special requirements for disposal are required and it is usually burned.[97]

94 Regulation (EU) No. 2019/627.

95 The Swedish Board of Agriculture 2020.

96 Regulation (EC) No. 1069/2009.

97 Regulation (EC) No. 999/2001.

What different products are used for depends on demand but also on access to equipment/handling and logistics. From pigs in particular, parts that we do not normally eat in Sweden, such as the tail, snout, ears, fat and rind, are exported to markets where there is demand. Very little blood is used as food.

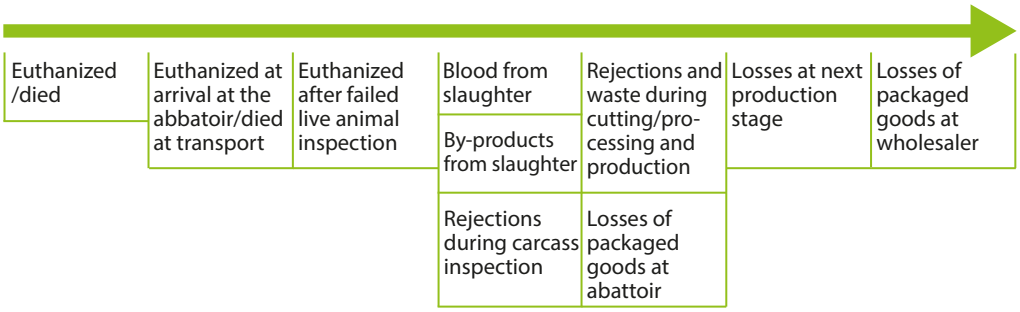


Figure 7. *System description of food loss in the production of pork and beef for each link in the chain up to the stage before the supermarket. The present method covers losses up to and including the abattoir. Source: SLU.*

5.2.1 Method pork and beef

Stakeholders

Follow-up will be carried out primarily at the point of primary production, during transportation to the abattoir, and at the abattoir.

5.2.2 Procedure

Beef production

The follow-up in primary production will be carried out by retrieving data on the number of animals that died a natural death/were put down from the Central Register of Bovine Animals (CDB), where all beef producers report their animals.[98] This data then needs to be converted to lost carcass weight. The recalculation is based on annual carcass weight statistics from the advisory organisation Växa, which are available for different breeds, sexes and ages, which are then matched with corresponding data from CDB.

To make the calculation, two main breed groups should be created: one for dairy breeds (breed code 01-06 in CDB), and one for beef breeds (breed code 07-99 in CDB *other breeds*). For each breed group, the number of animals with the different outcomes should then be added up; died a natural death/put down with *carcass disposal* (code 7), and *non-disposal of the carcass* (code 8), which can then be linked to age groups and sex. Weights for these groups can then be calculated for each breed/sex/age group based on statistics from the

98 The Swedish Board of Agriculture is responsible for the Central Register of Bovine Animals (CDB).

advisory organization Växa on carcass weights. This means that the number of animals lost can be converted to lost weight, which can ultimately be summed up to a total. This total lost weight can then be related to total produced weight according to official slaughter statistics, so that a percentage for beef losses in Sweden can be presented.

The age groups used in the calculation can be based on the monthly groups in the table below. Possibly the upper age groups such as 48–84 months can be added together as there is probably not much difference in weight in adult animals, although they can be used separately for understanding the pattern of losses at different ages, leading to insights about the underlying reasons.

Table 2. *Age groups, in months, which can be used to determine the weight of the losses.*

The animals' age groups in months	
Stillborn	24–36
< 1	36–48
1–3	48–60
3–6	60–72
6–12	72–84
12–18	< 84
18–24	

Losses during transportation of cattle were described in the 2014[99] report on beef losses as minor. These losses are reported to the CDB as put down/died a natural death and are therefore included in the total figure which also includes primary production.

Pork production

For pig production, the follow-up is carried out using averages from the production follow-up programme WinPig, which is provided by the advisory organization Gård och Djurhälsan (Farm and Animal Health). The data is presented in aggregate form over the proportion of deaths during rearing, divided between the suckling period, growth period, and fattening period.

Currently, there are no official compiled and public statistics for pig mortality during transportation to abattoirs but a report from Statistics Sweden in 2012[100] showed that the mortality of pigs at transport to abattoirs is very low, about 0,00028 percent.

The slaughter of beef and pork

Follow-up at the abattoir is carried out by means of the Swedish Food Agency's statistics on the number of rejected animals during live inspections, as well as the number of rejected carcasses and rejected animal parts over 10 kilograms,

99 The Swedish Board of Agriculture 2014:07.

100 Statistics Sweden. Djurhälsa och läkemedel 2012.

which can be obtained at an anonymized and aggregated level from the Swedish Food Agency. Rejected weights can then be calculated from the Swedish Board of Agriculture's own standard values of weights in cattle and pigs. Based on this, the weight of the losses can be set against the Swedish Board of Agriculture's statistics on slaughtered animals so that a percentage can be produced.[101]

For pigs, the number ofrejected animals and rejected carcasses, can also be calculated on the basis of averages in the WinPig production programme[102, 103].

Currently, no official statistics are reported regarding how different parts of the animals are utilised as food versus non food. In the environmental reports from the abattoirs, on the other hand, there is some information, but this is voluntary data and the companies present it in different ways. According to SMED,[104] there is often data about the amount that goes to biogas or animal feed, but there is no information about which parts of the animal that is usedfor different types of processing, it is usually designated as “carcass residues” or similar.

Information on the amount of food, food waste and other animal waste, as well as by-products that are sold/sent elsewhere from abattoirs is recorded by the abattoirs and should, if possible, be collected. This is based on the assumption that abattoirs want to provide this type of data to the authorities, and data probably needs to be handled with confidentiality and compiled into aggregated data. In such a survey, quantities and destinations of potential raw materials for food and other goods could be listed from each abattoir. The follow-up needs to include questions about infrastructure, contracts or sales of by-products for different purposes including export. The sale of different parts of the animal can thus depend on what provides the best payment at the time of slaughter and is based on market demand. Sometimes a raw material can be animal feed, sometimes it can be sold or exported as food to a market where there is a demand, and sometimes it becomes waste such as a raw material for biogas, or it is used for biofertilizer or biofuel. If any raw material alternates between different sales categories, several destinations need to be listed.

It would also be interesting to follow-up the flows at meat producers, i.e., the stage directly after the abattoir, if possible. Most of what does not go on to become food is probably classified as food waste and not food loss, which the current method is about, but is nevertheless interesting, as national statistics on food waste are not collected at that level of detail, neither at the product level nor at the specific level of operation. When meat products consist of a number of ingredients, several raw material chains merge, such as beef, pork and potato flour. This can complicate the breakdown by raw material. But it can still give an indication of the magnitude of the losses/resources, but such studies then require further dialogue with industry representatives and additional funding.

101 The Swedish Board of Agriculture, 2020.

102 WinPig 2020.

103 WinPig Support 2020.

104 Svenska Miljö Emissions Data (SMED) – Swedish Data on Environmental Emissions.

5.2.3 Demarcations

The method captures losses of animals and their corresponding carcass weight (the estimated weight of the carcass at time of death) as well as losses of carcasses and rejected animals at the abattoir, and as far as possible how different parts of the animal such as blood, edible organs and other parts are used. Products that can go to human consumption based on Swedish and importing countries food culture, but which do not do so due to lack of demand in the domestic or export market are included in the follow-up. Weight loss in the form of animal fluids or fluid in the meat is not included in this follow-up, as it is too detailed.

Home slaughter means that the producer slaughters animals on their own farm for consumption in their own household. This meat does not need to be inspected by a veterinarian, and cannot be sold. Home slaughter is not seen as a loss as the meat is consumed in the producer's household. The losses that can arise in association with home slaughter are not known. They are probably small in this context, as home slaughter of cattle constitutes about 3 percent of the commercial slaughter according to the Swedish Board of Agriculture's Central Register of Bovine Animals (CDB). Home slaughter of pigs is also considered to be very small. Therefore, home slaughter is not included in the follow-up.

5.2.4 Discussion

Since it is possible to obtain very much information about cattle losses from the CDB (age, sex, breed) and that all cattle in Sweden are included, it is possible to, relatively easily, acquire knowledge about the losses within beef production at the farm level. According to an earlier study from 2014[105] most of the losses occurred at farm level (blood losses not included), which would indicate that it is more important to follow-up primary production compared with transportation and losses at the abattoir. One fact to take into account are that reporting still-born calves (including live born, but died within 20 days) is voluntary, so the proportion of these that are included in the statistics is not known. Another aspect is that losses during transportation to the abattoir and animals that are rejected at the abattoir are registered as having been put down/died a natural death in the CDB, i.e. they are included in the figure for the losses in primary production. Cattle that pass the live inspection, but where the carcass is then discarded, are counted as slaughtered in the CDB. Approved carcasses are reported to the Swedish Board of Agriculture, and constitute the basis for official statistics on Swedish beef production.

Regarding the follow-up of pigs, the method is expected to give an approximate estimate of the magnitude of food loss within pig production, albeit a rough approximation. Information about the losses in primary production is followed up in the form of mortality, which is reported in the production follow-up

105 The Swedish Board of Agriculture 2014:07.

programme WinPig. Every year, parts of these averages are reported publicly, divided into sows, fattening pigs and piglets separately. WinPig includes about 40 percent of Sweden's primary producers[106] and is the single largest production follow-up programme within primary production. This is deemed to give a sufficiently representative picture of Sweden's pig production. Increasing the data sets in primary production, for example by asking questions in association with veterinary visits or the like, would have increased the certainty of the estimates and would also have provided information on the causes. However, surveys or interviews are time-consuming and at present the representation provided by WinPig is considered sufficient to be able to follow developments and to scale up to national statistics.

WinPig is based on self-reported data, which can be a source of uncertainty. The averages that are reported publicly also only include growing animals, but growing animals account for 95 percent of the slaughtered weight of pork[107], and obtaining information about other animal categories would provide a marginally increased amount of data. Corresponding public information about sows and other breeding animals is lacking, but is available at Gård och Djurhälsan, which is the company that compiles the WinPig averages in Sweden. Previous research results show that 49.9 percent of Swedish sows are culled every year.[108] Of the herds that report to WinPig, 16 percent of the culled sows did not go to slaughter in 2019 and these thus became part of the food loss.

Regarding the slaughter of both cattle and pigs, a large proportion of the statistics needed to follow-up losses, such as the number of rejected animals, completely rejected animals and partially rejected animals over 10 kilograms, are already collected by the Swedish Food Agency. Therefore, this can be easily retrieved for this follow-up. However, there are no official data from the authorities regarding organs that could be expected to be consumed, or other animal parts for which there is little or no demand in the Swedish market (but which could go to human consumption in other markets) as well as blood.

In a circular and resource-efficient economy, it is of the utmost importance that we take good care of the resources that have already been produced. There is a lot of work being carried out at many abattoirs to optimize the sale of the entire animal, but there may be potential for further product development and export. Thus, the potential to obtain data from the abattoirs, either through their industry organisations or through direct contact with the abattoirs themselves, is something that is important for the follow-up. The abattoirs probably already collect this data themselves and have information on the different parts from beef and pork that are sold, but there is a lack of public information about how food, by-products and waste is divided up, which would provide an overview. In terms of being able to process the entire animal, different conditions prevail in large and small abattoirs. Processing blood often requires an investment in a

106 WinPig.

107 The Swedish Board of Agriculture 2020.

108 Engblom 2008.

special vacuum-suction knife, which small abattoirs can rarely afford. They may also have a varying capacity to enter into agreements, where large abattoirs more easily reach the volumes that make it worthwhile to export, for example organs and animal parts that could be sold abroad or used for technical applications.

It is a matter of compiling data and arranging this in a similar way so that data from different abattoirs can be compiled into a whole. It can also be sensitive information because this is data about the business that companies conduct, and therefore confidentiality is important. Further discussions need to take place with the abattoirs about what such a follow-up might potentially be like. The Swedish Meat Enterprises Svenska Köttföretagen are positive about increasing knowledge about resources and flows that can be utilized more resource-efficiently at abattoirs, but the discussion about providing data should continue with the abattoirs[109].

In order to get a better picture of the losses, the weight of completely and partially rejected animals as well as the live weight during live animal inspections that are not approved could also be collected. Most abattoirs probably have that information, at least for partially rejected animals over 10 kilograms. In order to gain knowledge that would enable loss prevention, data on the reasons for animals failing live animal inspections, as well as of completely and partially rejected animals could also be collected. However, as these data may require special studies, this is not suggested in this follow-up, but may be interesting to keep in mind when developing the method and for future research studies.

Even if home slaughter, when the producer slaughter animals on their own farm for consumption in their own household, has not been included in the method, but is calculated using a template, it would be beneficial to gain further information about home slaughter and how important it is as a loss- and waste reduction measure. This is to evaluate whether and how home slaughter can be facilitated and expanded so that more animals that would otherwise have been disposed of are utilized. It could possibly be an interesting topic for a dissertation or similar undertaking. In association with such a follow-up, it would be interesting to find out if more animals could have been used if the rules had allowed more people than just the producer's household to consume the meat.

Further discussion is needed with the abattoirs and their industry organisations regarding how data collection for the production stage after primary production could be carried out.

5.3 Milk

In the production flow of milk from the farm, transportation of the milk to the dairy and the processing of the product at the dairy plant, food losses occur

109 Personal statement, Theres Strand.

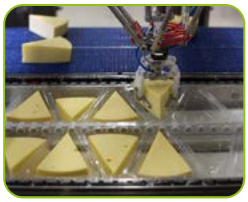
almost exclusively on the farm and at the dairy. The figure below gives an overview of the flows and the possible causes.

Primary production of milk, causes of food losses

- Ongoing treatment (antibiotics)
- Withdrawal period (antibiotics)
- Cleaning of milking equipment and tank
- Losses for other reasons (strange taste, contamination with antibiotics)

Transportation to the dairy, causes of food losses

- Strange taste of the milk
- Contamination of the milk in the truck with bulk milk containing antibiotic residues



Processing at the dairy plant, food losses vary between processes

- Consumption milk
- Fermented products; white water food loss
- Butter and other cooking fat; buttermilk food loss
- Cheese; whey food loss
- Milk powder
- Cleaning of equipment and silo

Figure 8. *Flow chart for milk and its processing at the dairy. Food losses occur almost exclusively on the farm and at the dairy, with losses being greatest at the dairy. Source: SLU and Jan Lindmark (cheese).*

For obvious reasons, not all of the milk produced on the farm is delivered to the dairy. Colostrum, i.e. the secretion which a cow produces in the first days following calving, cannot be delivered to the dairy due to its deviating composition. Colostrum is vital for the new-born calf; high levels of immunoglobulins in colostrum give the calf passive immunity during the first few weeks of its life. The calf is fed for the first six to eight weeks with whole milk, or alternatively some form of milk substitute (powdered milk) until it only eats roughage and concentrates.

About 10 percent of all dairy cows suffer from acute mastitis at some stage during a given year and are for this reason be treated with antibiotics.[110] Of all the countries in the EU, Sweden uses the least antibiotics for food-producing animals.[111] This is due to extensive and successful work with animal welfare and infection control. Furthermore, antibiotics can only be used in Sweden to treat sick animals. Milk from cows undergoing veterinary treatment, as well as milk produced during the subsequent withdrawal period, cannot be delivered to the dairy and should not be used to feed calves as this can have an adverse effect on the calves' intestinal flora. The bulk tank milk on the farm is regularly tested for the presence of antibiotic residues within the framework of the dairies' quality programme for milk. If antibiotic residues are detected in the milk in a bulk

110 Växa 2020.

111 EMA 2020.

tank, a follow-up takes place, and the producer cannot deliver milk to the dairy until a negative result has been obtained. A producer can also be stopped from delivering milk if it is discovered that the milk has an uncharacteristic smell/taste, for example milk that is affected by so-called blueberry taste.[112]

Milk from farms is normally collected every other day. In connection with the collection, a sample of the milk is taken from the bulk tank, and this is used for analysis of various quality attributes at a certified milk assessment laboratory. If the milk in the bulk tank does not conform to quality standards e.g. if it is contaminated with antibiotics residues, then the milk in the milk truck is also at risk of being contaminated. This is unusual and some dairies use preferential treatment, i.e. give the producer a certain amount of payment for the contaminated milk, if they report that milk from a cow undergoing treatment ended up in the bulk tank.

Upon arrival at the dairy, a sample of the milk truck's contents is also taken. This milk sample is used for various analyses, the analyses carried varying between dairy cooperatives. However. It is common that the milk truck is tested for presence of antibiotic residues.

Furthermore, each dairy silo must be analysed for antibiotic residues before the milk goes into production. If the result is positive, the milk in the silo cannot be used for food.

At the dairy, the milk is processed into various products, which can be divided into fresh products (consumption milk and fermented milk products), butter, cheese and powdered milk. In some of the processes, larger side streams occur, such as whey in cheese production, and buttermilk in butter production. In many instances, whey and buttermilk are used in food products, whey is for example used in health drinks and buttermilk powder is used in the manufacture of ice cream. Whey can also be used for pig feed. Whey is increasingly fractionated into a protein part that is used as a food ingredient and a lactose part that is used as a food ingredient or becomes biogas. According to the food resource hierarchy, (see Chapter 2.4) it is desirable if by-products can firstly be used as food, secondly as animal feed and thirdly recycled into energy, fertilizer or fuel. Opportunities to utilize side-streams differ between dairy plants depending on logistical circumstances, access to processing equipment and demand.

In the production of fermented milk products such as sour milk and yoghurt, which are often flavoured with a variety of jams, losses occur in the form of so-called white water. White water consists of product that must be flushed out of the process line before the production of the next product can be initiated. The volume of residual flows in the processing stage thus differs between products and between dairy plants.

112 Milk that tastes of blueberries cannot be delivered to the dairy. There is still no evidence-based explanation for the problem, which is suspected to be related to disturbances in the cow's metabolism and negative energy balance. Research is ongoing at SLU in collaboration with several dairy associations and advisory organisations to remedy and prevent the problem (2021-).

5.3.1 Method milk

Stakeholders

Follow-up will be carried out for primary production and dairies.

5.3.2 Procedure

Follow-up in primary production will be carried out using statistics from the Swedish Board of Agriculture regarding weighed-in milk at Swedish dairies[113], which is adjusted for the proportion of milk produced on the farm that is not delivered to the dairy and compared with statistics on antibiotic treatments in dairy cows of different breeds. The advisory organisation Växa Sverige compiles production data from herds throughout the country that are affiliated with their milk production programme Kokontrollen, and their report contains data on the proportion of milk that is delivered to dairies, just over 92 percent (2019).[114] The amount of weighed-in milk at dairies that is reported by the Swedish Board of Agriculture is thus adjusted by this percentage to reach the amount of milk that is actually produced on dairy farms. The milk that is not delivered to the dairy is thus about eight percent consisting of milk that is consumed in the farmer's household, direct sales to consumers and whole milk (including colostrum) for calves, and which in this method is not seen as a food loss. But part of the eight percent also constitutes food losses in the form of milk from dairy cows being treated with antibiotics that cannot be consumed as food.

The milk losses in primary production must in turn be estimated with regard to dairy cow breed (Swedish Holsein cattle SLB, Swedish red and white cattle SRB, Swedish Jersey cattle SJB, Swedish homless cattle SKB, and others) as average milk yield and treatment incidence differ between breeds. The number of cows belonging to each breed can be calculated by multiplying the proportion of cows of each breed[115] by the total number of cows in the country (according to the Swedish Board of Agriculture's statistics). The incidence of clinical mastitis and leg and hoof diseases in each breed[116] (i.e., the diagnoses primarily leading to antibiotic treatment) is then multiplied by the number of cows belonging to this breed. The number of cows treated with penicillin, tetracycline and sulfa-trimetoprim respectively can then be calculated on the basis of the proportion of treatments performed with the respective antibiotics in accordance with Table 3. The amount of milk which cannot be delivered to the dairy in connection to the antibiotic treatment can be calculated using templates for the total number of days (treatment + withdrawal period) [117], see Table 3. The discarded milk for

113 The Swedish Board of Agriculture's statistical database.

114 Växa 2020a.

115 Ibid.

116 Växa 2020b.

117 Personal statement, Karin Persson Waller, and Växa 2019.

each antibiotic and breed can be calculated by multiplying the number of cows treated by the sum of the number of treatment days and days of withdrawal, multiplied by the average daily yield for the breed. Templates for daily milk yield can be calculated on the average annual milk yield for the breed (the advisory organization Växa) divided by the standard lactation of 300 days. Finally, the discarded milk for the different breeds should be added up.

Table 3. *Templates for the proportion of antibiotic treatments that take place with different preparations and for the associated number of treatment days and days of withdrawal respectively (Växa, 20193).*

Antibiotics	Incidence	Percentage of antibiotic treatments	Treatment	Withdrawal period
	Per 100 cow-years	**%**	**number of days**	**number of days**
Beta-lactam antibiotics	11.24	88.1	5	5
tetracycline	0.8	6.3	3	4
sulfa-trimetoprim	0.72	5.6	3	4

Losses on the farm in the form of milk residue that remain in milking equipment, such as the tubing during cleaning or the bulk tank on the farm do occur, but in very small quantities. Today, high demands are placed on the milking equipment, e.g. it must be drainable with incline requirements so that the milk can flow down efficiently. The losses in the milking equipment are estimated to be very small in this context, about 0.06 percent[118], corresponding to 1.6 thousand tonnes of milk. These losses can therefore be disregarded in relation to this follow-up.

Regarding follow-up of food losses at the dairy, an industry-specific guide has been produced for how to measure losses at dairies within the framework of the Swedish voluntary agreement for reduced food loss and waste - SAMS.[119] The recommended method is based on mass balance regarding the dry matter content of each product stream. As an example, one can compare the amount of milk in products sold according to the recipes that are used for their production, with the amount of weighed-in milk, divided into skimmed milk and milk fat. The difference then constitutes milk waste at the dairy over a given period of time. The same approach can be used on other inputs at the dairy. Currently, the measurements are voluntary and initially two of Sweden's largest dairies, Arla Foods and Norrmejerier, were included in the partnership to set up the method. To find out more about (SAMS) see Chapter 4.3. The intention is that all Swedish dairies will be able to work according to the guidelines in the long term. Arla and Norrmejerier together account for about 74 percent of all weighed-in milk in Sweden[120], and scaling up their results to the national level should therefore be relatively reliable.

118 Personal statement, Henrik Idensjö.

119 Östergren et al. 2020.

120 The Swedish Board of Agriculture 2020b.

One alternative to using the aforementioned method to follow-up food losses at the dairy level would be to use the total weighed-in milk and the production at Swedish dairies together with the Swedish Board of Agriculture's conversion templates for milk equivalents.[121] This can then be used to calculate losses based on different residual flows,[122] which gives a very rough picture of the losses. Although this method would not meet the data quality required for a national follow-up, it can be an interesting comparison. The templates can be found below:

Whey is a residual flow in cheese production, 10 kg milk = 9 kg whey + 1 kg cheese.
Buttermilk is a residual flow in butter production, 20 kg milk = 2 kg cream (+ 18 kg skimmed milk) and 2 kg cream = 1 kg buttermilk + 1 kg butter.
Water in milk is released during the production of powdered milk, 6 kg milk = 1 kg powdered milk. As the water is put back upon dissolving the powdered milk , the water should not be included as a loss in the calculations and the powdered milk production should be excluded in the calculations.

5.3.3 Demarcations

In this follow-up, only milk that is discarded due to antibiotic treatment is seen as a loss in primary production. Whole milk (including colostrum) for calves does not count as a loss, as one must take into account that the milk is intended for the calf and that the calf needs the milk as nutrition during the early stages of its life. Milk that is consumed in the dairy farmer's own household as well as direct sales of milk and other dairy products on the farm is food and should of course not be seen as a food loss.

Food loss in association with the transportation of milk is not included in the follow-up as the loss is considered insignificant. All milk weighed in at the dairy is an edible raw material unless it is discovered that a dairy silo contains residual antibiotics.

At the dairy, the measurements are based on mass balance for the dry matter content, and the water losses that occur in powdered milk production are therefore handled by the method.

5.3.4 Discussion

The method is expected to give an approximate, but still sufficiently accurate, estimate of losses in both primary production and at the dairy. The biggest loss on the farm is milk that must be discarded in connection with the cows being treated with antibiotics. Efforts to keep the animals healthy and to use

121 The Swedish Board of Agriculture's statistical database.

122 The Swedish Board of Agriculture 2020b.

antibiotics very restrictively is already being carried out for several reasons in addition to reducing food losses. In addition to promoting good animal welfare and reducing the risk of resistant bacteria due to animals being treated with antibiotics, reduced food loss is an additional aspect to include as an argument for this important work. Calculations made when developing the method show that the proportion of losses in production is small. About 0.4 percent of the milk produced in primary production is lost. However, discarded milk corresponded to approximately 11.5 thousand tonnes in 2019, which shows that it is not an insignificant amount in total after all.[123]

The Swedish Board of Agriculture's production statistics on weighed-in milk at Swedish dairies are reliable and are used to calculate the amount of milk produced on farms. The amount of weighed-in dairy milk is adjusted using statistics from the advisory organization Växa, due to the fact that not all the milk produced on farms is delivered to dairies. These statistics are reported by the farmers themselves and should be seen as an estimate.

As the method is adjusted for differences in breeds in respect of the incidence of treatments and milk yield, the calculations of the volume of losses become more reliable. The cattle statistics from the advisory organization Växa regarding the amount of milk produced per cow is based on statistics from herds that are affiliated with the advisory programme Kokontrollen, herds that in total comprise 77 percent of dairy cows. As herds that are affiliated with Kokontrollen work preventively and obtain advice to reduce animal health problems, the calculations of the losses might possibly be slightly overestimated. The incidence of diseases that require antibiotic treatment could be greater in herds that are not affiliated with the advisory programme Kokontrollen, but it is difficult to adjust the method to account for this.

Regarding data from the Swedish voluntary agreement for reduced food loss and waste - SAMS, see Chapter 4.3), the statistics on food loss at dairies is expected to be very detailed. The advanced method for the dairy production will provide comprehensive data on the losses of protein and fat in the various product streams. Although cheese and butter production will always lead to residual flows such as whey and buttermilk, it is important to work to reduce losses of fat and protein in each product flow, and it is therefore important to be able to measure these correctly.

As the data from the dairies, despite covering a large proportion of Swedish production, only come from two major dairy companies, it may be important to conduct more studies that show food loss at smaller dairies and their ability to dispose of the flows that arise. The hope is that more dairies will eventually join the partnership and/or start using the same measurement procedure, and may consider providing data for the national follow-up.

123 Lund 2020.

5.4 Seafood

The total catch of seafood in Sweden, is is about 200 000 tonnes per year. This is partly pelagic fishing, in the open water, mainly of herring/Baltic herring, sprat, sand lance and mackerel, and partly demersal fishing, near the seabed, of species such as cod, haddock, saithe, plaice, shrimp and Norway lobster. Aquaculture, which involves cultivating species for human consumption, accounts for a small proportion of seafood production, approximately 11 kilotonnes/year in total or a carcass weight of 9.4 kilotonnes, where rainbow trout, arctic char and blue mussels dominate. Estimates from farms that require a permit show that the loss in the production stage of fish in aquaculture (died a natural death, sick, injured) is around 2–4 percent.[124]

Figure 9 shows quantities and flows based on official statistics and research studies. Of the total amount of seafood from Swedish waters, approximately 35 percent become gutted fish and shellfish processed for food, and approximately 5 percent is discarded or cleaned on board fishing vessels. The largest amount, about 60 percent, of the fish caught are fish for the production of fish meal and fish oil, and can be described as *planned feed production* (see definitions in Chapter 1), as it was never intended for food. Instead, it is intended to be animal feed, primarily for fur farming and fish farming (such as fish meal or fish oil). There are also other uses for fish meal and fish oil such as dietary supplements, and other types of animal feed.

There are several reasons why fish are used for purposes other than food. Firstly, the demand for human consumption is low relative to the supply of these pelagic fish species, which mainly go to animal feed production. Secondly, demand is affected by the dietary recommendations that the Swedish Food Agency provides to vulnerable consumer groups regarding environmental toxins such as dioxin and PCBs in fish. However, the fish that is used to produce fish meal/fish oil are purified in a process that renders them safe to use. The catch can also be damaged by sticklebacks, and some fish are too small to be filleted, which makes them more difficult to utilize. Another cause of food loss can be due to deficiencies in the refrigerated storage on board. Seals can also damage fish, which is a major problem in demersal fishing.[125] With demersal fishing, a larger proportion of the catch goes to human consumption, but it also has larger by-catches of unwanted species or unwanted sizes (too small)[126].

For quota species, all catches must be landed, that is, discarding substandard fish is not permitted nor is discarding catches below the minimum conservation reference sizes – minimum size, MCRS. Catches under the MCRS cannot be used for direct human consumption in accordance with EU legislation in the Common Fisheries Policy, but may be used for other purposes.

124 Personal comment W. Hansen.

125 Personal statement, Tore Johnsson.

126 Bergenius et al.. 2018

Fish for human consumption is gutted on board fishing vessels where the remains are thrown into the sea (this refers to demersal fishing). According to studies that have been carried out, this includes cleaning/trimming and discard of unwanted catches of non-quota species, approximately 5 percent of all catches of wild-caught fish and seafood[127, 128].

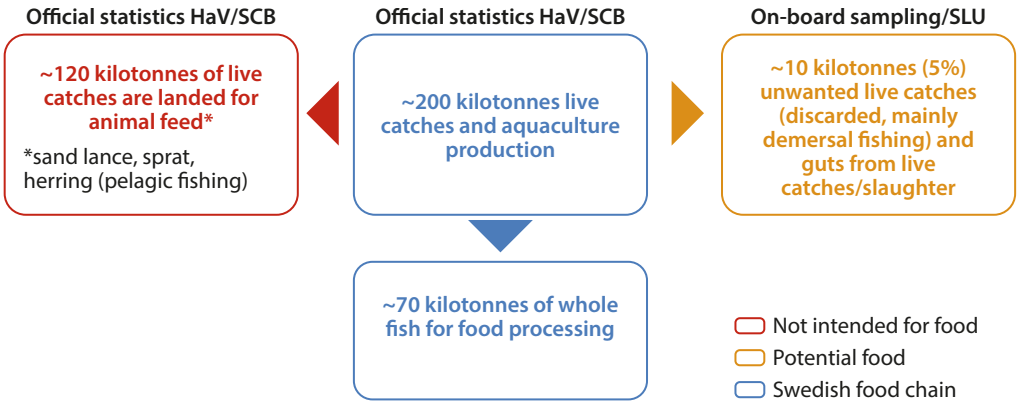


Figure 9. *Division of the total Swedish fish and shellfish production into different markets, exact figures vary from year to year. Explanation: The part that goes to the food production chain mainly includes whole fish. The red arrow indicates seafood that was never intended for food, the blue arrow indicates what goes on to become food and the orange arrow indicates what could potentially become food but currently does not enter the production food chain. Source: Bergenius et al.. 2018, Sundblad et al.. 2020*

Of the whole fish and shellfish from Sweden intended for food, mainly farmed rainbow trout and mussels are exported, but previously also cod.[129] When whole fish and shellfish are prepared for human consumption, the inedible parts are removed (bones, head, intestines and gonads, shells, scraps after filleting). How much is lost in the preparation depends on the species. Most is lost, up to 90 percent, in species where only the roe is used (vendace, lumpfish) and least is lost where the fish is resold whole (for example to smokehouses) where only the intestines and gonads are removed. Average calculations and key figures show that about half of seafood is lost during this stage.

127 Ibid.

128 Sundblad et al.. 2020

129 Cod fishing has been banned in the eastern Baltic Sea since 2019.

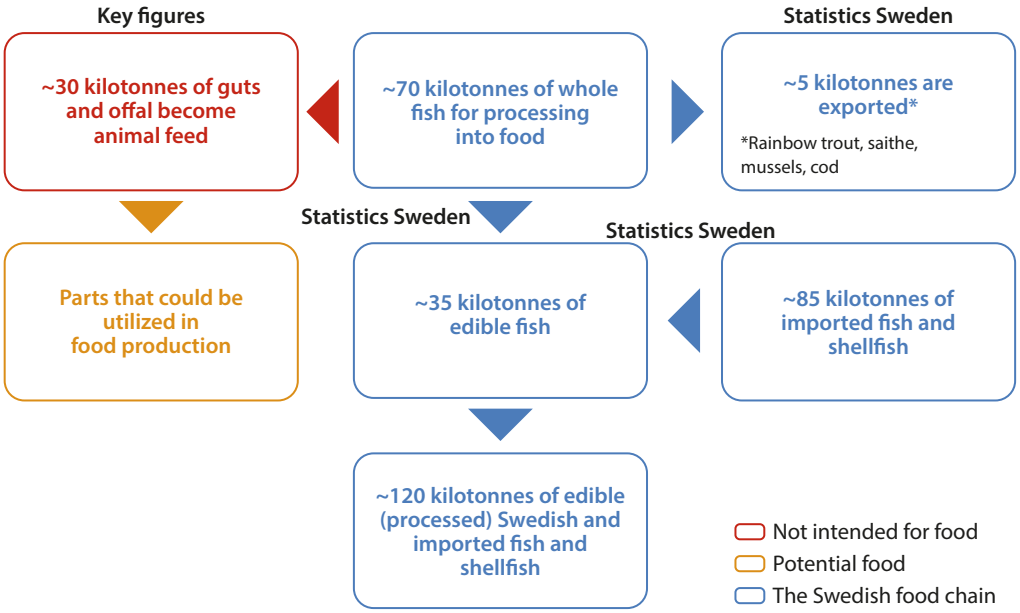


Figure 10. *Flow chart of volumes (biomass) of fish and shellfish in the Swedish food sector from whole fish to edible product, exact figures vary between years. Explanation: The red arrow/box indicates seafood that was never intended for food, the blue arrow indicates what goes on to become food. Most of the by-products go to animal feed, but the orange boxes indicate what could potentially become food, up to a third of the losses. Source: Bergenius et al.. 2018, Sundblad et al.. 2020, Ziegler & Bergman 2018. SLU.*

5.4.1 Method

Stakeholders

Primary production of seafood and preparation, processing/distribution.

5.4.2 Procedure

Public data on landed catches from commercial fishing shall be used and based on Statistics Sweden's compilations[130] based on data from commercial fishing logbooks and the wholesalers' contract notes.

Data are collected on discarded species not covered by the landing obligation. These species are identified, weighed and measured by independent observers who, at random, accompany selected fishing trips, representative of the fisheries with the largest amount of discarded catch. Data are normally collected for about 0.5–1 percent of all fishing trips for a given amount of fishing per year. Data are available via the SLU Department of Aquatic Resources[131] but probably need to be processed and compiled. In order to obtain an indicator of secondary flows at the producer level, the quota between live weight of consumer fish/shellfish over total catch/production, including undesirable by-catches, shall be used.

130 Statistics Sweden 2020.

131 Bergenius et al.. 2018

For aquaculture, it should be possible to obtain data on death, sick or injured fish from environmental reporting from fish farms that are subject to authorization from the County Administrative Board.[132] For mussel farming, how much of the total production that is not for sale is not reported.

Official data on discarded fish and by-catches can be supplemented with interviews/surveys with about 40 fishermen divided into approximately 10 of the pelagic and 30 of the demersal fisheries, as well as with the aquaculture farmers who are part of Matfiskodlarna. Results from surveys could provide information on the causes of unwanted catches and their experience of whether the unwanted catches are increasing or decreasing.

In the process stage, there are conversion factors between live weight and filleted or edible weight that the FAO has developed[133]. They indicate how much of the inedible parts are lost in the processing industry in the form of heads, bones, skin, etc. based on the total amount of landed and farmed fish and seafood. However, it is a very crude value and is not suitable for repeated follow-ups of side streams. For losses at the processing and wholesale level, there are currently no statistics available on losses or secondary flows at the aggregated level. One possibility may be the data on food losses that come from the Swedish voluntary agreement for reduced food loss and waste - SAMS , SAMS (see Chapter 4.3). Companies in the partnership promise to measure the losses within their operations in order to find effective action and then disseminate their experiences. At the end of 2020, however, only one fish processing company was involved in the partnership, so the data can hardly be used as national data.

If not more companies within fish processing join the partnership within the next years, or alternatively start measuring according to the method that the partnership has developed, and share that data, then there is need of supplementary monitoring. A survey should be designed and sent to processing companies. The survey can be designed with questions about how much is bought and what does not go on to become food in different segments (salmon/white fish/pelagic fish/shellfish) as well as reasons for losses, questions about the proportion that goes on to become food as well as the ultimate destination of fish, inedible parts of fish, etc. Inspiration and experience can be garnered from similar survey studies conducted in Norway.[134] Surveys can then be sent to 20–30 different companies, if possible in collaboration with Fiskbranschens Riksförbund (The Association of Swedish Fisheries).

5.4.3 Demarcations

The proposed method quantifies the flows of fish for the production of fish meal and fish oil, unwanted catches and by-products, even if all flows do not by

132 SMP Svenska MiljörapporteringsPortalen – Revision 928 (lansstyrelsen.se).

133 FAO 1989.

134 Carvajal et al. 2020.

definition constitute food loss. Fish for the production of fish meal and fish oil are not included in the method as a food loss but is still interesting to monitor in a resource perspective. An increased proportion could go to human consumption under other conditions such as adapted consumer advice or purification processes, larger sizes of fish, better selectivity in the catch, higher demand and less damage to the catch. The method therefore monitors the amount but does not report it as a food loss. It is primarily pelagic fishing for sprat, herring and sand lance where the catches go to the animal feed industry but also by-catches from demersal fishing.[135]

For the unwanted catch, there is potential to increase food use if there was higher demand or perhaps better distribution chains. We have therefore included these flows in the method, even though fishers cannot always influence the fact that there are unwanted catches Similarly, most of the inedible parts of the fish go to the animal feed industry, but technological development could mean that, in the future, parts of this could be used for food or dietary supplements (see discussion below). The inedible parts of the fish that currently become waste would, for example, have the potential to be used more resource-efficiently.

5.4.4 Discussion

The method for primary production in fishing is appropriate for monitoring the aggregate volume flow of fish and shellfish, but can be a crude method for studying the effects of measures to prevent food loss. Major flows are linked to animal feed production, and flows are due to changes in catch or demand rather than handling. Interviews or surveys with fishers are expected to provide some feedback on whether the quantities are correct, but above all will provide a better basis for the causes and challenges that exist and how these vary over time.

In the preparation, processing and distribution stages, data on food waste, including food loss and waste, are currently relatively unknown. There is a need for further discussions with the industry about how food loss and waste from fish processing can be followed up. Most of the by-products from these stages currently go to animal feed, or are anaerobic digested/composted. It is not the intention that bones, skins, shells, heads, etc. should become food, but it is still a resource that can be valuable to quantify and follow-up. Research and development may make it possible in the future to extract proteins and oils from by-products which can then be sent back to the food industry or used as health supplements/medicines.[136] Similarly, it is sometimes possible to export the parts that we do not normally eat in the Swedish market.

135 Bergenius et al.. 2018, Statistics Sweden 2020.

136 Ziegler och Bergman 2018.

According to industry representatives,[137] the processing companies are interested in the issue of food waste and resources, and it is likely that many of them measure their losses as there is an economical incentive to reduce loss. One major fish processing company participates in the newly established voluntary agreement for reduced food loss and waste (SAMS see Chapter 4.3), and uses the method developed by SAMS for measurement at company level. As more companies join the partnership, more data may be obtained from this source. Furthermore, it is possible that the methods developed through SAMS will also be available to those stakeholders who have chosen not to join.

At present, surveys of the processing companies are considered to be the most appropriate way of collecting data from the processing companies. However, surveys have their limitations as they are partly based on self-assessments and because questions can be misunderstood or interpreted differently. However, to easily obtain data, it might be the most accessible way.

5.5 Wheat

In primary production, food loss can occur during harvesting, transportation and storage. Furthermore, pre-harvest losses can occur when wheat cannot be harvested due to lodging, attack by pests or deer and other herbivorous animals, or disease. In 2014, 1.3 percent of the autumn wheat harvest and 2.1 percent of the spring wheat harvest were lost due to wildlife damage. Wild boar is the animal that causes most damage in most crops in Sweden except spring rape, where deer causes the greatest harm. This is a low proportional share, but in weight the wildlife damage amounts to around 35,600 tonnes of winter wheat and 7,300 tonnes of spring wheat respectively.[138] Growers also state that the damage has increased since 2014.[139] Wild boar cause the most damage in all crops except oats, where moose cause the most damage. Variations are generally considerable, both geographically and between crops, and according to Statistics Sweden, many farmers report no damage from wildlife damage at all, while others report that more than half of their harvest was destroyed.

The food loss during harvest and storage is small in relation to the production. Cereals have a low financial value in relation to volume, so if minor spillage occurs during harvest and storage, it usually does not have major financial consequences for the individual producer. However, as large volumes of wheat are grown in Sweden, the total loss across the country will still be quite considerable. In a previous study,[140] the losses during harvest were measured at 2 percent, but since the total amount of wheat produced is large, this means that up to 52,600 tonnes of waste is generated at harvest.

137 Personal communication with Jörgen Davenil.

138 Statistics Sweden 2014.

139 Personal statement, Gerda Ländell.

140 Franke et al. 2016.

The proportion of wheat that is milled or used as feed varies somewhat from year to year. This is due to the demand from the food market but also to the requirements placed on wheat that will be used as a raw material for bread or other food products. Protein value and falling number are examples of quality measurements according to which cereals are categorized and which can mean that wheat for food can be reclassified as animal feed if the quality levels are not achieved. Price also has an effect, in the event of a shortage of animal feed it can be more profitable to reclassify the wheat as animal feed. A five-year average of usage, shows that about 20 percent of the wheat goes to food purposes in Sweden, while the rest goes to animal feed, industrial purposes, seeds or export. In Sweden, about 20 percent is used for industrial purposes and just over 30 percent for animal feed, while just under 30 percent of the wheat produced is exported and a large proportion of this is for food purposes. This may mean that about 50 percent of the wheat grown in Sweden is used for food purposes.

Some cereal growers store their grain on the farm, while others send it away for storage. Storage problems such as mould infestation can thus occur either at the primary producers or at grain retailers. In the cereal trade, food losses occur in instances where the recipient does not have the capacity to receive incoming deliveries and is therefore forced to let the wheat be stored in a non-optimal way. There can also be a different variations of deliveries, which can lead to a lower quality, and cause the wheat to be reclassified as animal feed or other possible uses.

In the milling industry, wheat bran could potentially be described as a food loss as it could be included in more food products than it is today, see reasoning in the discussion below.

In the production process at bakeries, waste occurs which varies with product and process, and mainly includes dough residue, faulty baking and products that are damaged. Often, bread approaching its best-before date is removed from stores by bakeries and is used for yeast production. It is also used for animal feed or recycled for energy production. From a resource perspective, food waste should primarily be prevented, and based on the resource hierarchy, it is better if food is consumed by humans than recycled as animal feed or used energy production, see Chapter 2.4. According to the baking industry, many bakeries work actively to reduce waste and increase resource use, and many of the bakeries gather statistics on their production flows.

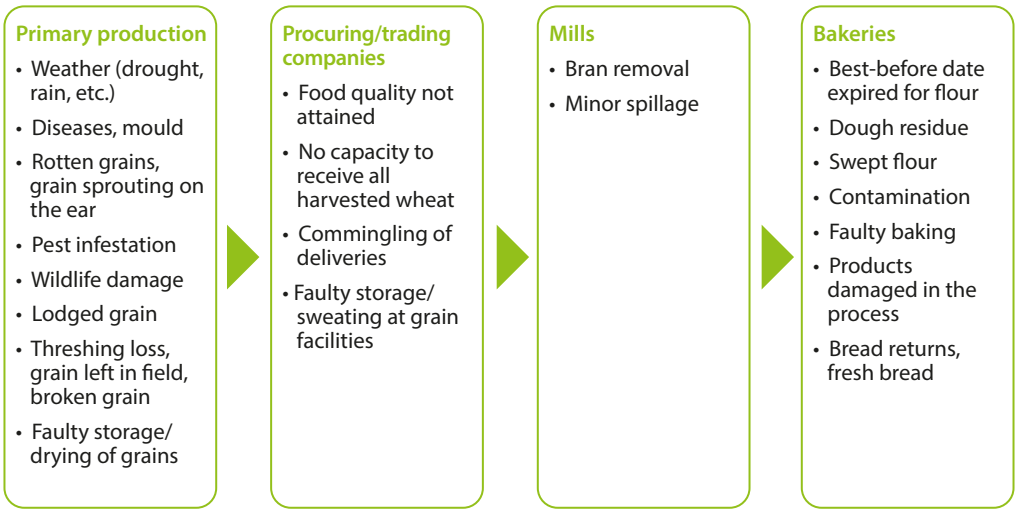


Figure 11. *Flow chart for milling wheat and causes of food loss in different parts of the wheat production chain. Source: SLU*

5.5.1 Method

Stakeholders

Cereal growers, procuring companies, mills and bakeries/food industry.

5.5.2 Procedure

Statistics Sweden's data on unharvested acreage that is published annually are used to estimate losses in the field, i.e. what could not be harvested due to e.g. wildlife damage, pest infestation, drought, precipitation and similar factors. Statistics from Statistics Sweden on wildlife damage in the field will also be used.[141] As the statistics on damage from deer and herbivorous animals is from 2020, this needs to be adjusted somewhat based on whether the harvest was early or late, as the damage tends to increase in years when the harvest is late.

Data on primary production will be obtained through interviews with growers. The interviews should preferably take place in association with other planned activities such as advisory service. The producer should then be asked to estimate the loss (weight, or volume that is converted to weight) up to the point of delivery, and to state the reasons for the losses. In instances where the producers themselves store the wheat before sale, data could be collected regarding the estimated loss during storage, i.e. harvest that is stored minus harvest that is delivered = storage loss.

For procuring companies, mass balance calculations (inflow - outflow = loss) have been proposed as a possible way of collecting data. The companies

141 Statistics Sweden 2020. Damage to agricultural crops from deer and herbivorous animals in 2020.

annually report the amount received in tonnes of wheat contracted as milling wheat, as well as the amount of wheat that is resold as milling wheat, and the difference constitutes the loss of milling wheat.

For mills and bakeries, it is proposed that data from direct measurements and mass balances should be retrieved. For mills, the amount of wheat received and the amount of wheat flour/proportion of wheat in flour mixes delivered to customers are weighed, and the difference constitutes waste. As the largest proportion of food loss in mills consists of bran, the difference more or less corresponds to this product.

If an evaluation of food loss could be carried out at the bakeries , it would be relevant to register the amount of wheat flour received/proportion of wheat in flour mixes, and the weight of products delivered to customers. The proportion of wheat in the finished product should then be taken into account. The difference constitutes waste. As the wheat flour is mixed with other ingredients (other types of flour, water, yeast, etc.), a template can be developed for calculation of loss of wheat. Bread returns and data on the resource use of the bread should also be included in such an estimation. An alternative to the calculations/data collection described above is to conduct surveys or interviews with bakery companies to increase knowledge about losses and resources. As with the other methods in the report, data would be provided on a voluntary basis.

5.5.3 Demarcations

The method only covers milling wheat and thus does not include wheat that is grown solely for animal feed or industrial purposes. The part of the wheat harvest that is designated as animal feed is seen as planned feed production and is thus not considered food loss. This flow could still be interesting to note and monitor from a resource perspective, even if it should not be seen as food loss or food waste.

5.5.4 Discussion

In fact, it is only after harvest when the wheat has become food that it can by definition be considered food loss. Losses before harvest are nevertheless significant both from an environmental and resource point of view, as well as financially. Efforts have been made to sow, cultivate the soil and use plant protection and plant nutrition. Statistics on unharvested acreage are available and recurring give an indication of these losses. Furthermore, it is relevant to follow the wildlife damage in wheat fields, as the statistics for 2014 showed a high level of damage and growers have stated that it is increasing.

Obtaining data from primary producers through interviews leads to uncertainty in the results as the values are estimated and subjective. If interviews are used for data collection, the questions should first be tested on a smaller sample of

growers. Many primary producers state that it is difficult to assess the size of their harvest as the crop is used as animal feed on their own farm. Furthermore, it can be difficult for the primary producer to provide reliable data in instances where the crop has not yet been sold when the interview is being conducted.[142] For better data quality, field surveys could also be carried out for a number of representative farms (at least 10), where the residues in randomly selected experimental plots are weighed after harvest. However, there is a need to further investigate the interest and resources for this type of study.

If field studies are to be carried out, the reliability of the data set depends on the number of farms included. More farms obviously means a more reliable data set. To get a representative result, it has been proposed to include 1) smaller and larger farms 2) farms that use older combine harvesters and newer combine harvesters, and 3) farms that use their own combine harvester and farms that rent a combine harvester from e.g. an agricultural machinery rental company, as the waste probably varies depending on the type of combine harvester and the pace of the threshing. The farms will be selected from the areas in Sweden where the main wheat production occurs, i.e. Skåne County, Västra Götaland County and Östergötland County. The measured values for the waste will then be scaled up to a national value based on registered harvest statistics.

Currently, when there is a market surplus and low demand for bran for food, bran is used as animal feed and the question is whether it should be considered as food loss or animal feed. It is nevertheless an interesting resource to monitor in the method, as it is possible that it could be in greater demand in the future, for example as an additive in foods with health-promoting properties.

There is currently already a focus on the issue of waste at mills and bakeries, and an interest in being able to gradually reduce waste. A national estimation of waste would be about compiling and arranging the data in a similar way into a combined whole. If data from the Swedish voluntary agreement for reduced food loss and waste - SAMS , see Chapter 4.3, is to be used, more companies need to become members. An alternative that would achieve greater coverage is if a survey could be sent to stakeholders who trade in cereals, as well as to mills and bakeries. However, the data collected from a business organization can be sensitive information , and thus confidentiality is critical. Further discussions need to take place with the companies and their industry organisations regarding the set-up of such a follow-up. See also section 5.9.

5.6 Potatoes

In Sweden, both ware potatoes and potatoes for starch manufacture are cultivated. The concept of ware potatoes includes three different flows: early new potatoes, autumn/winter potatoes for stores, farm shops and peeling plants, as well as industrial potatoes for crisps, French fries, mashed potatoes

142 Statistics Sweden 2020b.

and ready meals. This introduction provides an overview of the different potato flows, but the method for follow-up focuses on autumn/winter potatoes.

Potato cultivation, like all other cultivation, can be adversely affected by precipitation, drought, pests, disease, as well as wildlife damage. Of growers of ware potatoes and potatoes for starch manufacture, 19 and 24 percent, respectively, were estimated to have suffered from wildlife damage. When harvesting potatoes, some sorting of green/damaged potatoes occurs and some very small tubers are not harvested, they are wasted. According to a study on potatoes for starch manufacture, the waste during harvesting can be around 6 percent, but varies between 0.5 and 15 percent[143]. This significant variation may be related to whether it is a new or old harvester, a two-row or six-row self-propelled harvester and whether the potato harvester has been optimally calibrated. According to a Finnish survey, Finnish potato growers estimated that they had 1 to 15 percent waste in the field, an average of 5 percent,[144] which are figures similar to the Swedish waste survey of potatoes for starch manufacture. Potatoes for starch manufacture are usually larger and thus easier to harvest and probably produce less waste compared to ware potatoes.

The autumn/winter potatoes are then stored loosely or in boxes at the grower's until the potatoes are either to be sold to a packing plant or sold in a farm shop. There are growers who have their own packing plants. Most of Sweden's major packing plants are owned by large potato growers who buy potatoes from other growers and pack and resell them. If the potatoes are to be sold in the grower's own farm shop, the potatoes are sorted on the farm. It is also common for growers to also sort the potatoes to be delivered to the packing plant,[145] which means that the potatoes will be sorted twice, with removal of flawed or damaged potatoes on each occasion.

At the packing plant, the potatoes are sorted, nowadays usually using optical sorting. A report from the Nordic Council of Ministers[146] stated that 9.5 percent of waste occurs when sorting after the harvest of ware potatoes, and that the loss after harvest is non-existent for new potatoes and very low (0.4 per cent) in potatoes for starch manufacture. According to Finnish surveys, the loss is about 10–15 percent when sorting,[147] but individual growers estimate the loss to be upwards of 20 percent. The fact that there are a lot of differences between different studies may also be due to different definitions and demarcations for what counts as loss/waste.

The sorting at the packing plant is based on the Swedish Potato classification, SMAK,[148] which the trade requires. SMAK class I potatoes, which generate the highest price, must be whole, healthy, typical of the variety and be free from

143 Lantbruksnytt 2012.

144 Ahokas et al. 2014.

145 Personal statement, Lisa Andrae.

146 Franke et al. 2013.

147 Ahokas et al. 2014.

148 Svensk Potatis.

defects such as common scab and other fungal diseases, insect damage such as larval damage, mechanical damage and discolouration. Some defects are cosmetic and have no major significance for eating quality, while other defects are of greater importance. According to SMAK, medium-sized potatoes are 40–65 mm and these tubers often generate a high price, while larger tubers usually obtain a lower price. Tubers that are less than 40 mm are classified as size C and can, if of high quality (SMAK class I), generate a good price as they are sold to restaurants as delicacy potatoes, but often the small tubers go to mashed potato or animal feed. The tubers that are sorted are sold, regardless of size, sometimes as class II, or go to mash or animal feed, depending on the proximity to different buyers. However, the potato grower does not always get paid for the proportion that becomes class II or mashed potato. This has led to a discussion among potato growers about who owns the potatoes that have been sorted.[149]

Example from a grower's packing plant in Skåne County:

> *Normally about 14–15,000 tonnes come in, and 13,000 tonnes of packed goods go out. It is estimated that 65 % goes to class I, 20 % to class II, 10 % to industry (mash/starch), 5 % to animal feed (pig production). This packing plant packs all sizes over 20 mm. 20–30 mm is a delicacy potato for restaurants. Really large potatoes are also sold, and these go to shops in areas with consumers from other food cultures who prefer slightly larger potatoes. Most are sold on via wholesalers to the grocery trade. Potatoes are sorted on the basis of greenness, growth cracks, discolouration, or bad (diseases). The company grows about 250 hectares of potatoes itself and collaborates with a number of growers in the area. The company usually helps these growers with something during the season, e.g. the purchase of seed, and purchases at least class II, according to what is called a gentlemen's agreement (oral mutual agreement).*

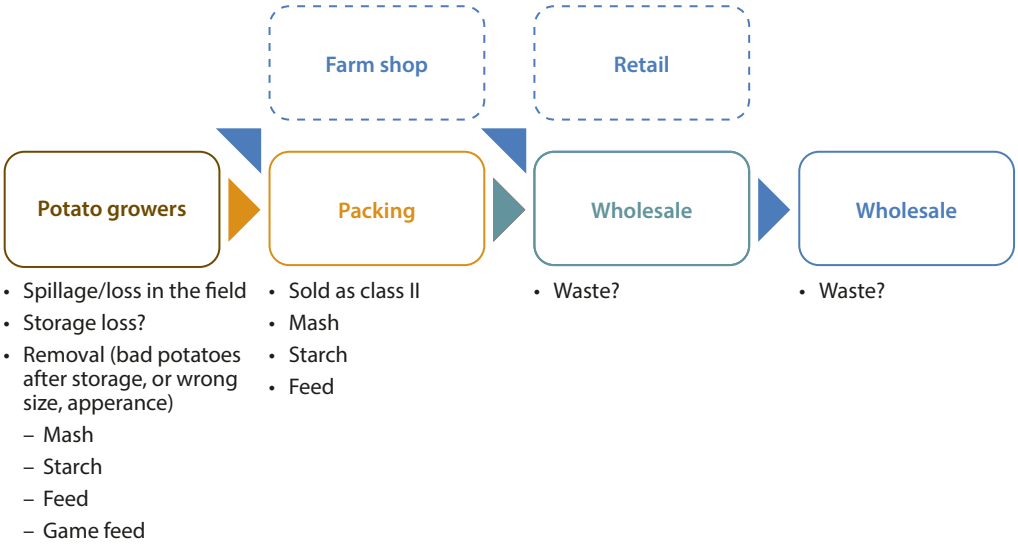


Figure 12. *Flow chart of the ware-potato chain with a number of causes of food loss. Source: SLU.*

149 Personal statement, Lisa Andrae.

At the wholesaler and in stores, the potatoes can go bad or deteriorate in quality during storage, handling and sale. In some instances, they can still be used as food, for example in ready meals, or be donated to charity, but they also go to waste that is turned into biogas.

New potatoes command a high price compared to ware potatoes, which should lead to lower losses in general. Furthermore, when harvested, the new potatoes are placed directly into small boxes which are then delivered to the wholesaler/ retailer. The new potato tubers are small and the peel is thin and therefore greater care is taken when harvesting, with smaller harvesters and a gentler cleaning process. This should also result in a lower level of loss when harvesting new potatoes compared to autumn/winter potatoes.

At the same time, it is a seasonal product and the price can affect new potatoes as sales can be affected around holidays such as Midsummer. If a grower's new potatoes are not sold in time, the tubers will become too large, and then they can easily turn green and it will not be possible to sell them. This risk is greater in new potatoes in particular because they are planted more densely, both in terms of the distance within the row and the distance between the rows, but this is also due to the fact that cultivation takes place in light sandy soil that lets in a lot of light if the grower removes the tops to prevent the potatoes from becoming too large. Low prices can mean that the potatoes are not harvested but left in the field instead. Late order cancellations can also mean increased waste as the grower is not able to sell their new potatoes.

When growing **industrial potatoes** for companies that make ready meals, French fries and mash, losses occur during potato harvesting. In the past, most were delivered directly to the food industry after harvest but today, the potatoes are stored to a greater extent by growers. This means that risk-taking has been transferred from the food industry to the growers. Industrial potatoes are traditionally stored in bulk and thus durable varieties are required, but nowadays some are also stored in boxes. The potatoes are sorted by the food industry, which means that sorted potatoes that cannot be used for ready meals can be used for other things, such as mashed potatoes. Only potatoes that are green or rotten need to be sorted out and discarded.

Another focus with industrial potatoes is the production of **crisp potatoes**, where there are also losses during potato harvesting. The potatoes are stored in storage clamps in the field and are usually delivered to the crisp industry fairly quickly. In the event of late harvest and delivery, the clamps may need to be covered to protect them from frost as these conditions may result in a loss. The potatoes are sorted by the crisp industry, where green and other poor quality potatoes are removed. Potatoes that have been sorted and removed as well as wastage that occurs in chip production can be utilized in different ways and one example from a crisp producer can be seen below.

- *Raw potatoes that have been sorted and removed go to biogas production (sprouts and discarded potatoes) and to the manufacture of starch (potatoes*

that are too large and too small). Waste from production, such as starch and crisp waste and discarded pre-packaged snacks go to bioethanol production.

Potatoes for starch manufacture
In Sweden, there is only one factory that manufactures potato starch, which is located in northeastern Skåne County. They have contract growers, but also accept discarded ware potatoes. Ware potatoes do not contain as much starch as the starch varieties, but are still accepted.

Business practices that cause food loss
In addition to waste and sorting, potato growers, just like other food suppliers, can be exposed to unfair trading practices such as late order cancellations and unreasonable returns. This can lead to food loss as growers need to find another outlet for the potatoes within a short period of time. When the stock is opened, the quality deteriorates if the potatoes are put back into stock. It will entail a loss from both an environmental and resource perspective and will have financial consequences for the grower if the potatoes cannot be sold at the estimated price. Although the potatoes can be sold as animal feed, resources have been invested in producing the kind of potatoes consumers demand (without discolouration and the like) and the price obtained will be much lower.

5.6.1 Method

Stakeholders

Follow-up will be aimed at: primary production of autumn/winter potatoes and packing plants. If possible also follow-up companies that make potato products and crisps.

5.6.2 Procedure

Statistics Sweden's data that are published annually on unharvested acreage should be used to estimate losses in the field and what could not be harvested due to e.g. wildlife damage, pest infestation, drought, precipitation and similar factors. Statistics from Statistics Sweden on wildlife damagewill also be used.[150] As the statistics on damage from deer and herbivorous animals are from 2020, this needs to be adjusted somewhat based on whether the harvest was early or late, as the damage tends to increase in years when the harvest is late.

In primary production, the quantity of potatoes that are left in the field after harvest must be investigated.investigation In order to obtain a representative baseline, it is important that investigation are carried out in a number of places with different types of harvesting systems. The number of companies investigated

150 Statistics Sweden 2021.

should be at least fifteen, but it would be preferable to include more for a better statistical basis.

The investigation in the field only includes autumn/winter potatoes, as new potato production differs considerably in terms of cultivation technology and quality requirements, and the waste is assumed to be very low in new potato cultivation.

In order to obtain a larger statistical basis, field investigation need to be supplemented with either interviews with or surveys of potato growers where both losses in stock and in any home sorting are stated. According to one potato advisor who was interviewed, it is common for the potatoes to be sorted even before they are delivered to the packing plant, which should be captured in the study. It is also important to indicate to where the different categories were sold to find out if the potatoes remained in food production or became animal feed, energy or waste.

In the survey on the flow of potatoes from the packing plants, the amount of discarded potatoes needs to be stated, as well as where the discarded potatoes go. One way to coordinate surveys is if data collection could take place in connection with the potato growers' already existing harvest inventory in the autumn. In Sweden, it is carried out every year and about eighty different samples are taken in Skåne County, Halland County, Östergötland County and Västergötland County. Furthermore, interviews are conducted in other counties and quality checks are carried out. Investigation is needed as to whether parts of the follow-up could be carried out in connection with this, but the survey needs to be initiated as early as during the growing season, so that growers remember to take note of what is left in the field and to estimate the number of boxes in the warehouse, etc.

In packing operations, packing plants that have their own cultivation as well as packing plants that do not must be included in the survey. These also need to be spread geographically throughout the country as the proximity to major potato industries in different parts of the country can greatly affect the possibility of selling potatoes that cannot be sold as class I or II. For example, packing plants in southern Sweden have plenty of opportunities to sell discarded potatoes to both major companies in the food industry and starch manufacturers, depending on the quality. It can be much more difficult to sell discarded potatoes as food further north.

In interviews with or surveys of growers and packing plants, questions about order cancellations and returns should be included to obtain information about whether there are business practices that lead to food loss.

The industry and wholesale levels could probably be followed up via data from the relatively new voluntary agreement (see Chapter 4.3). The aim is to collect data from a number of major industries and wholesalers who handle potatoes. In order to have a more comprehensive statistical basis, the hope is that more

major industries in the potato sector will join this partnership. Alternatively, if surveys can be sent to food companies within potato processing, see Chapter 5.9.

5.6.3 Demarcations

Only autumn/winter ware potatoes should be included in the proposed surveys. New potatoes could possibly be included as a separate part of the survey/ interview study regarding order cancellations and business practices that can lead to food loss.

Losses before harvest should be included in the form of unharvested acreage and wildlife damage. Even if the potatoes are not considered as a food before harvest, these losses are important to highlight from a resource and economic perspective.

Most potato varieties will be included in the study as the focus of the selection will be on capturing the variation between growers and getting a sufficiently large geographical spread. All potato tubers should be included in the study, including tubers that are sorted as non-food, for example for animal feed and biogas. This should be included to get an overall picture of the potato flows.

The weight loss of the potatoes during storage is not taken into account, so the potential amount of ware potatoes is the weight taken out of storage.

5.6.4 Discussion

According to the current definition, food loss can really only occur after harvest, as that is when the product becomes food. Losses before harvest are nevertheless significant both from an environmental and resource point of view, as well as financially. Efforts have been made to plant the potatoes, cultivate the soil and use plant protection products and plant nutrition. Statistics on unharvested acreage are available and recurring statistics give an indication of these losses. Furthermore, it is relevant to follow the development of damage from deer and herbivorous animals in potato cultivation as the statistics for 2014 showed a high level of damage within potato cultivation.[151]

For financial and logistical reasons, the waste surveys could be located in a region such as Skåne County, where potato cultivation is significant. Surveys at packing plants, on the other hand, need to be spread throughout the country, as the ability of packing plants to send sorted potatoes for food processing or animal feed can be affected by their proximity to companies in the food industry.

As there are indications that new potato growers are exposed to unfair trading practices (see Chapter 2.3), questions could also be asked via surveys or interviews about the practices that can lead to food loss such as late order cancellations and returns.

151 Statistics Sweden 2014.

5.7 Carrots

Food losses occur in the various stages of carrot production, distribution and processing. Extensive food loss occurs when sorting carrots. When harvesting carrots, which usually occurs mechanically, the harvester can miss carrots, which then remain in the field as losses. Representatives of carrot companies have stated that they do not know how much is left in the field, and some have even expressed that it would be of interest to have this amount estimated.

Following harvest, carrots are transported for washing, sorting and packaging if they are to be sold directly. However, the majority of the carrots are placed in storage shortly after harvest, and are washed, sorted and packaged in connection with sales throughout the year. Some companies adopt the practice, entirely or in part, of "storing" harvest-ready carrots in the field under straw, and harvest them later in connection with sales, which is said to reduce storage losses. During sorting, which often occurs using optical reading, but which can also be supplemented with an inspection carried out by personnel, food loss occurs. It has been estimated by staff interviewed at several carrot companies[152] to be about 20–30 percent, for some fields up to 50 percent and then they mostly go to animal feed. In a worst case scenario, if a storage facility of carrots has been affected by mould, for example, everything may need to be discarded. It has also become more common for smaller companies to store and distribute their carrots via a larger carrot company.

When sorting, it is possible to measure how much goes to food, and how much becomes fodder carrots, or is completely rejected. The sorting is done in accordance with the specifications set by the growers' customers and they generally set higher requirements than the EU's trading standards. A sorting result obtained from companies would constitute a fairly solid basis, if the companies want to report these results to the Swedish Board of Agriculture. In instances where a larger company stores and sorts for smaller companies, the sorting result forms the basis for payment to the smaller companies and should therefore have a high degree of accuracy. Carrots can be stored on the farm, and during storage losses can occur if carrots deteriorate due to storage diseases caused by moulds and bacteria. During distribution of the carrots from farm to store, at processing plants or restaurants/the catering industry, reloading and even a shorter period of storage can occur at the wholesaler's. Losses can occur here as well. Processing companies may have different quality requirements than the retail trade, but food waste can arise in the processes for various reasons. Wholesalers generally have their own statistics on losses, but it is unclear whether they are compiled, and this is probably also the case with the food industry.

The raw material flow of carrots from farm to retail, and carrots for processing and for restaurants or the catering industry can go via slightly different distribution chains, see Figures 14 and 15. The first two distribution chains, at

152 Olsson 2020.

the top of Figure 13, are estimated to account for a major proportion of sales and distribution of carrots. In addition to food products, carrots are also used as fodder carrots for animals (horses, rabbits, chickens, deer, etc.), for certain technical products such as skin care products (however, it was difficult to determine how much is produced in Sweden), but what is rejected can also go to biogas. The majority of carrots produced in Sweden are intended to be food, and of the proportion that does not meet the requirements set by the growers' customers, a large proportion become fodder carrots. Carrots that actually meet the agreed quality requirements can also become fodder carrots instead, if a delivery agreement with a buyer must be fulfilled, but this is probably less common. In interviews with growers, there have been various reports as to whether they send unsold carrots to biogas plants, and the reasons for this may be whether they can sell the remainder as animal feed or not, and whether there is a biogas plant nearby that can accept the unsold product.

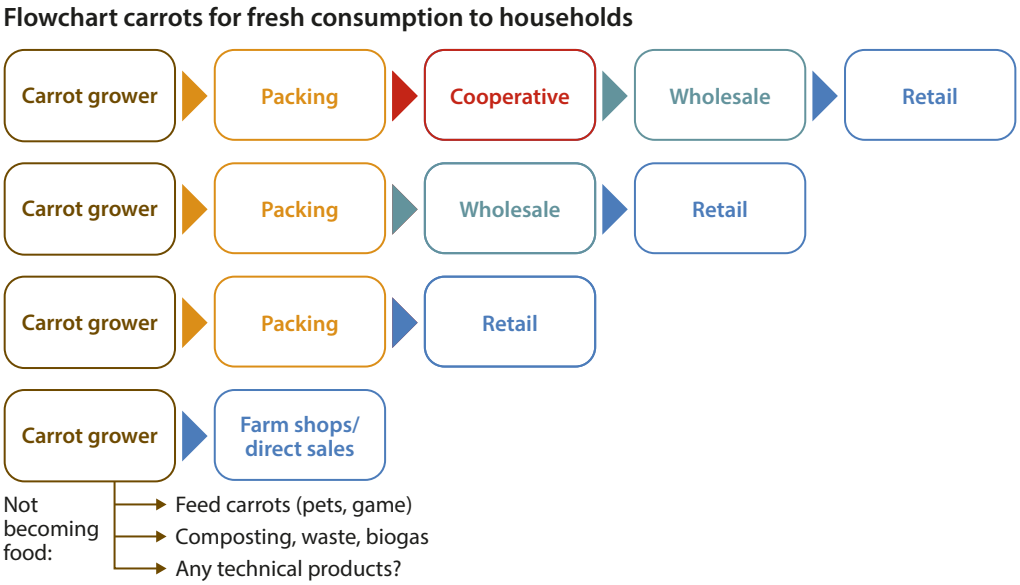


Figure 13. *Raw material flow from the farm level to the retail trade. Source: SLU.*

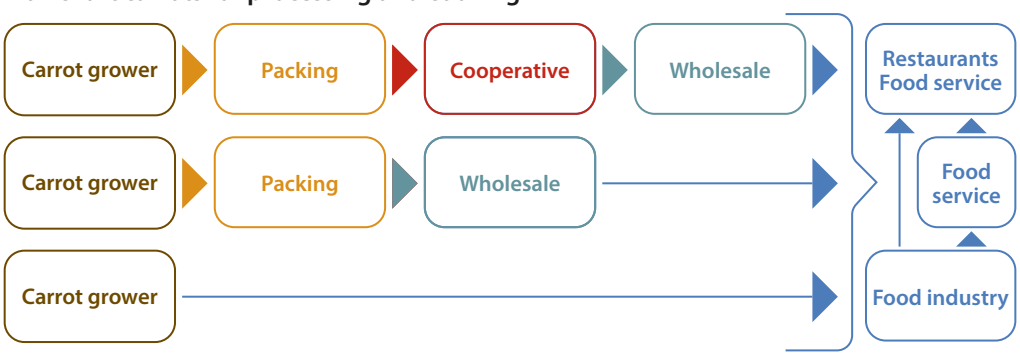


Figure 14. *Raw material flow from the farm level to processing plants. Source: SLU.*

5.7.1 Method carrots

Stakeholders

Follow-up will be carried out in primary production, at the wholesale level and in the food industry.

5.7.2 Procedure

In primary production, field investigation should be conducted of how much of the production is left in the field on about fifteen selected, representative farms, and several fields per farm are surveyed. It is also appropriate that data are provided on sorting at growers' companies. Estimated harvest before storage should be reported, as well as sorting results divided into: food, fodder carrots, waste for composting or biogas, as well as other uses. Cultivated acreage, as well as any unharvested acreage, should be reported. We have data that indicate that the losses in primary production are significant, which is why this stage should be a priority.

When following up with growers and packing plants, questions about order cancellations and returns should be included to get information about whether there are business practices that lead to food loss. At the wholesale level, the larger wholesale companies that handle distribution to the retail level should also be consulted about data, as well as the companies that distribute to the catering industry (public kitchens and other restaurants). The companies can then report the weight of carrots received, delivered weight, and the difference between the two, which constitutes the food loss. Furthermore, the weight of rejected goods during quality control on arrival should also be reported. Losses in the food industry should also be followed up with a survey or that companies, in other ways, report the weight of carrots received, estimated waste in production, and how much of the waste is used for animal feed or goes to biogas. Furthermore, the weight of rejected goods during quality control on arrival should also be reported.

5.7.3 Demarcations

The surveys should include the whole carrot without the tops. Bunches of carrots are a special product that are sold with their tops, which should not be included because they make up a small proportion of the entire production. Weight loss during storage is disregarded because the carrots are not weighed before storage, so stored weight can only be estimated by a company from the number of carrot bins in storage, and an estimated weight per bin when sorting. When stored, the carrots still have some soil on them, so weighing would be misleading. In total, carrots are registered for food, for animal feed, for biogas and

other uses. The follow-up should be carried out from harvest as data collected from the Swedish Board of Agriculture are based on harvest per hectare.

5.7.4 Discussion

The data set in primary production regarding products remaining in the field is dependent on the number of producers/fields investigated, and more included fields provide a more secure basis.

When measurements of food losses in primary production are to be carried out, it is necessary to make a selection as it is not possible to measure all production units. In order to be able to make a representative selection, methods should be based on knowledge of the production unit's structure and geographical location. As 75 percent of carrot production in Sweden occurs at the 30 largest cultivation companies (from 10 to more than 30 hectares) in Skåne County, Gotland County and Östergötland County,[153] the surveys should mainly be based there to increase representativeness. This also applies when reporting sorting results directly after harvest or following storage, where the larger units have a greater opportunity to report more reliable results, and today often have their own data that can more quickly be compiled annually and reported to the Swedish Board of Agriculture. To increase the reliability of the method, the method of mainly measuring at the larger production units should be supplemented with a selection of measurements at medium-sized production units over the course of a year, in order to verify the assumption that the larger companies can be considered representative. However, the discrepancy should not be very large as the total production on the medium-sized and smaller units is not so extensive.

Measurements in the counties where the majority of the production occurs (Skåne County, Gotland County, Östergötland County) should be considered representative, and it is unlikely that production in the other counties, which represents just under 10 percent, would be so significantly different that it would change the scaled-up the values for the country.

The data set at the wholesale level should be reliable, as the companies usually are able to produce statistics from purchasing and sales. For conversion to the national level, data may be less reliable due to significant diversity in distribution channels and the difficulty of overseeing these.

It is difficult to estimate the reliability of data collected from the food industry, as this is due to the difficulty that companies have in estimating this in different processes. Companies may have their own statistics on the weight of purchased goods and the weight of finished products.

153 The Swedish Board of Agriculture 2020c.

5.8 Strawberries

Strawberries are produced in a number of cropping systems such as in open field production, in tunnels or in greenhouses. Losses in primary production occur in part due to frost damage to flowers and harmful organisms (especially fungal diseases and insects)[154]. At present, there are no data available on the extent of this damage.

However, the largest losses in primary production occur when perfectly good strawberries are not picked but left in the field. A relatively large part of the cultivated land is self-picked by consumers.[155] Allowing consumers to do the picking is a common strategy, and the choice to let the consumers do the picking or not is part of the company's strategy and requires very different resources. It is also a question of choice of cultivar, personnel and logistics. If no pickers can be employed (e.g. in the event of travel restrictions or a shortage of labour), the losses risk amounting to 100 percent if switching to self-picking by consumers does not take place. Allowing consumers to do the picking is a common strategy, and the choice to let the consumers do the picking or not is part of the company's strategy that requires very different resources. It is also a question of choice of cultivar, personnel and logistics. According to industry representatives,[156] in some instances more than half of the strawberry yield risks being left unpicked when consumers do the picking, but data on this is not compiled systematically. Self-picking has increased in recent years in parallel with the fact that it has become more difficult for growers to employ their own pickers. Losses on farms also occur when buyers do not collect all the strawberries they have ordered. Such situations can arise when there is a large supply of strawberries (Swedish or imported). This can sometimes be handled by the grower lowering the price of the strawberries, which results in a financial loss for the grower even if they can be sold as food.

Harvested strawberries are distributed in part directly to wholesalers and in part to the warehouses of the major supermarket chains. In addition, strawberries are also sold directly from growers to stores. The waste at warehouses is estimated by the chains to be 0 to 5 percent at the major Swedish supermarket chains[157]. These data are not reported systematically. The fact that the waste in the warehouses of retail chains is so low may be due to the fact that they solve it through returns and order cancellations, with the risk that the loss is instead incurred by the grower.

Almost 50 percent of the fresh strawberries sold in supermarkets are Swedish – the rest are imported.[158] However, as a large proportion of the Swedish strawberries are also sold in markets, on farms, etc., the total imported share

154 The Swedish Board of Agriculture 2015.

155 Estimated at almost 50 percent according to HIR and LRF.

156 Stenberg 2020a.

157 Ibid.

158 The Swedish Board of Agriculture 2015.

is 30 percent. The major supermarket chains collect data on the total amount of strawberries and the level of waste on a daily basis. We have read the internal statistics from several supermarket chains which indicate that Swedish strawberry losses are higher than for imported strawberries[159]. The difference is probably due to the fact that the surplus of strawberries is greater during the summer when Swedish strawberries are delivered, but may also be due to the fact that imported strawberries are cultivars produced to withstand transportation to a greater degree than the Swedish ones. Another possible explanation is that imported strawberries are treated, to a greater extent, with pesticides to prevent fungal diseases, and therefore do not suffer from grey mould to the same extent. It can also depend on how the strawberries are packaged, Swedish strawberries are packaged in open cardboard cartons whereas imported strawberries come in closed resealable plastic packaging (where consumers cannot remove and replace the strawberries in the store). Rejected strawberries are burned, composted, or become biogas, but systematic data is not available for this.

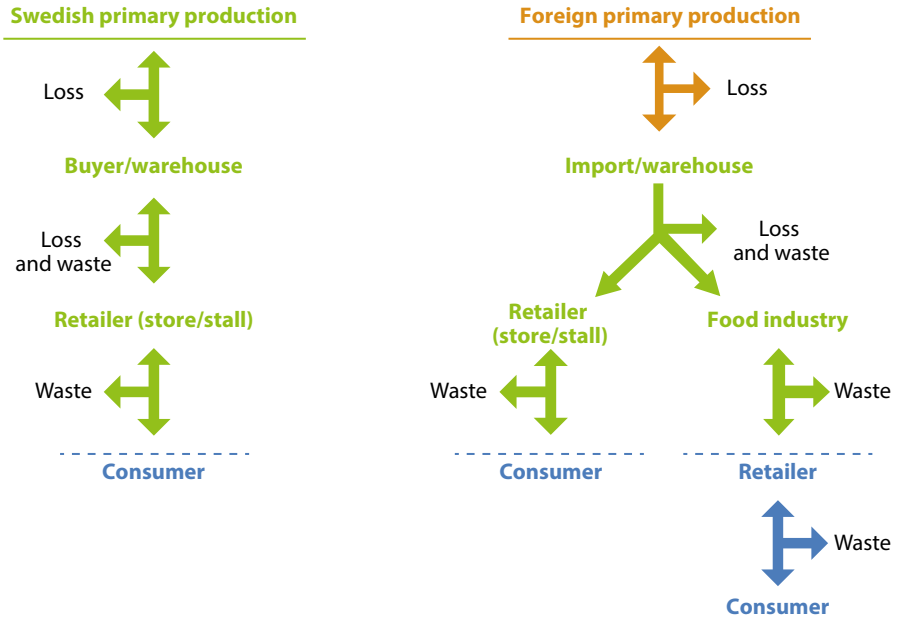


Figure 15. *Flow chart for Swedish-grown strawberries (left) and imported strawberries (right). In the food industry, only imported strawberries are processed, while both Swedish-grown and imported fresh strawberries are sold to consumers via retailers.*

159 Stenberg 2020b.

5.8.1 Method

Stakeholders

Primary production

5.8.2 Procedure

Preliminary results from interviews with representatives of stakeholders, representing all stages of distribution, indicate that the loss in primary production is much greater than in other stages. Follow-up should therefore primarily focus on primary production.

Waste in the field should be investigated by systematically collecting data on fields that are unpicked or self-picked. The proposed field investigation includes 10 companies/growers who pick their own strawberries and 10 companies/growers who let consumers do the picking. In practice, many companies use both strategies (in-house pickers + consumers) and it would be more practical if companies that use both picking strategies could be investigated. If the proposed field investigation cannot be carried out in full (due to lack of resources), the number of small areas per field could be reduced, but the number of fields should not be reduced for statistical reasons.

Data on waste that occurs when buyers do not collect strawberries that have been picked and packed in the field can be followed up via surveys directed at growers. This should be carried out during the off-season and in connection with the growers meeting. The annual berry meeting in Hook (a village close to Jönköping), where all of Sweden's major growers meet, is one proposal for a forum for scheduling a survey.

Strawberries collected by buyers are distributed directly to retailers and to the warehouses of the major supermarket chains. The waste in these stages is estimated to be negligible. As the channels can also be complex, we propose that these stages be mainly excluded from follow-up. In interviews with or surveys of growers, questions about order cancellations and returns should be included to obtain data on the extent to which the segment is affected by business practices that lead to food loss.

The major supermarket chains collect data on the total amount of strawberries and the level of waste (in kilograms or SEK). A survey could be conducted with the three largest Swedish supermarket chains to follow-up the waste in warehouses and stores. We do not believe that other stakeholders can be included because the work it would entail would be too extensive.

Although we are proposing a possible survey method to follow-up the losses in warehouses/stores, we want to emphasize that indications show that the loss at these stages is relatively minor. In the context, the proposed survey is

a low priority and can be excluded in the event of a lack of resources. What is important to capture, however, are the stores' business practices towards their suppliers, such as late order cancellations, which lead to waste.

The food industry here refers to processed strawberries in dairy products and jam/juice, for example. In principle, 100 percent of all strawberries used in the food industry in Sweden are imported. In the Swedish food industry, there are a few major companies and a large number of small companies that process strawberries. However, our interviews indicate that the losses are very small and we therefore propose that the food industry be excluded from follow-up.

5.8.3 Demarcations

Our method measures waste in primary production in conventional open field cultivation. Loss is calculated as the proportion (percent) of strawberry mass that is left in the field of the total produced mass.

Losses due to frost-damaged flowers are not included because this cannot be measured and because the losses occur before the strawberries have developed. The plants can also compensate for the damage to some extent by flowers that survive developing slightly larger berries.

Cultivation in tunnels and organic farming are excluded, but should be included in the future as their relative importance is expected to increase.

5.8.4 Discussion

About a hundred growers who represent about 70 percent of all strawberry production in Sweden are connected to Federation of Swedish Farmers (LRF), which facilitates the collection of data on primary production and losses that occur there. In the proposal for the advanced follow-up method, we therefore propose that resources should primarily be directed towards primary production. The proposed survey, which is aimed at LRF-affiliated growers, is expected to be both easy to implement, easy to interpret and effective. Although not all growers participate in LRF's berry course in Hook, the aim is to effectively capture growers who represent as large an area as possible. Smaller growers are less important in this context and we do not see any major problems with them being excluded. One risk, however, is that the berry course in Hook cannot take place due to the prevailing pandemic. In that case, we might consider replacing the survey with phone interviews with about 20 producers.

We consider the proposed field investigation to be too time-consuming to be carried out by the growers themselves. In order for data from the different fields to be comparable, it is important that they are collected by a single individual. The two investigations (questionnaire survey + field investigation) that focus on primary production must provide answers to how extensive the losses in the

field are and what they are due to. We expect that waste in the field could be greatly reduced if the primary producers have secure access to labour, safe plant protection methods, recommendations on when/how picking by consumers is appropriate, and secure relationships with buyers. The relative importance of these measures will be clarified by the proposed method.

A possible survey of the supermarket chains should be limited to the three largest companies, as the survey would otherwise be far too extensive and probably too difficult to interpret. However, the level of waste at these three chains seems to be relatively minor. In the event of a lack of resources, we think that this survey could be excluded (because the loss in primary production must be prioritized).

Farm sales and roadside sales, in temporary stalls, etc., account for significant volumes. But as a trade-off between benefit and scope must be made, we believe that smaller stakeholders in the complex warehousing and retailer side should be excluded.

Although losses at the three major supermarket chains are limited according to the interviews conducted, it appears that many specific measures could be taken to further reduce the losses in stores and also the losses inflicted on the grower when strawberry orders are cancelled by the store. The chains currently work in a variety of ways to reduce the waste within their own businesses, for example by lowering the prices of unsold strawberries and processing unsold strawberries from warehouses and stores to make juice or ready meals. The chains can probably learn a lot from each other's strategies and the result from our proposed follow-up method would provide a good basis for such efforts. However, order cancellations by stores are a major problem for fresh produce such as strawberries.

5.9 Supplementary indicators

In addition to following specific raw materials and product flows, more transverse data could be used. Below are some examples.

5.9.1 Follow-up of companies in the food industry

Since 2019, The Swedish Food Federation has had a sustainability manifesto consisting of five commitments, one of which is to *halve food waste by 2030 in their own production and to contribute to reduced food waste at the primary production, trade and consumer levels*.[160] About 80 companies in the food industry that are members of The Swedish Food Federation have adopted this commitment/goal. Discussion has begun with The Swedish Food Federation about an upcoming follow-up of the food waste target, which could also contribute to the national follow-up of food loss. For example, if surveys are

160 Livsmedelsföretagen 2020.

sent to companies with questions about how large amounts of the production do not become food, as well as the amount of by-products and residual products. It is also important to obtain data on the destination of these flows, whether they become animal feed, ethanol or are used for biogas, composting or are incinerated.

The companies in the food industry that have adopted this food waste target have production that is included in the eight product flows presented in the method, and statistics from these could thus have contributed to the national follow-up of food losses but also to improved waste statistics.

5.9.2 Follow-up of unfair trading practices

In 2021, a Swedish regulatory framework will be introduced based on the EU Directive on Unfair Trading Practices. It remains to be seen which investigations and follow-ups will be carried out at a national level within the framework of Swedish legislation. See Chapter 2.3. If national follow-ups contain data on methods that cause food loss and other food waste, this may also be relevant to monitor within the framework of the follow-up of food losses.

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A National Food Strategy for Sweden – more jobs and sustainable growth throughout the country can be found at www.government.se

The Swedish Environmental Protection Agency www.swedishepa.se The website has information on Swedens milestone targets where the two milestone targets aim to minimise the total food loss and waste in the entire food supply chain.

The Swedish Food Agency www.livsmedelsverket.se/en.

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Method beef				
Levels/stakeholders	**Procedure/data set**	**Unit**	**Data quality**	**Definitions**
Primary production	Extract from CDB. Ordering of selected categories expressed as CDB codes and time periods.[161]	**Number of animals/year** with outcome put down/ died a natural death, home slaughter and commercial slaughter, for each animal category.	High-quality official national data. Import and export complicates the picture, but are not included in the simple method.	Voluntary registration of stillborn calves. Commercial slaughter (code 3) = approved live inspection.
Primary production	Annual statistics on birth weights and slaughter outcomes for different sexes, ages and breeds. Multi-year averages were sourced from Växa.[162] Dressing percentage obtained from Gård och djurhälsan.[163]	**Kg lost carcass weight/ animal.** Birth weight (live weight) respectively carcass weight for different age groups, sexes and breeds.	Industry data based on extensive, but not fully complete, data. Healthy animal weight proxy for destroyed animals. Dressing percentage for dead calves from template.	For age groups between list values, interpolations were made. Weighted average (common breeds have a greater impact) is created for the group dairy breed and beef breed for each age group and sex.
Primary production	Calculations of lost carcass weight.	**Tonne lost carcass weight/ year**	Based on the data above, so relatively high quality.	The hypothetical carcass weight is multiplied by the number of animals lost in each group. Summary.
Primary production	Calculation of lost carcass weight in relation to production. Animal production Annual and monthly statistics[164].	**% lost carcass weight of produced carcass weight/ year.**	Relatively high quality. To be reconciled with what CDB reported on commercial slaughter, which gives the carcass weight before rejections.	The annual losses are related to the annual production. Home slaughter is not included.
Transportation to the abattoir	Mortality during transportation. Data collection from the Swedish Food Agency's data on the number of animals that died a natural death during transportation to the abattoir and any data from the abattoirs. This item will not be added to what is obtained from the CDB but is produced to report losses during transportation separately.	**Number that can be converted to weight and percentage.**	The number of animals is recalculated to the proportion of mortality (%) calculated with the Swedish Board of Agriculture's statistics on the total number of animals slaughtered.	Animals that died during transportation to the abattoir. The weight is based on live weight at slaughter which is converted to carcass weight.

161 CDB, Central Register of Bovine Animals which is managed by the Swedish Board of Agriculture.

162 Växa 2020c. Växa is an advisory organization.

163 Gård och djurhälsan 2016.

164 The Swedish Board of Agriculture 2019:2.

Method beef				
Levels/stakeholders	**Procedure/data set**	**Unit**	**Data quality**	**Definitions**
Abattoir	Rejected from slaughter at abattoir = loss at live inspection. Included in CDB code 7/8, if the abattoir registers correctly, but is included to be able to be reported separately. Data from the Swedish Food Agency on rejected animals at abattoirs.[165]	**Number of rejected animals/year.** **Tonne/year.** **% lost carcass weight of produced carcass weight/ year.**	Since the weight or age of the animals is not known, the total weight lost is somewhat uncertain. But as it is a small number, this should not be particularly significant.	A template is used for weight. Also conversion to carcass weight. Animals that are found dead during unloading following transportation are not included in rejected animals, but are included in died a natural death.
Abattoir	Loss during carcass inspection[166], divided into: Completely rejected Partially rejected Data obtained from The Swedish Food Agency.	**Number/year (The Swedish Food Agency).** **Tonnes/year.** **% lost carcass weight of produced carcass weight/ year.**	Since the weight or age of the animals is not known, the total weight lost is somewhat uncertain.	Only partially rejected animals exceeding 10 kg are included. Weight of completely rejected animals and partially rejected animals using the Swedish Board of Agriculture's template of historical data 2000–2009.
Abattoir	Investigate how data can be collected/compiled on what different parts of the animal are used for, incl. organs and blood. Inquiry to both large abattoirs and the smaller ones.	Tonnes of lost food and tonnes that could go to human consumption but do not, preferably with different sales channels.		Sales decisions are made at each abattoir. Pharmaceutical, technical, animal feed sales can also be mapped.
Meat production companies	Investigate whether it is possible to examine the flows in meat production companies, in dialogue with industry organisations (see Chapter 5.9) or interviews.	Tonnes	The amount of food produced and what does not go on to become food, with data on destinations regardless of whether these are classified as food waste or food loss.	

165 Personal statement Linda Lundberg.

166 Ibid.

Method pork				
Levels/stakeholders	**Data source**	**Unit**	**Data quality**	**Definitions**
Primary production	**Mortality in primary production.** WinPig/Gård and Djurhälsan[167, 168]	kg	Reported as a percentage of mortality (%) across suckling, growth and adult pig periods. Standard live weight suckling period: 2 kg; growth period; 15 kg: adult pig period 75 kg. Self-reporting, the data covers about 40% of Sweden's producers. To be scaled up to national figures.	Calculation of the number of animals is based on the number of animals slaughtered according to the Swedish Board of Agriculture's statistics. Includes only growing animals. The weight is based on an average weight of the live weight and is converted to carcass weight (/ 1.34).
Transportation	**Mortality during transportation.** Data collection from the Swedish Food Agency's data on the number of animals that died a natural death during transportation to the abattoir and any data from the abattoirs.	Number that can be converted to weight and percentage.	The number of animals is recalculated to the proportion of mortality (%) using the Swedish Board of Agriculture's statistics on the total number of animals slaughtered.	Animals that died during transportation to the abattoir. The weight is based on live weight at slaughter which is converted to carcass weight.
Abattoir	**Number of slaughtered animals to be able to calculate national figures.** The Swedish Board of Agriculture Animal production Annual and monthly statistics 2019:12[169]	Kg	Reported as number of animals slaughtered and carcass weight produced per year and animal category. Includes all approved abattoirs in Sweden. National figures.	Includes only animals that are approved carcasses, and only carcass weight (not live weight). Does not include home slaughter or slaughter not intended for human consumption.
Abattoir	**Animals that fail live animal inspections and completely *rejected animals** Firstly data from the Swedish Food Agency, secondly from WinPig/Gård och Djurhälsan.	Number of rejected animals/year. Tonnes/year % lost carcass weight of produced carcass weight/year.	The Swedish Food Agency: Number of animals and number of completely rejected animals. WinPig: Reported as proportion of completely rejected animals (%). Self-reporting, the data covers about 40% of Sweden's producers. To be scaled up to national figures (see description of data quality).	WinPig: Calculation of the number of animals as well as carcass weight is based on the number of animals slaughtered according to statistics from the Swedish Board of Agriculture. The proportion of completely rejected animals is also assumed to include animals that fail live animal inspections according to discussion with WinPig support.

167 WinPig average fattening pigs.

168 WinPig average sows.

169 The Swedish Board of Agriculture, monthly slaughter statistics.

Method pork				
Levels/stakeholders	**Data source**	**Unit**	**Data quality**	**Definitions**
Abattoir	Partially rejected animals Data obtained from The Swedish Food Agency.	Number/year (the Swedish Food Agency) Tonnes/year % lost carcass weight of produced carcass weight/ year.	Since the weight or age of the animals is not known, the total weight lost is somewhat uncertain.	Includes slaughter in both large and small abattoirs. Only partially rejected animals in excess of 10 kg are included. Weight of completely and partially rejected animals using the Swedish Board of Agriculture's template of historical data 2000–2009.
Abattoir	Investigate how data can be collected on what different parts of the animal are used for, incl. organs and blood could. Inquiry to both large abattoirs and the smaller ones.	Tonnes of lost food and tonnes that could go to human consumption but do not, preferably with different sales channels.		Sales decisions are made at each abattoir. Pharmaceutical, technical, animal feed sales can also be mapped.
Meat production companies	Investigate whether it is possible to examine the flows in meat production companies, in dialogue with industry organisations (see Chapter 5.9).	Tonnes	The amount of food produced and what does not go on to become food, with data on destinations regardless of whether these are classified as food waste or food loss.	

Method milk				
Levels/stakeholders	**Procedure**	**Unit**	**Statistical data**	**Definitions**
Primary production	Milk produced on farms is calculated as weighed-in milk at Swedish dairies[170] with an adjustment for the proportion of milk that is not delivered to the dairy[171]. Discarded milk due to antibiotic treatment is calculated with the treatment incidence for clinical mastitis and bone and hoof diseases within each breed of cow[172]. The number of cows in the breed is calculated using statistics from Växa[2] and the Swedish Board of Agriculture[1]. The proportion of treatments with the most common preparations, and templates for the number of days the milk is discarded during treatment and withdrawal are used. Discarded milk quantity per cow within the breed is calculated (standard 300 days of lactation)[2].	Thousand tonnes of milk	The Swedish Board of Agriculture's statistics refer to weighed-in milk at Swedish dairies (> 99 % of total milk weighed. The production statistics from the advisory organization Växa are based on farms affiliated with the production programme Kokontrollen (77 % of the dairy cows in 2019)[2]. Treatment incidence[3] is shown in Växa's statistics. Some uncertainty in how much milk is lost in connection with treatment as the yield and incidence in herds that are not affiliated with Kokontrollen may differ from herds that are affiliated.	In addition to discarded milk, milk that is not delivered to the dairy includes milk for household consumption, direct sales of milk and dairy products on the farm, colostrum (colostrum) and full-cream milk for calves.

170 The Swedish Board of Agriculture's statistical database.

171 Växa 2020a.

172 Växa 2019.

Method milk				
Levels/stakeholders	**Procedure**	**Unit**	**Statistical data**	**Definitions**
Processing at the dairy	Losses in dairy production are measured using a method (industry-specific guidance) developed within the Swedish voluntary agreement SAMS (2020)[173]. The method is based on mass balance regarding the dry matter content of each product stream. Losses in process and rinsing water are determined by COD analysis (Chemical Oxygen Demand)[174]. The losses at the dairy could also be roughly estimated as losses from white water (milk or residual products in the production line that is washed away in between 2 different productions), washing and waste water and residual flows. For the calculation of the losses from white water, water from washing and waste water, the 5 %[175] template of weighed-in milk is used[1]. For a rough calculation of losses in residual flows, mainly whey and buttermilk, templates are used[176]. The amount of milk used for the production of powdered milk is calculated on the basis of a template. The milk as well as the amount of powdered milk produced are not included in the calculations of losses at the dairy, as the residual flow, i.e. the water that is released during drying, cannot be considered as an actual loss.	Thousand tonnes of milk for each dairy product		Milk with residues is defined as a non-edible raw material and cannot be used for food production. This milk is never taken into the production process but is separated at the silo level. Negligible frequency.

173 Östergren et al. 2020.

174 Losses in process and rinsing water are determined by COD analysis (Chemical Oxygen Demand). COD is a measure of the amount of oxygenconsumed during complete chemical decomposition (total oxidation) of organic substances in water.

175 Personal statement Anna-Karin Karlsson.

176 The Swedish Board of Agriculture's statistical database.

Method Seafood				
Levels/stakeholders	**Procedure/data source**	**Unit**	**Statistical data**	**Definitions**
Fish (caught for consumption)	Summary of data from Statistics Sweden, independent landing inspection.	Thousand tonnes	Based on log books, fishing records, contract notes.	Only fish/shellfish for consumption, whole animals.
Fishing (feed, by-catch)	Landed catch for consumption as a proportion of total catch incl. discarded fish estimated from independent on-board sampling.	%	Random on-board sampling low proportion of total catch/landings.	Indicator showing the proportion of live total weight used for food
Aquaculture	Environmental reporting from fish farms subject to authorization from County Administrative Boards.	Weight	Unclear, small volume relative to wild-caught fish.	Died a natural death, sick or injured fish.
Fishing and aquaculture	Interviews/surveys	%	Aimed at both fishermen in demersal (30 pcs) and pelagic (10 pcs) fishing as well as to aquaculture farmers (whereby contact needs to be made with Matfiskodlarna).	Quantities and reasons why flows are not used as food.
Preparation, gutting	In situ calculations, conversion factors,	Proportion of whole fish	Conversion factors uncertain for some species, depends on size.	The largest secondary flow is guts from whole fish
Processing/Distribution	Surveys	%	Random selection of representative companies if possible via Fiskbranschens riksförbund	With this method you can follow-up quantities and different flows of by-products
Processing/Wholesaler	Available data from the voluntary agreement SAMS[177], which will hopefully increase when more companies join.	Weight	In January 2021, there was only one major fish processing company participating in the partnership	With this method you can follow-up quantities and different flows of by-products

177 Östergren, Andersson and Hellström 2020

Method wheat				
Levels/stakeholders	**Procedure/data source**	**Unit**	**Statistical data**	**Definitions**
Primary production	Compilation and analysis of statistics from Statistics Sweden on unharvested acreage and for wildlife damage.	Tonnes and proportion in %	All agricultural companies	
Primary producer	Interview in connection with advisory service, producer is asked to estimate loss up to delivery and reasons for the loss, as well as where the waste goes. In instances where the producer stores the wheat on-farm, data is collected on the estimated loss during storage.	Tonnes/hectare	Some uncertainty regarding data as the values are estimated and subjective.	Grain weight No specification of the proportion of evaporated water out of the total storage loss.
Primary producer Options for data collection subject to interest and resources	Investigation of losses in the field. At least 10 farms should be selected. Several plots are randomly selected in each field where the waste is measured after harvest.	Tonnes/hectare	Should be performed on a sufficient number of farms to give a representative estimate. Suggestion include • smaller and larger farms • farms that use older combine harvesters and newer combine harvesters • farms with their own combine harvesters and farms that rent combine harvesters Measured values are scaled up using reported harvest statistics.	Grain weight
Procuringcompanies	Mass balance calculations (inflow of contracted milling-wheat - outflow of wheat sold as milling wheat)	Tonnes	Suggested to follow-up 2-year-old figures as there is a delay in terms of sales. The companies produce statistics from purchases and sales, the source data should be reliable. There are a few procuring companies who cover the entire market, it should therefore be possible to obtain data from all the companies.	Grain weight. No specification of the proportion of evaporated water out of the total storage loss.
Mills	Direct measurements or mass balance calculations	Tonnes	The companies compile statistics from purchases and sales, the source data should be reliable. A few mills cover most of the market, data from these mills should provide a reasonably representative data set.	Weight of wheat recieved. Weight of wheat delivered. Taking into account the proportion of wheat in flour mixes.
Bakeries	Direct measurements, mass balance calculations or surveys/interviews	Tonnes	If possible, the companies should compile statistics on the amount of wheat purchased and sales, as well as the calculation of the proportion of wheat in the finished product. Alternatively, interviews with companies or surveys, about the proportion sold as food and other usage.	Weight of wheat flour delivered to the bakery, taking into account the proportion of wheat in flour mixes. Weight of bread, biscuits, crackers, etc. for delivery, taking into account the proportion of wheat flour in the product. The mixing of wheat flour with other ingredients means that estimation of waste is done using a template. Weight of returned bread, estimation of waste using a template.

Method potatoes				
Levels/stakeholders	**Data source**	**Unit**	**Statistical data**	**Definitions**
Primary production	Compilation and analysis of statistics from Statistics Sweden on unharvested acreage and for damage by deer and herbivorous animals in the field.	Tonnes and proportion in %	All agricultural companies	
Primary producer	Waste survey in the field. Perform waste testing on approximately 15 farms with different types of capture systems. Several measurement boxes should be randomly selected in each field where the waste is measured. The measurement boxes should also be dug through to find potatoes that have been ploughed down and left behind.	tonnes/hectare	If it is carried out on a sufficient scale and on farms with small/large and new/old harvesters, it should be possible to scale up the results with the help of Statistics Sweden's harvest statistics.	Only tubers are weighed. Soil is removed as much as possible.
Primary producer	Survey or interview regarding waste in the warehouse and sorting before transportation to the packing plant. How much is discarded during sorting? Where do the discarded potatoes go? Why are they discarded? Reach out to many growers with a survey (> 100 respondents), through grower meetings. Ask local potato advisers for help disseminating the survey or that the survey comes from SJV (Statens Jordbruksverk). Interview with about 10–20 new potato growers about waste due to poor pricing and late order cancellations	tonnes (number of boxes)	It is important to reach both large and small potato growers in geographically important potato growing areas. The downside is that the values are estimated and subjective. On the positive side, it can provide a lot of information from a large number of growers.	Growers of autumn/ winter potatoes Growers of new potatoes
Packing plants	Collect data from packing plants. These indicate how much is discarded, where the discarded potatoes go and in what quantities, and why they are discarded. The goal is to send the survey to the 50 companies affiliated with Svensk Potatis (SMAK).	tonnes	Optimal if all packing plants provided information, but otherwise small/large packing plants and packing plants in the densely populated regions must be included. Participation from several parts of the country is important as the potential to use discarded potatoes depends on the proximity to different industries.	
Industry/wholesalers	The voluntary agreement SAMS includes some major companies/wholesalers in the potato industry. One option is to contact the processing industry with surveys, as described in Chapter 5.9.	tonnes	Hopefully, additional companies/wholesalers within the potato industry can be included in this partnership so that more comprehensive data can be collected.	

Method carrots				
Levels/stakeholders	**Procedure/data source**	**Unit**	**Statistical data**	**Definitions**
Primary producer; field	Field survey at growers' companies, with several fields included at each company. About 15 large/medium-sized companies, and three fields per company. Experimental plots should be assigned randomly in each field shortly after the harvest is carried out, and the remaining products in each experimental plot are weighed. Any discrepancies in the fields should be noted. Data is obtained from the producers on the estimated harvest per hectare.	Tonnes/hectare	Fewer companies/fields in the survey will make the data more uncertain. If possible, companies with different harvesting machines should be selected. Counties with high production should be selected.	Carrots without tops should be included. Soil on the carrots remaining in the field should be removed as far as possible.
Primary producer; packing plant/warehouse	Five to ten larger growers' companies should be asked to report losses during sorting, which can occur during sales immediately after harvest, or following storage. The companies will report estimated harvest before storage by the number of bins stored and the average weight in total when sorting per bin, as well as sorting results divided into: food, fodder carrots, waste for composting or biogas, and other uses. Cultivated acreage should be reported, and any unharvested acreage should also be reported.	Tonnes/hectare	The larger companies often have the opportunity to produce their own sorting statistics, and frequently store and sort for smaller companies, which is why the data should be reliable. Fewer companies entail greater uncertainty in terms of representativeness.	Carrots without tops should be included. Storage losses in the form of evaporated water should not be included.
Wholesalers	Wholesalers should be asked e.g. via Samarbete för minskat matsvinn, about the reporting of losses to the Swedish Board of Agriculture. The companies should report the proportion of the products received (by weight) that do not go on to the retail sector or restaurants/the catering industry. In addition, how large a proportion in weight that is rejected on arrival in connection with quality control of lots should be reported, and if the company is an intermediary, how large a proportion they get back and what happens to this.	Tonnes, as well as % of products received	Companies are usually able to produce statistics from purchases and sales, which is why the source data should be reliable. Upscaling to the national level can lead to more uncertain data due to considerable diversity in distribution channels.	Carrots without tops should be included.
Food companies	Survey or data collection with the larger companies. The companies should report the incoming weight of carrots and estimated waste in production. Furthermore, how much of the waste is used for animal feed or goes to biogas should be reported. The weight of rejected goods during quality control on arrival should be reported. On-site investigations should be carried out in collaboration with certain companies to estimate on-site losses and their causes.	Tonnes, % of received products	It is difficult to estimate the reliability of the data, as this is due to the difficulty that companies have estimating this in different processes.	Carrots without tops should be included.

Method strawberries				
Stakeholder	**Procedure/data source**	**Unit**	**Statistical data**	**Definitions**
Primary producer	Survey Data obtained through the survey: 1a) the percentage of cultivated land that is not harvested. 1b) the reason why the land is not harvested. 2a) the percentage of cultivated land harvested by consumers picking strawberries. 2b) the reason why the land is harvested by consumers picking strawberries. 3a) the quantity (kg) and the proportion (percent) of picked strawberries that are neither picked by the purchasers nor sold directly to consumers. 3b) the reason why the picked strawberries were not collected/sold	1a) percent 2a) percent3a) kg and percent	Most of the growers will be included if the survey is conducted in connection with LRF Trädgård's berry course. If this is not possible, we recommend that 20 growers be interviewed by phone instead.	
Primary producer	Field survey of growers About 10 companies with employed pickers and picking by consumers should be selected in collaboration with LRF Trädgård. Many companies use both of these picking strategies and can therefore be used for both measurements to minimize the number of trips. At each grower, ten small plots should be randomly selected per picking method (employed pickers/picking by consumers). Each small plot should consist of two metre-long rows of plants. These small plots will be checked as soon as possible after harvest. The strawberries left in each small area should be weighed. Based on the amount of strawberries left in the small plots examined, the total amount of strawberries left (kg) per hectare can be estimated. The proportion (percent) of waste can be calculated by dividing the amount of strawberries left by the total amount (harvested + strawberries left behind). Data on the amount of strawberries harvested can be obtained from the grower.	kg/hectare percent	Smaller samples from many growers are preferable to large samples of stock from a few growers.	Only ripe strawberries are weighed. Unripe fruit is excluded.
Retailers	NB: this potential survey is only recommended if sufficient funds are available. Data collected through the survey: 1. Quantity of strawberries sold. 2. Estimated waste in the store. 3. Estimated waste at the central warehouse. The supermarket chains already have internal statistics – either centrally (e.g. Axfood) or at the store level (e.g. ICA). In instances where data is only available at the store level, a number of representative stores should be contacted. Results for all stores within the Group can then be scaled up through statistical modelling.	1: kg 2: kg and percent 3: kg and percent	Warehousing and retail are dominated by the three major chains.	

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