

LITERATURE LIST

Report summaries from the Swedish Food Waste Reduction Project 2013-2015

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National Food Agency



Swedish Board of Agriculture



Swedish Environmental
Protection Agency

Summaries of reports from the Food Waste Reduction project 2013-2015

Contents:

Final report – Government assignment for reduced food waste 2013-2015. A good start.....	3
What is food waste within poultry meat and egg production?	6
Reduced Food Waste – environmental benefits and cost saving	7
Managing avoidable food waste. Data, measures, and policy instruments, as seen in the Nordic countries, Great Britain and the Netherlands.....	11
Losses of Swedish beef – from primary production to slaughter	15
Waste of iceberg lettuce in primary production and retail	17
Why do we throw away fruits and vegetables unnecessarily? Food waste and Trade standards in fresh fruits and vegetables	18
Food waste and Trade standards in fish and shell fish	19
Actions for reduced food waste in the food industry – a perspective from the industry and food chain.....	20
Waste reducing actions in the food store – effects on quantity, economy and climate	22
What effect would a lower temperature in the cool chain have on food waste?.....	23
What is discarded when durability date is passed? – a microbial survey of selected refrigerated foods	25
Food and drink disposed to the drain – a questionnaire to Swedish households	26

Earlier reports relating to waste from Swedish governmental agencies

Store the food correctly and it will last longer – scientific background concerning optimal storage of food.....	28
Avoidable food waste in households and schools	31

Final report – Government assignment for reduced food waste 2013-2015. A good start.

Summary

The current level of food waste equals about one third of all food produced in the world today. This is a waste of resources such as water, land, energy, manpower and capital which in turn, leads to unnecessary emissions of greenhouse gases and contributes to the global climate change. In a world where the population is heading towards 9 billion, production areas ought not to be used to produce food waste. According to recent surveys in Sweden, the amount of food waste produced by retailers, restaurants and households is beginning to decline, possibly through the contributions of the government assignment and the work involved with this.

Together with the Swedish Board of Agriculture and the Swedish Environmental Protection Agency, the National Food Agency Sweden was given a three-year assignment to find ways in which to reduce food waste. The assignment incorporated the following five key areas:

1. Analysing of opportunities and possible obstacles

According to the results of a number of surveys carried out as part of the government assignment, there are many ways in which to reduce food waste. A summary list of waste reducing measures that could be implemented at various stages in the food chain has been developed and distributed. The National Food Agency Sweden has together with other stakeholders revised current guidance on food handling so as to facilitate the compliance of regulations while avoiding unnecessary food wastage.

2. Information campaigns targeted at consumers

Based on the results of the many consumer surveys carried out, considerable efforts of different kinds of communication activities have been taken to inform and raise awareness among the consumers. The National Food Agency Sweden's website has incorporated a number of highly frequented pages offering advice to consumers about food waste. An online consumer awareness campaign was also conducted via the website of www.stoppamatsvinnet.nu. The campaign was successfully advertised and promoted via social media. The work within the government assignment has generally enjoyed good media coverage, both in terms of the subject area itself, the consumer awareness campaign and the launching of various reports.

3. Increased collaboration between different stakeholders

A close dialogue has been maintained with stakeholders in the Collaboration Group for Reduced Food Waste (Samverkansgruppen för Minskat Matavfall (SaMMA)), a network that has grown and now includes around 80 different organisations such as food manufacturers, distributors, retailers, restaurant owners and caterers, researchers and authorities. This forum has increasingly provided opportunities for interaction between stakeholders and the exchange of knowledge and experiences. The surveys carried out within the framework of the government assignment has provided a valuable basis for constructive discussions and knowledge development.

The fact that three government agencies, i.e. the National Food Agency Sweden, the Swedish Environmental Protection Agency and the Swedish Board of Agriculture, in addition to the Collaboration Group for Reduced Waste, have worked together on the government assignment to reduce food waste, has led to a common understanding and enhanced cooperation.

In addition to working with the Collaboration Group for Reduced Waste, a working group was set up to promote a lower cold chain temperature with the aim of further reducing food waste. The objective is for a lower cold chain temperature to be in force by 2020, thus extending the shelf-life of food products. The government agencies have also been represented at various seminars, fairs and events, providing facts and information about food waste. This, together with the dialogue held with individual stakeholders, has led to a high level of relationship building and increased knowledge. A dialogue has also been held with food waste stakeholders in other countries as a result of which, the agencies have contributed to the work on food waste within the EU and internationally. Furthermore, the Swedish Board of Agriculture has initiated an international working group on the impact of trading standards on food waste.

4. Spread information about good practices

Examples of good practice have been distributed to stakeholders at different levels in the food chain, including municipalities and county councils, through the websites of the government agencies, the network Collaboration Group for Reduced Waste, webinar, conferences and meetings. Many examples of good practice can be found in the surveys carried out and published as part of the government assignment. Stakeholders have been given access to a PowerPoint presentation with basic facts and examples of different food waste reducing measures. A factual document with recommendations on how to avoid food waste in various professions and providing inspiration for individual municipal efforts have been distributed to various municipalities. The Swedish Environmental Protection Agency has launched a website with a number of practical guides, videos and advice on how to reduce food waste.

5. Promote the increased use of unavoidable food waste for the production of biogas and utilisation of digestate

Online material about better utilisation of unavoidable food waste has been produced and distributed.

Future work opportunities

According to a survey carried out among stakeholders, most of them are appreciative of the work carried out in connection with the government assignment. A number of the stakeholders claim, for example, to have great confidence in the knowledge base generated by the assignment and see the work as a good start to a long-term process. This is a view that is shared by the agencies involved in the work with the government assignment.

The fact that three government agencies, i.e. the National Food Agency Sweden, the Swedish Environmental Protection Agency and the Swedish Board of Agriculture, have been working together on the government assignment has not only led to the efficient utilisation of resources but has also been valuable in the process of finding overall solutions. This type of interagency cooperation is equally important for the work in future. In 2016, upon completion

of the government assignment, it is the intention of the agencies involved to continue promoting and working, at a basic level, for a nationally reduced food waste. However, such work would essentially be limited to the continued efforts of the Collaboration Group for Reduced Waste and the agencies themselves. It would not involve an in-depth dialogue with stakeholders.

There is, however, a need for a long-term strategy on how Sweden could best fulfil its commitment to reduce food waste in line with Sustainable Development Goal 12.3, i.e., to halve the per capita global food waste at retail and consumer levels by 2030 and reduce food losses along production and supply chains, including post-harvest losses. Reducing food waste is also an important part of the development towards a circular economy. The European Commission's Communication on Circular Economy proposes that actions are taken in order to achieve target 12.3 of the United Nation's Sustainable Development Goals.

It is proposed that Sweden's long-term strategy for reducing food waste should be based on the following: The overall assessment of interagency cooperations within the government assignment, the experiences gained as summarised in this report, the opinion and feedback of the Collaboration Group for Reduced Waste and the Swedish Environmental Protection Agency's Report to the Government on proposed interim targets for 2013. Based on the above, it is further proposed that such a strategic approach to the reduction of food waste should take the following into account:

- **Communicate food waste reduction target.** Sweden has committed to fulfil target 12.3 of the UN's Sustainable Development Goals and halve per capita global food waste at retail and consumer levels by 2030 and reduce food losses along production and supply chains, including post-harvest losses. This needs to be communicated in order to drive the development forward and support the food waste prevention work of the stakeholders.
- **Collaboration.** There is also a need for a more in-depth dialogue with different stakeholder groups and an ongoing participation in various collaborations within the EU and internationally. There is a need to work with interrelated food waste issues in the food chain and among stakeholders.
- **Knowledge base.** To allow for the monitoring of future developments, it is essential for recurrent food waste surveys to be carried out at different levels in the food chain. At present, there are knowledge gaps in, for example, public procurement opportunities to prevent food waste and interrelated food waste issues in the food chain where the implementation of surveys would provide increased opportunities for the reduction of food waste. Another possibility would be to investigate 'exported' food waste to ensure that other unnecessary food waste is not generated in producer countries as a result of actions taken by companies in Sweden.
- **Communication and tools.** Long-term communication activities are essential if consumers are to be able to change their behaviours and reduce food waste in their own homes. Stakeholders are asking for practical and readily available tools such as educational material, videos, easy to follow guidebooks, advice and tips for different target groups.
- **Application of regulations.** It is important that the work on the application of regulations and food controls continues in order to provide retail businesses, caterers and restaurants as well as inspectors with the necessary guidance. It is equally important to continue the dialogue about cold chain temperatures in order to realise the ambition of a lower refrigeration temperature by 2020.

What is food waste within poultry meat and egg production?

Summary

Food waste in this report is all parts from poultry that could potentially be used as food in Sweden, but isn't. With this definition there is no food waste within poultry meat production. Within egg production food waste appears when:

1. Healthy breeding animals and hens at the end of lay are taken out of production and not being sent to slaughter.
2. Day old male chicks are killed at the hatchery when sex is determined.

Why is food waste generated?

Whether laying hens are sent to slaughter or not is dependent on economic factors and the distance to an abattoir that slaughter laying hens. With the current transportation regulations hens from the Northern part of Sweden cannot be sent to slaughter, thus they must be killed at the production farm. The risk of hens being injured before and during transport also affect the possibilities for sending them to the abattoir.

Half of the chicks are male and they do not lay eggs. Only female chicks and a few male chicks are needed in egg production. There is no or little demand for male chicks and thus they are killed at the hatchery.

How much food waste is generated?

Approximately 67 per cent of the hens after the end of lay are used within food production which makes 33 per cent food waste. Animals that are not sent to an abattoir are disposed or used for mink feed in Denmark. In areas where an abattoir lies within a reasonable distance, 72 per cent of the animals are slaughtered and the food waste is 28 per cent. In Sweden 5,6 millions of laying hens are replaced each year. Nearly the same amount of male chicks are killed and destroyed at the hatcheries each year.

Is it possible to reduce food waste?

In order to reduce the food waste in poultry egg production we need to seek possibilities to use a larger share of the laying hens in food production after the end of lay.

If the production time for the laying hens were longer, fewer animals would be needed each year. Fewer animals hatched each year would result in fewer male chicks hatched each year. Thus food waste would be reduced, but this also leads to a lower egg production per day for the hen, since a hen lay fewer eggs with higher age.

There is research going on to come up with methods to determine sex before hatching. Efforts have also been made to raise male chicks for food production, but they grow slower and have higher digestibility than broilers, which makes such production less profitable.

Reduced Food Waste – environmental benefits and cost saving

Summary

In this report we calculate the gross benefit of decreasing food waste by 20 % in all parts of the food distribution chain (“the food chain”) except for primary production. Hence the food production industry, grocery stores, restaurants, institutional kitchens and households are included in this analysis. The gross benefit is calculated as the sum of economic savings for firms and households and the value of the avoided environmental costs associated with the decrease in food waste. Costs for measures to reduce food waste are not included in the analysis. The 20 % goal is based on Sweden’s proposed milestone target for food waste reductions.

Food waste is assumed to consist of two parts; unavoidable waste (such as coffee grounds and bones) and unnecessary waste (all food that could have been eaten if treated differently). The sum of these is referred to as total food waste. We further assume that reductions in total waste can only be made in the unnecessary waste category.

In table S1, the main results from the analysis are summarized, based on two scenarios for reductions. According to the analysis and the assumptions made, a 20 % reduction of food waste in Sweden during 2012 would have resulted in benefits of approximately 10 – 14 billion SEK, of which economic savings for firms and households are assessed to approximately 7,6 – 8,6 billion SEK and the benefits from reduced environmental impact are assessed to approximately 2,3 – 5,8 billion SEK. For reduced greenhouse gas emissions, the interval is wide, from approximately 60 million SEK to approximately 3,3 billion SEK. The width of the interval is explained by uncertainties associated with template values for the damage cost associated with the emissions. It is not possible to conclude which point in the interval represents the actual damage costs the best. Scenario 1 implies that each stage of the food chain decreases *total food waste* by 20 %. Since *unnecessary waste* makes up different portions of the total waste for the different stages this implies that the reductions differ across the sectors. However, a 20 % decrease of the total food waste leads to a decrease in the unnecessary waste corresponding to 34 %. In Scenario 2 the *unnecessary food waste* is instead decreased by an equal amount, 34 % in all stages. One should note that these are only two possible ways of achieving a 20 % total reduction of food waste and since costs of reductions are not considered in this report they do not represent any “optimal” solution with regards to economic efficiency, merely two examples.

Table S1. Total yearly gross benefit in millions of SEK

		SCENARIO 1 All sectors decrease waste by 20%		SCENARIO 2 All sectors decrease unnecessary waste by 34 %
		Min (million SEK)	Max (million SEK)	
Cost reductions		8 564	8 564	7 634
Avoided environmental cost	Greenhouse gas	60	3 365 emissions	59
	Eutrophication	1 643	1 643	1 643
	Acidification	133	133	131
	NMVOG	19	56	19
	Human toxicity	0,3	65	0,3
	Ecological toxicity	494	494	494
	Total environmental	2 348	5 756 benefit	2 345
Total benefit		10 912	14 319	9 979

Note: For some of the environmental template costs the minimum and maximum values are identical due to the template being reported as a point estimate and not a range, see table 6.

There are several reasons for using two reduction scenarios to reach the 20 % reduction goal. Firstly as an illustration that there is more than one way to achieve the goal and that the choice of method will have different implications, possibilities and problems. Earlier studies have primarily studied a situation similar to Scenario 1 which warrants its inclusion for comparison purposes. Secondly, the use of several scenarios grants the possibility to study distribution effects. Thirdly, it is of general policy interest to observe how the waste is distributed, and can be reduced, over the stages of the food chain. In general we conclude that Scenario 2 implies greater savings in the food production industry and retail stages but that total savings are larger in Scenario 1. This is due to that Scenario 1 implies greater reductions for households whose waste is the most “valuable” given its place at the top of the food waste hierarchy.

This report implies an update when compared to earlier efforts, based for example on new data and newly developed template costs for environmental damages. This report is also the first Swedish report to include data on liquid food waste for households.

In table S2, the underlying food waste data and the two scenarios are outlined.

Table S2. Decrease of total food waste by 20 % in each sector (Scenario 1) and a 34 % decrease of unnecessary food waste in each sector (Scenario 2). In tons, all data for 2012 except when otherwise noted.

	Total waste 2012	Total unnecessary of waste 2012 to	SCENARIO 1 Required reduction of unnecessary waste to	SCENARIO 2 Required reduction unnecessary waste
	Tons	Tons (% of total	achieve 20 % total waste reduction Tons (% of unnecessary	achieve 34 % reduction of unnecessary waste in all stages Tons (% of unnecessary waste)
Industry*	183 654	183 654 905 (100 %)	36 731 (20 %)	61 (34
Retail	70 000	63 700 471 (91 %)	14 000 (22 %)	21 (34
Restaurants	142 000	88 040 676 (62 %)	28 400 (32 %)	29 (34
Institutional kitchens	58 000	30 160 166 (52 %)	11 600 (38 %)	10 (34
Households**	995 365	494 215 586 (50 %)	199 073 (40 %)	166 (34 %)
Sum	1 449 019	859 769 804 (59 %)	289 804 (34 %)	289 (34 %)

*No updated data for 2012, data for 2010 is used and inflated by the average growth rate of waste in the other stages in the food chain between 2010 and 2012. Naturvårdsverket (2012) state that the industry in 2010 created 171 000 tons out of which 100% should be considered unnecessary.

** Includes liquid waste for the households (224 365 tons) out of which 100 % should be considered unnecessary. These data are for 2014.

The analysis of benefits rests upon a number of assumptions. Here three crucial ones are addressed. Firstly, we assume that the total gross benefit consists of cost savings for firms and households and the value of avoided environmental damage costs due to decreased production. Secondly, waste reductions in one stage of the food chain are assumed not to have any direct influence on the waste in other stages of the food chain. Thirdly, waste reductions are assumed to lead to decreased production and hence a smaller environmental impact. The analysis disregards any general equilibrium or rebound effects.

This implies for example that no analysis is made on how households choose to spend the additional available income that should follow from decreased spending on food.

Calculating and analyzing environmental benefits presents a substantial challenge. The analysis is founded on template figures in two stages. First concerning the environmental impact from food waste and secondly concerning the monetary value of this impact. Environmental costs are divided into greenhouse gas emissions, eutrophication, acidification, photochemical oxidation (NMVOC), human toxicity and ecological toxicity. For the environmental impact of food waste, the calculations are based on Naturvårdsverket (2012), who in turn base their estimates on data from BIOS (2010) and ETC/SCP (2009). For monetary valuation, we suggest that the setup of values reported in Ecovalue (Noring, 2014) provides the most thorough template for the context. Earlier studies have used templates based on existing environmental taxation (ECOTAX, Finnveden et al., 2006) and

Swedish National Food Agency

transport sector environmental impact (ASEK, Trafikverket, 2015) and while we include these for comparison we argue that Ecovalue is a more appropriate measure based on its independence of impact source and its focus on avoided damage cost as a measure of benefits.

A number of potential sources of errors and uncertainties are identified in the report. The largest uncertainties are related to data on waste quantities, estimates of how much waste is unnecessary, the environmental impact from food waste, and the damage costs caused by these impacts. The aforementioned assumptions are also simplifications and are likely sources of uncertainties. The disregard of general equilibrium and rebound effects is one such prominent example.

The study has been produced by Enveco Environmental Economics Consultancy (Linus Hasselström and Erik Wallentin) on behalf of the Swedish Environmental Protection Agency. The project has been funded by the Swedish National Food Agency as a part of a government-instigated assignment to the Swedish National Food Agency, the Swedish Board of Agriculture, and the Swedish Environmental Protection Agency, to reduce the unnecessary food waste in all stages of the food chain. The authors are solely responsible for content and conclusions of in the report.

Managing avoidable food waste. Data, measures, and policy instruments, as seen in the Nordic countries, Great Britain and the Netherlands

Summary

Currently, we throw away large amounts of food, which with different handling could have been consumed as intended. If the food that we discard unnecessarily was consumed instead, human impact on the ecosystems that support us would be reduced. This would diminish the environmental impact from the entire food production chain – including production, distribution, consumption and waste management. In a wider perspective, food produced then could contribute to the needs of more people without increased environmental impact. Discarded food also represents a significant economic cost throughout the food chain. Reducing avoidable food waste can also influence the waste streams society produces, improving resource efficiency and thereby making our consumption more sustainable, and further contribute to attaining the Swedish generational goal, and the national environmental quality objectives. The most recent estimates indicate that in 2012 food waste in the Swedish food supply chain (except in the primary production) totalled more than 1.2 million tonnes, equal to 127 kg per capita. Households give rise to the largest single amount of food waste, corresponding to 81 kg per capita. Of the amount from the household sector, a proportion of 35% is considered unnecessary, or avoidable food waste. Moreover, food and drink rinsed down the drain is not included in this figure. Not only do households throw away large amounts of food, but their impact is amplified by influencing the large waste streams produced upstream in the food supply chain, thus indirectly causing more food waste. Therefore, designing measures to stimulate change in household attitudes and behaviours, along with technical and organisational solutions that facilitate these changes, becomes particularly important.

Studies and initiatives regarding total food waste and avoidable food waste in the Nordic countries, Great Britain, and the Netherlands is reviewed – highlighting causes, measures and policy instruments, as well as examples from every link in the food supply chain. Various aspects of packaging, storage, and transports are also addressed.

Different aspects of definitions and delimitations, among other things between different parts of the food chain are discussed. Consequences of various approaches are discussed including the consequences of defining a fraction “possibly avoidable food waste” in accordance with regional cultural traditions. The purpose of definitions and delimitations is to visualize the flows that can be avoided, and to create incentives for doing so. Moreover, in the report it is discussed how different approaches can hide measures that return food to human consumption, and contribute to shifting focus from or reducing emphasis on these flows when designing measures, monitoring, and policy instruments.

Also various aspects of methods for measuring unnecessary or avoidable food waste are discussed in the report. In this context it is important to emphasise absolute changes rather than the current preferences of emphasising percentage change, since large percentages can actually represent small absolute changes, while smaller percentages can represent large absolute figures. The report summarises policy instruments that are possible to apply in order to control and to stimulate measures designed to reduce avoidable food waste, for example support to

municipalities to establish advisory functions, communication efforts, clarification of national guides and guidelines, studies that give the factual base for establishing more on-site kitchens in for example schools and hospitals, voluntary agreements that include commitments as well as support, changes to food pricing patterns, and the revision of existing and development of new regulations.

Suggestions for a series of specific studies on various types of stakeholders and links in the food supply chain are included, proposing cooperation within and between links. Generally, more quantitative data and more specific measurement of various products are needed that we today lack, or that we cannot judge whether possible to estimate using data from other products or not. The report also includes suggestions for more research to confirm current understanding or to provide greater precision, all to acquire improved quantification and reduction of uncertainties in estimates, monitoring, and priorities. There is need to verify assumptions and standard conversion factors used in various fields. Data is perishable, and it is important to ensure that assumptions and data used in monitoring do not affect the findings of the monitoring. Food and drink that is rinsed down the drain need to be measured and included in studies, measures, and monitoring. Determining whether the increases or decreases in food waste and wastage correspond to real change requires determining the amplitude of background variation. This includes the need to study variations in patterns over the year, between locations across the country, and within conversion factors.

There is a risk that effects of measures meant to stimulate changed behaviours, for example personnel education, fade over time. Thus, studies are needed to determine how long behavioural changes remain, and how they change over time. Moreover, tools or packages of measures need to be developed that include partial steps to make these changes last longer and eventually becomes the norm. With regard to behavioural changes, we need to study actual behaviour by using for example walk-along-studies, providing direct observation of behaviour rather than (as is often the case today) relying on answers from interviewed persons on how they experience and say that they act.

Many proposals for measures in each stage of the food chain are considered in the reviewed studies such as:

Primary production:

- Surveys determining how regulations covering feed and by-products indirectly impact food waste associated with primary production
- Advice to and collaboration between farmers
- Husbandry that brings good animal health, and careful harvesting and storage
- Fast chilling after harvesting is appropriate for many fruits and vegetables
- Developing products and markets for goods that are not currently utilised, such as horse meat and fishery by-catch
- Improving production planning and harvesting fields several times to reduce overall surplus production

Processing

- Advice and knowledge sharing
- Technical development
- Revised regulatory framework, such as for date labelling

Swedish National Food Agency

- Review how by-products can be used in product development
- Improved hygiene and cleaning when switching between products in production lines
- Closer collaboration between buyers and suppliers to improve forecasting and implement greater flexibility in ordering
- Review contracts including returns for unsold goods
- Packaging development

Wholesale and Retail

- Review the number of items offered in different product categories
- Review quality requirements that cause unnecessary food waste due to inflexibility in relation to natural variations of the product
- Careful handling and exposure of products to avoid damage
- Increased use of production planning tools in collaboration with suppliers and utilise the potential of using digital order tools
- Revising discount offerings concerning volume and package sizes
- Incorporating avoidable and other food waste issues into environmental work
- Ensuring that clear responsibilities exist for avoidable and unavoidable food waste issues
- Information directed at consumers

Institutional and Commercial Kitchens

- Remove the separate plate at the salad buffet
- Measure and follow up, keep statistics to successively increase planning precision and to remove from the menu meals that are not eaten
- More flexible demand for fruits and vegetables of varying quality
- Combining purchasing planning and menu planning
- Storing raw products and prepared food in the correct environments
- Preparing portions in correct sizes, prepare food in successive batches and offering food in different sized portions
- More kitchens where all food is prepared on-site that can quickly adapt the number of portions and prepare food as needed
- In the kitchens that take delivery of some components or all of the lunch, prepare pasta, rice and potatoes on-site to avoid waste of these
- Improved reporting of student absence in advance of preparing school lunches
- Information and positive feedback to staff and customers
- Offering customers the opportunity to take left-overs with them

Private households

- To reassess preferences of cosmetically perfect foodstuffs in all situations
- To eat as much of the product as possible, such as eating the broccoli stem, and learning to prepare these to be more appetising
- Empty packaging completely
- Selecting longer 'best before' dates for food planned for farther in advance, and shorter dates for food planned for sooner
- To understand the information contained in date labelling, and relying on your own senses rather than strictly following the 'best before' date
- Maintaining correct temperatures and placing chilled products correctly in refrigerators to reduce the likelihood of spoilage
- Implementing knowledge and information about storage, food preparation, portion sizes and utilising left-overs creatively
- Planning shopping using meal plans and shopping lists, and checking what food is available in advance

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This study was conducted as part of a government mission during 2013 to 2015 that was given to the Swedish National Food Agency (Livsmedelsverket) in cooperation with the Swedish Board of Agriculture (Jordbruksverket) and the Swedish Environmental Protection Agency (Naturvårdsverket, SEPA), with the aim to reduce avoidable food waste throughout the food supply chain. This project was financed by the National Food Agency and SEPA.

Losses of Swedish beef – from primary production to slaughter

Summary

Losses in primary production increase the environmental footprint of food. Beef production has a significant climate impact and therefore it is important to identify the losses occurring in the beef sector. This report describes and quantifies losses in the production chain for Swedish beef from farm to slaughter. This includes losses in the form of stillborn calves, calf mortality, deaths among older animals and rejects in inspections before and after slaughter. It also includes handling of food-quality meat by-products at slaughterhouses.

Of the total number of beef animals born in 2012, at least 18 percent were stillborn, died of natural causes or were put down. In terms of live weight, around 24 000 tons of animal were lost, corresponding to approx. 12 000 tons of slaughter weight (meat and bones). Relative to total slaughtered weight in 2012, the losses represented 9 percent. If the Swedish beef production system had suffered no loss of animals 2012, it could have produced the same amount of meat with 220 000 ton CO₂e lower climate impact. For comparison, the combined effect of measures carried out within the Swedish Environmental Protection Agency's climate investment programme² (1998-2012) was 630 000 ton CO₂e/year, and the Swedish interim goal for limiting the climate impact requires greenhouse gas emissions in 2020 to be 20 million ton CO₂e lower (for sectors not trading in emissions rights) than the 1990 level. While total elimination of all losses within the beef production sector is not realistic, it is clear that decreasing losses in the sector could make a considerable contribution to the interim environmental goal.

Calf mortality is high at calving and in the first month of life. There are several reasons for that. Stillborn calves are more common among calving heifers than cows that have calved before. Mortality is also higher in the dairy industry than in the meat industry. This is partly due to the fact that some dairy calves are being put down at early age because of economic aspects. However, the majority of calves that die of natural causes or are put down are older than 6 months and they make up 85 percent of animal weight lost. The proportion of dairy cows that die or are being put down has increased and they now represent a significant proportion of total mortality in beef livestock. Rejection at slaughter is relatively low and mainly comprises rejection of whole animals (0.22 percent of carcasses inspected). Our investigation found that large slaughterhouses recover a large proportion of meat by-products for subsequent use as food, including exported parts. However, small slaughterhouses have fewer opportunities for utilising meat by-products. An animal must be healthy and able to stand on all four legs in order to be transported to the slaughterhouse. Animals that suffer injuries, but which are otherwise healthy, can be slaughtered on farm provided some specific conditions are met. However, this occurs to a very limited extent at present and instead the animal is destroyed, despite the meat quality probably being unimpaired. There is thus reason to discuss how a greater proportion of such animals could be returned to the food chain.

In order to formulate specific measures for decreasing losses in the beef sector, mortality should be recorded and monitored for different categories and age groups of animals. The Central Database for bovine animals (CDB) represents a unique resource and could be used to a much greater extent for annual monitoring of mortality within the beef animal sector. In addition to calf mortality, which is reported in annual statistical bulletins, it would be useful if mortality were reported for different age groups.

Finally, the unnecessary death of animals is an animal welfare problem, an economic problem for the farmer and a climate-related societal problem. Improved animal health could play an important role in decreasing losses within beef production, but also taking better care of the meat from animals being put down at farms could be a key to success.

Waste of iceberg lettuce in primary production and retail

Summary

Food that are wasted consumes resources and cause emissions in vain, besides the large economic values that are lost when the food is not eaten as intended. To reach the goal of 20 percent waste reduction from 2010 to 2020, there is a need for measures in all stages along the food supply chain together with a deeper knowledge of product specific causes for waste.

Iceberg lettuce is a product wasted in large amounts in supermarkets and has therefor been selected to be examined in detail in this report. The aim has been to investigate the losses incurred in the production of iceberg lettuce, and the main causes for this.

The losses of iceberg lettuce were measured on recently harvested fields where the losses was collected and later weighed. The field study was supplemented by interviews with producers to identify causes of lettuce discarded at harvest and why parts of the production were never harvested. To gain better understanding of lettuce losses and waste, this was mapped among wholesalers and retailers through interviews with company representatives, as well as by available literature. Life cycle assessment was used to calculate the global warming potential associated with lettuce produced in vain.

After harvest (19 t/ha), there were significant amounts (31.5 t/ha) lettuce residue left on the field. This consisted mostly of weeded outer leaves (28.3 t/ha), but also some whole lettuce heads (3.2 t/ha). Interviews showed that about 15 percent of the cultivated lettuce never was harvested. Taken together, this means that approximately 65 percent of the cultivated lettuce is lost during production. In addition, about 4 percent of the cultivated lettuce was wasted in the supply chain from producer to retailer.

The main reasons for loss of production in the primary production were insufficient quality (tip burn, rot, vermin), lettuce heads of incorrect size and bad matching between production and order intake. The main reasons for waste at distributors and wholesalers was insufficient quality (leaf edge burning, reddening of leaf veins, internal rot, insect damage) and handling damage.

The lifecycle of iceberg lettuce contributes with 0.44 kg CO₂-eq/kg product of Greenhouse gases. Introducing measures to avoid wastage and production losses have the potential to save 0.39 kg CO₂-eq/kg avoided waste and 0.15 kg CO₂-eq/kg avoided production loss. This is due to the large contribution of emissions from package and transportation which makes it less wasteful to sort out lettuce already in the field then wasting it at the retailer.

This study is carried out by the Swedish University of Agricultural Sciences, initiated by the Swedish Board of Agriculture and funded by the Swedish Food Agency. It is part of a Swedish food waste project which is initiated by the Swedish government and runs from 2013-2015.

Why do we throw away fruits and vegetables unnecessarily? Food waste and Trade standards in fresh fruits and vegetables

Summary

Food waste has received increased attention in the last years. In terms of fresh fruits and vegetables, trade standards are sometimes mentioned as one cause contributing to the waste. Trade standards are standardized product descriptions used by commercial buyers and sellers to facilitate communication about products that are not physically inspected by the buyer before the deal. The aim of this report is to discuss the reasons for waste of fresh fruits and vegetables, to what extent trade standards influence this waste and if possible to suggest measures to decrease the waste. The report covers the chain from production to retail. Several factors influence the amount of waste. Market requirements, i.e. the Requirements on appearance, variety, size, maturity etc. that wholesalers, importers and in the end consumers have, are essential as is the price they are prepared to pay for these products. In connection to harvest, products may be left in the field, or be discarded when sorted, either due to defects making them unsaleable or due to the price being so low that it is not profitable to sell them. If the marketed volume was lower, prices would increase and tolerances for defects would increase. A large marketed volume with low prices is however positive for consumers and for public health.

A central issue in relation to whether trade standards contribute to waste is to what extent trade standards reflect market requirements. If trade standards describe market requirements, these requirements exist irrespective of whether they are put down in trade standards or not. In this case it is mainly the market's requirements that cause the waste. Trade standards that are less strict than the market's requirements also have no impact on waste. If, however, trade standards do not reflect market requirements, but are stricter than these and thus prevent the sale of products, then they most likely increase waste.

We judge that trade standards only have a limited impact on food waste in the sector of fresh fruits and vegetables. This is based on the fact that retail chains that in Sweden answer for 80 per cent of food sold in Sweden have stricter requirements on quality than the lowest quality limit of trade standards. Only to a very limited extent do they buy products of a quality lower than category I. The lowest quality sold by the large retailer chains is therefore the lower limit of category I and not the lower limit of trade standards which is the lower limit of category II. It would be desirable to get traders, retailers and consumers to attach less importance to exterior qualities that do not influence eating quality. It is however probably not easy to achieve.

There are however a great number of practical measures that can be taken to decrease waste. Many of them are used already today but there is probably room for improvements; adjusting production to demanded quality, harvesting more than once, alternative outlets, correct cooling and management.

Food waste and Trade standards in fish and shell fish

Summary

Some captured fish and shellfish must not be sold as food, even though they are of approved food quality. This is because products that are comprised by a marketing standard have to fulfil its requirements. The most common reason why some fish must not be sold as food even though it is of approved food quality is that it is too small.

Common marketing standards for fishery products have been around for more than 40 years. The aim of the standards is to increase quality, facilitate trade and create fair competition. Yet, in discussions on food waste, marketing standards are mentioned as a factor that causes perfectly edible food to be disqualified from being eaten. In order to determine whether or not marketing standards contribute to increased food waste, one has to study their minimum marketing size requirements in relation to the biological minimum size requirements (minimum landing size), which aim to preserve marine resources.

This report notes that the marketing standard requirement on minimum marketing size in some cases may cause food waste, but not the other requirements of these standards (freshness categories, presentation, net weight, uniform lot). The minimum marketing size is often the same as the biological minimum size, and in those cases we believe that the requirement and any food waste caused by it are motivated by the aim of sustainable fishery. However, the minimum marketing size requirement of the marketing standards may cause unjustified food waste if it is smaller than the biological minimum size or if there is no biological minimum size. Considering the species and the capture areas for which those situations occur, our conclusion is that the marketing standards do not cause any significant food waste in Swedish fishery.

On 1 January 2014 a new common fishery policy entered into force. It made it clearer that the minimum marketing size requirements should correspond to the minimum conservation reference sizes (i.e biological minimum size), whenever there is one. This makes it clearer that the marketing standards are to contribute to sustainable fishery by ensuring that the market for fish and shellfish is only provided with products that are considered environmentally sustainable.

The reform of the Common Fisheries Policy includes the gradual introduction of a landing obligation. This ban is initially likely to result in an increase in the volume of caught fish and shellfish that are smaller than the minimum marketing size requirement. Such products must not be sold as food even though they would be edible, but they may be used as raw materials in e.g fishmeal. Since such products are cheaper, the sector has an incentive to use more selective tools. This development, and other measures are in time expected to reduce waste caused by the capture of fish and shellfish that are too small.

Actions for reduced food waste in the food industry – a perspective from the industry and food chain

Summary

Approximately one million tons of food waste is generated in the Swedish food chain. Part of this is avoidable food waste which could have been avoided, that is, edible food that is thrown away but could have been consumed if treated differently. The total amount of food wastage in the Swedish food manufacturing industry was for year 2011 estimated to 224 000 tonnes, which represent 3 % of edible parts of incoming raw materials and which is estimated to have a value of about SEK 2 billion. SIK also estimates that the food wastage in the industry, in a first step, can be reduced by 50 %. This has been validated by telephone interviews with three Swedish food producing companies who have already implemented the systematic working methodology suggested within this report. In a second step, further reduction of the wastage may be possible down to 25 % of today's level if the proper long term prerequisites can be arranged on a national level. The suggested control instruments are designed to create the long term prerequisites needed for achieving a total reduction of food wastage by 50-75 %, which means that the costs of food wastage in the food industry has the potential to be reduced by SEK 1-1,5 billion.

The control instruments suggested by SIK are:

- Governmental-financed program addressed to the food industry
- Research within the areas of Food Production and Supply Chain
- Management
- Dissemination of knowledge
- A platform/arena designed for operational collaboration on improvements
- of the supply chain with a holistic view

The causes of food wastage are at least hundreds, only within the food industry. In addition, there are causes related to the food supply chain as a whole and the complexity is high. The causes vary and are specific for the local conditions on site for each specific business. Therefore, it is not possible to generalize the measures needed to prevent food wastage to only a few single actions. The food wastage that is generated in the food industry can be divided into two main categories: (1) food wastage which the industry itself can affect and (2) food wastage by actor joint causes, meaning wastage which the industry cannot affect without collaboration with other actors since the causes are related to the fact that the industry is just one part of an interlinked chain.

Instead a systematic methodology is needed to handle the complexity and diversity behind the causes of food waste. For category 1, two measures can be generalized for the food industry. The first is an industry wide introduction of the validated and effective systematic working methodology (mapping causes of waste – root cause analysis – implementation of improvements) already implemented within some Swedish food producing companies. The control instrument *Governmentalfinanced program* aims to enable such an introduction. The control instrument food specific *Research* within the area of Food Production is suggested for building new knowledge that further wastage preventive actions need to be based on.

Regarding category 2, much of the knowledge needed is still lacking. Therefore, SIK suggests the instrument *Research* to understand the mechanisms in the food supply chain which drive food wastage. This will enable further reduction of wastage in the product and distribution flows from farm to fork. In Sweden today, very little research occurs within the area of industrial food production and the research occurring within Supply Chain Management is to a very high extent related to other sectors than the food sector. To be able to reduce the wastage further down to 25 % of today's levels, the Swedish food industry needs the same research support, to meet their challenges, as e.g. the automotive- and engineering industry already has been given. SIK also see a need for revising the forms of research financing within Sweden to make projects with a holistic perspective over the food supply chain better fit into the national research programs.

As the work with wastage reduction proceeds and new knowledge is built, the need to disseminate the new knowledge and most likely also to exchange experiences will arise. SIK therefore suggests the control instrument *Dissemination of knowledge*. The food supply chain has several cause chain reactions between different companies which in practice mean that some wastage occurs in one company but that the measure needs to be taken by another company. To deal with such supply chain effects, the control instrument *a platform/arena for operational collaboration* is suggested to be established. To reduce food waste in the Swedish food chains we must work with waste prevention in a more operational way within and between actors in the supply chain, but incentives are needed for the individual companies to take part in this work.

The instrument Government-financed program for the food industry has been estimated to cost about SEK 76 million per annum for six years when including 80 % of the 300 food manufacturing industries with twenty or more employees in Sweden. Since the costs for the wastage that can be avoided are counted in SEK "billions" and the costs for the Government-financed program are estimated to SEK "millions", the support program can be considered cost efficient. As a result of this, there should also be possibilities to invest in the suggested research.

SIK has within this study also been assigned to highlight the product safety and packaging issues. Prolonging shelf-life by decreasing temperature in the cold-chain would first need thoroughly made risk assessments since the temperature in the consumers' refrigerators cannot be controlled. SIK does not recommend a general prolongation of shelf-life with the aim of preventing food wastage, since such a change would rather increase the wastage than decrease it. The reasons is that increasing the shelf-life of products most likely would decrease the flexibility of the supply chain and thereby contribute to products spending more time in storages instead of the prolonged shelf-life being allocated to the end consumers.

Instead SIK recommends maintaining the shelf-lives as they are and instead increase the turnover of products through the supply chain. This would most likely decrease the amounts of wastage due to expired date labels. Regarding packages, SIK concludes that the formation of secondary packages can cause wastage in the later parts of the supply chain and also too large consumer packages. However, since these causes are not quantified in relation to other causes of wastage by other joint actor causes, such as expired date labels etc., it is not possible to rank the importance of different causes in relation to each other with the data available today.

Waste reducing actions in the food store – effects on quantity, economy and climate

Summary

Food that are wasted consumes resources and cause emissions in vain, besides the large economic values that are lost when the food is not eaten as intended. To reach the goal of 20 % waste reduction from 2010 to 2020, there is a need for measures in all stages along the food supply chain. In order to use the most efficient waste reducing measures, both the costs and the reduction potential of the measures need to be investigated. This project therefore aimed to describe and estimate the economic and environmental (here represented by greenhouse gases emissions) effect of six waste reducing measures, that could be implemented in supermarkets.

The measures were based on tested, described or proposed measures from the research project *Reduced food wastage in retail stores*, coordinated by the Swedish University of Agricultural Sciences, 2010-2013. In addition, charity donation was included, since this is an already establish measure. The six Willy's stores that participated in the main research project, wasted on average 86 tons per year and store (including reclamations). The waste reduction potential for each measure was calculated and related to the total waste to get the waste reduction effect. The cost efficiency per kg waste and per kg saved CO₂-equivalent was estimated. The evaluated measures were (reduction potential in brackets) :

- limiting the possibility to reclaim fresh fruits and vegetables (35 ton)
- donate food to charity (30 ton)
- increase the activity with the ordering system (6 ton)
- freeze and sell meat on a second hand market (1,5 ton)
- ban promotions on fresh fruits and vegetables (0,6 ton)
- sell minced meat as frozen instead of chilled (0,3 ton)

In comparison, limiting the possibility to reclaim fresh fruits and vegetables and give food to charity were the two measures with the largest ability to reduce the wasted mass. Increase the activity with the ordering system and limiting the possibility to reclaim fresh fruits and vegetables were the two measures with the largest ability to reduce the greenhouse gas emissions. The most cost efficient measures regarding wasted mass was to sell the special assortment of minced meat as frozen instead of chilled and to freeze and sell meat on a second hand market. Regarding reduction of greenhouse gases the most cost efficient measures was limiting the possibility to reclaim fresh fruits and vegetables (for the supplier) and increase the activity with the ordering system. Several of the investigated measures have a potential to increase the profit for the supermarkets. Many of the measures are possible to combine, but there will be less food to give to charity and to sell on a second hand market, if the waste is prevented on an earlier stage.

What effect would a lower temperature in the cool chain have on food waste?

Summary

Approximately one million tons of food waste is generated in the Swedish food chain. Part of this is avoidable food waste which could have been avoided, that is, edible food that is thrown away but could have been consumed if treated differently.

The goal of this project is to investigate how food waste in the retail and consumer level would be affected by a reduced temperature in the cold chain. The project is divided into three parts, an analytical model, a literature review and an interview study.

The analytical model shows that chopped green salad in a bag stored at 4 °C has a shelf life of 12–13 days. Raising the storage temperature to 6 °C shortens shelf life with 8–9 days, and at constant storage at 8 °C shelf life would be shortened with further to 6–7 days. The calculations also show that a “normal” home transport of about one hour at 12 °C (average value) has no detectable effect on shelf life.

The literature review compiles information on laws, food waste in stores and refrigeration in stores and households. According to current legislation, food producers are required to label their products with best-before date or expiration date and storage temperature. Product temperature must never, throughout the cold chain, exceed the temperature specified in connection with the date label.

The cold chain is often broken during transport from the store to the consumer’s home refrigerator. A study on how consumers keep food in their refrigerators shows that in almost half of the cases the food was stored at a temperature higher than the temperature on the package label. The survey also shows that many consumers do not know what temperature they have in their refrigerator, that the temperature is not the same on all shelves or how they best should store different foods in the refrigerator.

Studies show that temperature measurement, especially in open fridges in stores, can be difficult and that there is a risk that the groceries actually hold a different temperature than that shown by the temperature monitoring system. Lowering the temperature of a refrigerated display with uneven temperature could lead to a higher proportion of food waste due to frost damaged groceries.

The interview study is based solely on producers’ and store managers’ response, no measurements or inspections have been made. A reduced temperature in the cold chain would, according to producers, most likely involve extended shelf life for many chilled foods. The store managers believe that longer shelf life in combination with modified date marking on foods would reduce wastage of packed salad, packed delicatessen, minced meat and milk.

These four products are included in this study, but the reduction of food waste should reasonably apply to more products. Almost all the interviewed shops say that they probably could lower temperatures with their existing refrigeration equipment, but they also say that the risk of frost damage on the groceries, and also their energy usage, would increase.

A reduced temperature in the cold chain could allow food manufacturers to extend the shelf life date on their products. Longer shelf life, combined with modified date marking of products could reduce store waste of foods with date indication. A reduced temperature in the cold chain in combination with extended shelf life marking could reduce food waste for consumers who do not eat food, the date indication of which has been passed.

What is discarded when durability date is passed? – a microbial survey of selected refrigerated foods

Summary

Date labelling is one of the reasons for returns and rejections by actors in the food chain, for example retailers, wholesalers and households. Consumers today have high demands on food quality and many state they are afraid of getting ill from food whose durability date has expired. This contributes to the discard of foods that has passed durability date regardless of whether it is perfectly edible or not.

About one third of Swedish household food waste can be connected to date labelling. However, information about whether the discarded food is acceptable to eat or not is lacking. To increase knowledge about how much edible food that is discarded due expiration of the durability date, data on the incidence of spoilage microorganisms in various foods at expiration date is needed. As a first step, a small survey was performed where microbiological status in selected chilled foods at expiration date (best before-date or use by date) was investigated. First, the tested foods were stored in their unopened containers at the specified storage temperature until expiration date. Then, foods were analyzed for various spoilage microorganisms. When analyzing the foods, a simple sensory test was also made where overall impression, taste (not fresh meat), smell and appearance were assessed. A total of 98 samples from four different food categories were tested:

- Sliced, cured meats of pork, turkey and beef (19 samples)
- Fresh meat of beef, pork, chicken and lamb (18 samples)
- Fresh milk and cream (42 samples)
- Ready-to-eat mayonnaise based and fresh pasta- and bulgur salads (19 samples)

The presence of microorganisms and assessment of smell, taste and appearance varied between the products. The milk and cream products were often of good microbiological and sensorical quality. From this perspective, a longer shelf life for these products seems to be possible, which would reduce food waste. Some foods contained high levels of lactic acid bacteria and / or psychrotrophic (cold tolerant) microorganisms without affecting the smell and taste to any greater extent. Other foods were unacceptable to eat due to visible colonies of yeast and mould or presence of microorganisms causing bad smell and taste.

To some extent it was possible by means of smell, taste, and vision to decide whether the product was fit to eat or not. Most, but not all, investigated foods were edible at the expiration date. However, in some cases a slight quality deterioration in smell and taste due spoilage microorganisms was observed.

The advice *to taste* for determining whether a food is acceptable to eat is not always applicable. In this study, it counts especially for fresh meat. Further, cured meat products are refrigerated ready-to-eat foods with long shelf life in which *Listeria monocytogenes* can multiply. Persons belonging to risk groups for listeria infection are advised to follow specific dietary guidelines.

Food and drink disposed to the drain – a questionnaire to Swedish households

Summary

The consortium Swedish Environmental Emission Data (SMED) has conducted several studies to quantify the quantities of solid food waste in Sweden on behalf of Swedish Environmental Protection Agency (EPA). Different methods have been used for the production of statistics, for example waste composition analysis, environmental reports, surveys and interviews. Recently, the Swedish EPA published a summary report of food waste data; “Food Waste volumes in Sweden” (Swedish EPA, 2014). Food and drink disposed to the drain has not been included in studies before, neither from households nor from other sectors. Therefore, it has been unknown how large quantities of food and drink that take this route. Food and waste disposed to the drain is not included in the follow up in the Swedish milestone targets for waste, due to lack of data.

The Swedish Government has set up a milestone target for increased resource efficiency in the food supply chain. “Measures are to be implemented to increase resource efficiency in the food chain by ensuring that at least 50 percent of the food waste from households, catering facilities, shops and restaurants is separated and treated biologically so that plant nutrients are utilized, and where at least 40 percent is treated to recover the energy no later than 2018”. The proposal of an additional target is that the food waste should decrease with 20 percent by the year 2020, compared to 2010, in the whole food chain except primary production. In 2013 the Swedish EPA gave SMED the commission to conduct a pilot study to examine whether and how the quantities of food and drink disposed to the drain from households in Sweden could be quantified. SMED’s conclusion from the pilot study was that a questionnaire study was feasible and opportunities for an upcoming survey were presented. The aim of this study was to quantify food and drink waste disposed to the drain in Sweden in a year, in total and per person. Additional goals were to find out the frequency of different food and drink types thrown away, reasons for disposal and the differences in quantities between different types of households.

A paper questionnaire for households was developed and sent out to a random sample of 2050 people in Sweden, which should record the waste from their households. The households measured and recorded quantities of edible and drinkable food waste they disposed to the drain during four days. The survey contained instructions for respondents on how to fill in the survey. There were seven fixed categories of food and drink; dairy, coffee/tea, other beverages, sweet (ice-cream, smoothie etc.), sauce and soup, other liquid food waste and solid food waste. The respondents also recorded the reason they disposed food and drink down the drain. Only edible and drinkable food was recorded, which means that everything disposed of is unnecessary. This means for example that coffee grounds, tea-leaves and drainings from tins and meat juice were not included. The questionnaire was distributed and compiled during spring 2014. Households with macerators are not included in the calculations. This means that the total amount includes all households except those with macerators. A total of 515 responses were used to calculate the results.

Results show that around 224 000 tonnes of food and drink was disposed down the drain in a

year. This accounted to about 26 kg/person in a year or 0.5 kg a week. When comparing quantities of food and drink disposed to the drain with quantities through municipal solid waste collection (incineration and biological treatment) it shows that approximately 23 percent of the total quantity food and drink waste are disposed by households via drains. In food waste through solid waste collection is both unnecessary and unavoidable food waste included.

Earlier studies have given the result that about 35 percent (270 000 tonnes) of the food waste from households going to incineration and biological treatment is unnecessary food waste. If the 224 000 tonnes found in this study is included, it gives that about 50 percent of the food waste from households are unnecessary.

The largest quantities of food and drink disposed to the drain were coffee/tea, dairy products and other beverages. Nearly 40 per cent consisted of coffee/tea, 25 percent of dairy products, and 10 percent of other beverages (e.g. juice, carbonated drinks and alcoholic beverages). After that followed solid food waste (such as rice, pasta and cereals) sauce and soup. The smallest amounts were other liquid food waste and sweets. The results further showed that 70 percent of the waste was discarded because of leftovers from cooking etc., 26 percent were discarded because the item was old or had expired date, and four percent was discharged for other reasons.

The type of household which disposed the most per person were one-person households (32 kg/person and year), followed by two- and three-person households who disposed quite similar amounts (26–27 kg/person and year). Households with four people disposed 24 kg/person and year and finally five person households through the least, 15 kg/person and year.

Store the food correctly and it will last longer – scientific background concerning optimal storage of food.

Summary

The purpose of this report is to summarise current knowledge about optimum storage of various foods in relation to how they are handled by households. The report serves as a basis for the effort by the National Food Agency to develop advice for ways that consumers can minimise avoidable food waste by means of proper storage. Avoidable food waste refers to food that is thrown out but could have been eaten if handled differently. Promoting methods of reducing avoidable food waste is one component of the Agency's environmental effort.

Storage methods that extend the shelf life of food often focus on lowering temperatures, thereby slowing the growth of bacteria, yeast and mould, as well as preserving taste and consistency better. Many foods last much longer if stored in the refrigerator than at room temperature. Most foods can also be frozen, which extends their shelf life considerably. Some foods do best when they are stored below room temperature but not as cold as a refrigerator.

The 'best before' date does not indicate how long a product is safe to eat, but how long it is expected to maintain satisfactory quality, assuming that it is stored in accordance with the instructions. Consumers can expect that a product will remain edible after the 'best before' date, although its quality may begin to deteriorate. A **'use by' date**, which is the last day that the manufacturer guarantees the product to be safe, is assigned to highly perishable foods.

Produce should be stored at the lowest possible temperature without causing chilling injury – that approach slows down the ageing process. Thus, refrigeration is appropriate for many common fruits and vegetables, such as carrots, lettuce and berries. Nevertheless, tomatoes, bananas and certain other produce develop chilling injury when refrigerated. Frequently the best solution is to store them in a cool place. Water loss and ethylene effects can also cause the quality of produce to deteriorate faster. Wrapping produce or putting it in a container before storing it often prevents deterioration from accelerating. For instance, cucumbers last longer if wrapped or placed in a plastic container.

Animal-based products – meat, fish, dairy products and eggs – can spoil when bacteria that cause unpleasant odours or taste multiply on them. These bacteria propagate more slowly at lower temperatures. Thus, such products should be stored in the refrigerator, preferably in the coldest spot. Eggs have a long shelf life at room temperature but last even longer when refrigerated. **Left-overs** should also be refrigerated as cold as possible.

Dry goods should be stored in a dry, dark and (preferably) cool place. In order to minimise the risk of rancidity, **cooking fat** should be stored in a dark and cool place with little exposure to oxygen. The same thing goes for nuts. **Soft bread** should be stored at room temperature, or frozen if it is not going to be eaten for a long time. Refrigeration causes the quality of bread to deteriorate faster.

Discussion

The length of time that a food product is stored has a major impact on its shelf life. Modern technology offers effective options for extending shelf life. But maximising shelf life is not always necessary – it all depends on how soon the product is going to be eaten. In addition to proper storage, consumers can minimise avoidable food waste by carefully planning the purchase and consumption of their food.

The lower the temperature at which a product is stored, the slower the development of bacteria, yeast and mould, as well as many other processes that lead to deterioration of quality. In the view of the National Food Agency, 4-5 °C is a suitable temperature at which to keep a refrigerator in a typical household. Most refrigerated foods have a satisfactory shelf life at that temperature. Lower temperatures extend shelf life even more but use additional energy. The recommendation is consistent with the assessment of the Swedish Energy Agency that 5 °C is suitable for household refrigerators. (61)

By measuring the temperature in different parts of the refrigerator, a consumer can choose the coldest spots for foods that are most prone to spoilage. The air inside a refrigerator is dryer than the atmosphere in general. Storing food in its original packaging from the manufacturer, plastic container (for left-overs) or bowls covered with plastic wrap can keep it from drying out.

The freezer is the perfect place to store food for an extended period of time. Microorganisms can't propagate there, but food may become rancid and dry out eventually. Most foods can be frozen, although some last longer than others. For example, lean meat can last for a year or more, whereas sausage might be good for a month or two. A suitable freezer temperature is -18 °C. Swedish legislation that regulates deep freezing requires food business operators to keep their freezers at -18 °C or lower; thus, manufacturers proceed from that temperature when estimating the shelf life of frozen foods. Lower temperatures use more electricity, and the Energy Agency recommends -18 °C as well. (61)

Produce often does best when kept in the refrigerator in a plastic bag or other container. Refrigeration extends the shelf life of fruit and vegetables by slowing down respiratory metabolism, which leads to water loss. Some produce develops chilling injury after being in the refrigerator for a while and lasts longer if stored at 12-15 °C instead. As certain fruits ripen, they secrete ethylene, a gas that can lower the quality or speed up the ripening of other produce. Keeping produce in plastic bags or other containers can protect it against these changes and minimise water loss. Fruits and vegetables that shrivel and soften somewhat due to water loss are still edible. Mouldy produce should generally be avoided because of the risk that mycotoxins have formed, but small quantities of mould can be cut off. Potatoes form toxic glycoalkaloids when injured or exposed to light. They should be stored in the dark and protected from external impact. A number of factors affect the temperature at which potatoes should be stored. A cool spot is ideal, but room temperature is fine for short periods of time. Refrigerated potatoes form additional polysaccharides, which give them a sweet taste, as well as

stimulating more acrylamide formation when fried. But potatoes that are to be kept for an extended period of time require cold storage to prevent them from shrivelling and sprouting.

Most animal-based products – meat, fish and dairy products – need to be refrigerated or frozen so that food spoilage bacteria will not propagate quickly and lend them an unpleasant odour or taste. Storage in airtight containers reduces water loss and increases shelf-life. Because a temperature of approximately 0 °C ensures the longest shelf life, it's a good idea to keep animal-based products – especially sensitive ones like minced meat and seafood – in the coldest part of the refrigerator. Eggs don't go bad as easily and can be stored at room temperature, but they last longer in the refrigerator. Some refrigerated dairy products may develop mould growth. Small mould spots on hard cheese can be cut off. Mouldy crème fraiche and other dairy products with high water activity should not be eaten because the mycotoxins may have spread.

Given that left-overs are also vulnerable to mould and the propagation of food spoilage bacteria, they should be refrigerated or frozen. To prevent bacteria from multiplying, left-overs should be put in the refrigerator as soon as possible after preparation, preferably within a couple of hours. Small amounts can be stored immediately after cooking without raising the refrigerator temperature too much. Larger quantities can be placed in cold water first or divided up between smaller containers.

The quality of soft bread deteriorates in cold storage. The most rapid deterioration occurs at 4 °C, making the bread stale. Soft bread should be stored at room temperature or frozen. Crispbread and dry goods have a long shelf life due to their low water activity, which prevents microorganisms from multiplying. They should be stored in a dry – preferably dark and cool – place. Oils, nuts and other high-fat foods can turn rancid. The process is slower if they are stored in a dark, cool place with little exposure to oxygen.

Many consumers have trouble deciding whether the quality of a product has deteriorated too far or whether it is still edible. Furthermore, they often misinterpret the significance of the 'best before' date, leading to unnecessary food waste. The 'best before' date does not indicate how long a food is safe to eat, but rather the minimum length of time it is expected to maintain satisfactory quality, assuming that it is stored properly. A product that is stored as it should be – refrigerated if appropriate – is frequently edible after the 'best before' date. Making consumers more aware of this distinction is an important step in minimising food waste.

Because *listeria monocytogenes* can multiply to harmful levels even in the refrigerator, risk groups that are sensitive to the bacteria should eat certain foods immediately after preparation or well ahead of the 'best before' date. Such foods include refrigerated ready-to-eat products – such as or sandwich spreads and vacuum-packed raw spiced or smoked fish – that are not heated up before being consumed. The risk groups are pregnant women, the elderly and people with immunodeficiencies. The National Food Agency has put together separate advice for these groups.

Avoidable food waste in households and schools

Summary

The aim with this report is to compile existing knowledge about avoidable food waste in households and schools, which can be applied to Swedish conditions. Focus of the report is on food waste that could have been avoided if the food had been handled differently. This includes knowledge about the amount of avoidable food waste, the costs for the avoidable food waste, which foods that are thrown away and why. Concerning households, knowledge about which households throw away the most is also compiled.

Avoidable food waste in households

Based on existing studies in different countries with similar standards of living compared to Sweden, the Swedish avoidable food waste is likely to be slightly above 50 percent of the total amounts of food waste, which has been estimated to 910 000 tonnes per year. This would imply that the avoidable food waste is 56 kilos per person per year, which is similar to amounts from studies in other countries. Added to this is avoidable food waste disposed of via for example the drain. The avoidable food waste's proportion of food brought into the home is unknown for Sweden, as are the costs connected to avoidable food waste. In studies from other countries the avoidable food waste's proportion of food brought into the home is approximately 14 percent of the bought weight. The yearly cost according to these studies is 3 600-5 300 SEK per household. There is no reason to believe that the costs for Swedish households are significantly different. Fruits and vegetables are the foods that are thrown away the most. Bread is also thrown away to a large extent according to several studies. According to some studies, dairy products are also thrown away to a large extent. Meat, fish and eggs are not thrown away quite as much as other foods. However these foods have a larger environmental impact than most other foods, so their part of the environmental impact from avoidable food waste might nonetheless be considerable. The general knowledge about Swedish avoidable food waste and in particular which foods that are thrown away the most is not good enough to give a reliable estimate of the environmental impact of Swedish avoidable food waste. The reasons as to why the households throw away food is for example incorrect storage or too long storage, passed best before-dates or leftovers that are not eaten. The knowledge about who throws away the most is not thoroughly researched, but there are indications that single households are the ones that throw away the most.

Knowledge about avoidable food waste in Swedish households in general and which foods that are thrown away the most in particular is not sufficient to assess the environmental impact. However, estimates of the green house gas emissions from avoidable food waste generated by consumption in all parts of society, e.g. households, restaurants and cafés, approximate the emissions to 1,86 million tonnes of carbon dioxide equivalents. This means that two percent of the total green house gas emissions caused by Swedish consumption, which includes travels, accommodation, shopping and food, is caused by avoidable food waste.

Avoidable food waste in schools

Measurements in a number of schools in different municipalities show that the food left on the plate and thrown away is approximately 10 percent of the portion weight, which amounts to a waste of approximately 30 gram per portion.

Studies also show that the avoidable food waste from other parts of the school kitchen's food handling probably is approximately the same amount as the avoidable food waste from plates, which would mean that the total avoidable food waste is 60 gram per portion. According to the Swedish Environmental Protection Agency this would give a total avoidable food waste from Swedish schools at approximately 10 000-30 000 tonnes per year. The daily value from just plate scrapings is appreciated in the same study to 1,1 million SEK. There are very few studies that investigate which foods are thrown away the most. This also makes it difficult to assess environmental impact.

The avoidable food waste in the kitchens might be caused by bad planning and misinterpretations of rules. To decrease the avoidable food waste from the students several studies describe the importance of a calm environment when the food is eaten, because students will not or cannot finish their food otherwise. Making the food waste visible might also help to decrease the amounts of plate scrapings.