



# Quantifying liquid food waste

Levels of coffee waste, its causes and barriers and drivers for quantification in the Swedish food service sector

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# Quantifying liquid food waste. Levels of liquid coffee waste, its causes and barriers and drivers for quantification in the Swedish food service sector.

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## Abstract

Food waste is a waste of resources required throughout the entire supply chain, leading to environmental impacts that could have been avoided. Coffee has a relatively high environmental impact partially due to the high consumption. To identify levels and sources of food waste, and consequently prevent it, quantification is used. Although liquid food waste is included in food waste definitions, the inclusion of the waste stream in quantification standards and previous research is limited. Today's inadequate insight in liquid food waste generation makes it relevant to also recognise this waste stream in food waste definitions and thereby including it in quantifications.

This study aimed to quantify the level of liquid coffee waste in the Swedish food service sector. Additionally, the causes of liquid coffee waste as well as drivers and barriers for quantifying it was investigated based on surveys and interviews with food services active in the sector. The results show that serving waste of coffee is on average 3.26 kg (95% CI: 2.5, 4.0) per day and entity, corresponding to approximately 10 % of all coffee produced, based on quantifications in six entities. This corresponds to 0.72 kg (95 % CI: 0.57, 0.88) of coffee waste per employee. If this is applied to a national context, the yearly serving waste of coffee is approximately 17 000 or 25 000 tonnes, depending on the assumptions made for scaling up the results.

The causes leading to liquid coffee waste is business offer, difficulty in predicting consumption, lack of resources, production strategies and guest consumption patterns. The drivers motivating entities to quantify liquid coffee waste are demand from the organisation or industry, the potential cost-savings and resource efficiency it can provide, demand from guests and personal awareness. The barriers for quantification are team-structure, lack of resources, lack of credence in the problematics of coffee waste and entities considering the waste to be known, low or non-existent.

Further quantifications of this kind are needed to confirm the findings of this study and to further investigate what contribution liquid food waste has in the total food waste generation.

*Keywords:* sewage food waste, beverage waste, direct measurement, hospitality, restaurant, serving waste, food waste cause

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# 1. Introduction

Coffee production is a vast industry with a global trade of 38 billion dollars (423 billion SEK in 2023), representing 2.5 % of the trade for all agricultural commodities (Bozzola *et al.* 2021). Around 11 million tonnes of green coffee beans were produced globally in 2020 (FAOSTAT 2023) to provide the global consumers with coffee beverages of various kinds.

Coffee consumption has an important role for social life, especially in Scandinavia (Kjeldgaard & Ostberg 2007). It is primarily driven by habits that originates from tradition and culture (Samoggia & Riedel 2018). In the Swedish setting, this is displayed through “fika”, a meal were coffee with a sweet side is consumed, at home, at work or in food service establishments (Smaka Sweden 2022). Accordingly, Sweden has the third highest per capita coffee consumption (Bozzola *et al.* 2021) and has been relatively stable when looking at the direct consumption of roasted coffee beans. Between the years 2010 and 2020, the yearly per capita consumption varied between 7.5 kg and 8.8 kg (Swedish Board of Agriculture n.d.). Similar findings showed that Swedish adults consume on average 282 grams of brewed coffee per day (Lundberg-Hallén & Öhrvik 2015).

However, consumption of coffee comes with environmental impacts. One kg of ground coffee powder has been estimated to have a climate impact of 4.0 kg CO<sub>2e</sub> (Eneroth *et al.* 2022). The impact foremostly derives from the production stage. Biodiversity is affected by the deforestation that takes place to make room for more production land (Ahlgren *et al.* 2022). In addition to this, fertiliser and pesticide use is relatively high, emitting greenhouse gases, causing climate change and eutrophication (Cederberg *et al.* 2019; Moberg *et al.* 2020; Ahlgren *et al.* 2022). Due to the high consumption of coffee in Sweden and globally, the environmental impact compared to other food products is relatively high.

With foundation in the high coffee consumption and its associated environmental impacts, the World Wide Fund for Nature (WWF) decided in 2022, to include the food category of hot beverages in their consumer guide. The guide suggests for consumers to choose organically certified coffee as well as minimising the waste of the product (WWF 2022). Wasting food is a waste of the resources required in the supply chain (Johnson 2020). Preventing waste of coffee beverages avoids wastage of resources required for the final product (Büsser *et al.* 2008) and



consequently prevents the environmental impacts that occur from usage of those resources.

To minimise negative effects caused by food waste generation, several strategies have included the aspect in its goals. In 2015 the United Nations set the target to halve per capita global consumer food waste by the year 2030 (United Nations 2015). The same target is included in the Farm to Fork Strategy by the European Union (European Union 2020). Additionally, one of the milestone targets in the Swedish environmental objectives system aims to reduce total food waste, seen to its weight, by 20% between 2020 and 2025 (Swedish Environmental Protection Agency 2023).

Quantification is a method for obtaining clear data on food waste levels. The data can then be contextualised against food waste reduction targets (Geislar 2020), such as the ones mentioned above. Several standards have been developed to provide methodological practices for food waste quantification. However, there is a variation in definitions and scope of each standard, where liquid waste is frequently excluded (Tostivint *et al.* 2016; World Resources Institute 2016; United Nations Environment programme 2021; European Commission 2022; International Food Waste Coalition 2022; Swedish National Food Agency 2023). Exclusion of certain food categories or waste streams could risk missing areas where high levels of food waste are generated, where waste preventing measures are needed to mitigate food waste and to achieve reduction targets.

Food waste is generated in all sectors to different extent. Estimates of the Food Waste Index Report from 2021 show that households are responsible for the greatest share of global food waste, 61% , whilst the food service sector accounts for the second greatest share, 26% (United Nations Environment programme 2021). However, these estimates focus on solid food waste and research on liquid food waste generation is limited. Estimates gained through surveys by Swedish Environmental Protection Agency (2021) show that 190 000 tonnes of food and beverages was wasted through Swedish household drains in 2020. Almost 45% of this waste were tea or coffee. These 190 000 tonnes represents 23 % of total household food waste in Sweden (Swedish Environmental Protection Agency 2022b). Even so, estimates of liquid food waste in other parts of the food supply chain are lacking.

Even though households account for the highest share of food waste generation (United Nations Environment programme 2021), the food service sector is thus far a large contributor. With its many entities, visitors and high levels of production, a decrease in food waste generation can contribute to reducing the negative impacts that this sector accounts for. Coffee being offered in most of these establishments, makes it a relevant food category to focus on when exploring levels of liquid food waste in the food service sector.

With regards to the vastness of the coffee industry, the environmental impacts it associates with, the high continuing consumption as well as the identified coffee beverage waste in households and solid food waste in food services, there is a relevance to study to what extent liquid coffee waste contributes to total food waste. Sources of food waste need to be identified for it to be prevented. Currently, it is unknown to what extent coffee beverages are wasted in the food service sector and if and what types of waste preventing measures are needed to reduce it in order to minimise negative effects.

## 1.1 Study aims

The aim of this study was to quantify liquid coffee waste in the Swedish food service sector. Furthermore, the study sought to identify causes of coffee waste based on the perception of food services active in the sector. Moreover, this thesis explored what drivers and barriers there are for food service entities to perform coffee waste quantifications. The following research questions were answered in this study:

RQ1. What is the level of liquid coffee waste in Swedish restaurants?

RQ2. What are the possible causes of liquid coffee waste in food services?

RQ3. What drivers and barriers are there for food services to quantify liquid coffee waste?

In this study coffee waste always refers to waste of the liquid coffee component, e.g. the beverage.

## 2. Background

### 2.1 Environmental impacts related to coffee production

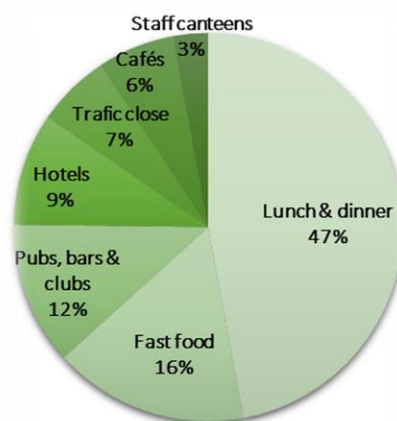
The supply chain of coffee consists of production, processing, trade, roasting, marketing and consumption (Bozzola *et al.* 2021). Although all parts contribute to environmental impacts, production has the highest influence. This is partly related to the application of fertiliser leading to emissions as well as eutrophication (Moberg *et al.* 2020). Deforestation and conversion of land rich in species, to make room for coffee production sites, affect biodiversity negatively (Ahlgren *et al.* 2022). Cederberg *et al.* (2019) emphasises that crops such as coffee is responsible for a significant amount of the pesticides used in crop cultivation. In additions to this, coffee is an agricultural crop with a high-water footprint seen to its weight. Almost 19 000 litres of water are needed to produce one kg of roasted coffee (Mekonnen & Hoekstra 2011). In total, the climate impact of one litre of brewed coffee (on the Swedish market) has been estimated to 0.25 kg CO<sub>2</sub>e (Eneroth *et al.* 2022). This includes also the energy required for making the beverage.

In the current climate situation the highest suitability for growing coffee is in Central and South America as well as South and Southeast Asia (Grüter *et al.* 2022). Grüter *et al.* (2022) predicts that by 2050 the suitability for coffee production will decrease substantially due to climate change and the increase in temperature that associates with this. Büsser *et al.* (2008) emphasises that avoiding waste of coffee is a way to avoid waste of all the resources required to produce the final beverage through the whole supply chain. Consequently, this will reduce climate change that threatens the future coffee production as well as other environmental impacts mentioned above.

## 2.2 The Swedish food service sector

Coffee of various kinds are offered in most Swedish food service establishments, filter coffee being a common type often included in the price of lunches or breakfasts. Filter coffee is made using drip-filter machines of various sizes and types. In 2018 the Swedish food service sector had 29% of the total national market share in coffee volume (fresh and instant coffee), whereas retail had the rest (European Coffee Federation 2019).

The Swedish food service sector consists out of 32 000 registered companies distributed on approximately 34 000 entities, that offer restaurant, hotel or catering services as their primary practise (Statistics Sweden 2023a) including both public and private sector. In the Swedish food service sector, with a yearly revenue of 160 000 billion SEK in 2022, lunch and dinner restaurants account for the majority of total sales (47%) (Statistics Sweden 2023b). This is followed by fast food restaurants (16%), see Figure 1 (public sector excluded).



*Figure 1. Share of sales for different subsectors in the private Swedish food service sector (SCB 2022).*

## 2.3 Food waste management

Food waste is generated in all sectors, the food service sector being one. To minimise negative effects related to waste, and to improve resource efficiency, waste management is legislated within the European Union. In Directive 2008/98/EC of the European Parliament and of the council of 19 November 2008 on waste and repealing certain directives, the waste hierarchy is used as a framework for how waste should be treated. In this directive, food waste is defined as any substance or product intended to be consumed by humans (including liquid food categories) that has become waste. This is one of many definitions and the

United Nations defines food waste as all substances (including liquid food categories) intended for human consumption that are removed from the human food supply chain in retail, food service or household areas (United Nations Environment programme 2021). Papargyropoulou *et al.* (2014) developed a framework applying the waste hierarchy specifically to food waste. The food waste hierarchy defines food waste as surplus food no longer fit for human consumption and should primarily be prevented. When this is not possible the other steps in the hierarchy can be applied according to the order in Figure 2. The study by Papargyropoulou *et al.* (2014) distinguishes between avoidable (food that has been considered edible but has gone bad or is unwanted) and unavoidable (food that has never been considered edible) food waste. The preferred waste management for these are indicated with arrows in Figure 2.

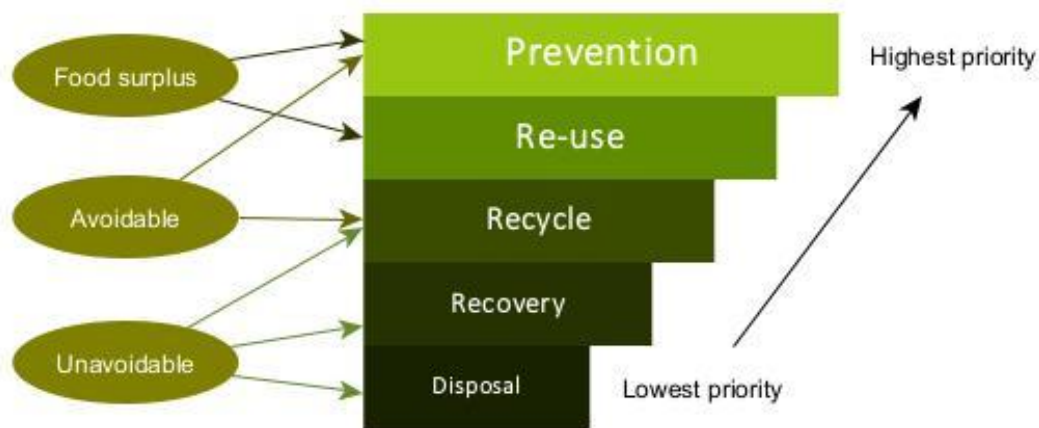


Figure 2. Illustration of the food waste hierarchy based on Papargyropoulou *et al.* (2014). Arrows from the circular shapes indicate the preferred waste management strategies for each group.

The current treatment of liquid food waste in Sweden follows the framework in the way that recycling is applied when nutrients of the sludge, formed in the wastewater treatment plants, are being used as soil, landfill coverage or fertiliser (Swedish Environmental Protection Agency n.d.). However, if recycled waste is considered surplus food or avoidable food waste, the prioritised waste treatments are no longer applied, and the purpose of the hierarchy lost.

In the context of this study, liquid coffee waste is considered avoidable food waste whilst coffee grounds are seen as unavoidable solid food waste. Placing this in the context of the hierarchy, liquid coffee waste should always primarily be prevented, secondly re-used to minimise the negative effects of this waste and improve resource efficiency.

## 2.4 Standards for food waste quantification

Food waste quantification is a way to identify levels and sources of food waste and its changes over time (Tostivint et al. 2016). By monitoring food waste one can identify where actions are needed to prevent it and how successful they are in the long run. Various quantification standards have been developed by different organisations to facilitate food waste quantification. Six of them, where the food service sector is included, are presented in Table 1. They vary in target group, objective and scope. Standards developed by EU based organisations aim for nations and policy makers, whilst industrial associations focus on companies in certain sectors and the goals of specific entities. For example, the European Commission states that by using the common methodology for food waste measurements, a baseline can be set and the progress for achieving the Farm to Fork Strategy goals can be monitored (European Union 2020).

Table 1. Examples of quantification standards for the food service sector.

Reference	Title	Objective and target group	Scope and boundaries related to liquid food waste
(European Commission 2022)	Guidance on reporting of data on food waste and food waste prevention	Providing policy makers with measures for monitoring food waste and supporting prevention.	Food drained as or with wastewaters are voluntary and should be reported separately from total food waste.
(International Food Waste Coalition 2022)	Measuring & Reporting Food Waste in the Hospitality & Food Service Sectors	Describes a methodology and scope defined to jointly report food waste in the hospitality and food service sector.	Waste destination sewer and food category beverage are excluded from scope.
(Swedish National Food Agency 2023)	National measurement method for food waste in public kitchens	Simplifying food waste quantification and comparisons for public kitchens.	Food category beverages excluded from scope. Other liquid food components included.
(Tostivint <i>et al.</i> 2016)	Food waste quantification manual to monitor food waste amounts and progression	Providing practical guidelines as a standard approach for EU Nations food waste quantification in the food supply chain.	User of manual decides on inclusion of sewage waste but should focus on most relevant destinations. Exclusion should be clearly specified.
(United Nations Environment programme 2021)	Food Waste Index Report 2021	Methodology for nations to quantify food waste (household, food service, retail) to follow progress for future targets.	Food waste to sewer included in scope of Level 3 measurements (objective of Level 3 is to provide additional information for policy and intervention).
(World Resources Institute 2016)	Food Loss and Waste Accounting and Reporting Standard	Enabling countries, cities, companies, etc to develop records of food waste and its destinations.	Entity decides whether to include sewer as waste destination and drinks as food category in scope.

The inclusion of sewer as waste destination and beverage or drink as food category (e.g., liquid food waste) varies between the recommended methodologies. Two of them excludes liquid foods completely, whilst three includes it as a voluntary part. One standard state it as included in some levels of the standard.

Quantifying food waste discarded in sewer is expressed as being difficult and could use extra guidance in the methodology (World Resources Institute 2016; Swedish National Food Agency 2023). Accordingly, none of the presented methodologies states inclusion of sewer waste as a mandatory inclusion in the scope of quantification. Parfitt et al. (2010) states that use of different methods, definitions and inclusion of alternative disposal routes in food waste quantifications causes comparing difficulties between entities.

## 3. Theory

Geislar (2020) expresses the importance of quantitative methods when managing the issue of food waste. It is a way to obtain clear numbers that can be contextualised against existing targets. Studies have used different scopes when quantifying food waste where food categories and waste destinations are included and defined to different extent. Xue *et al.* (2017) states that more primary data on food waste based on direct measurements are needed to assure reliability and improve accuracy. Recognizing the levels of food waste creates the opportunity to act on the results to prevent food waste.

### 3.1 Food waste levels in the food service sector

Several studies have explored the levels of food waste in the food service sector. Approximate estimates show that restaurants and hotels in 2020, generated 7 % (65 000 tonnes) of the total solid food waste in Sweden (Swedish Environmental Protection Agency 2022b). In 2018 the estimates showed a waste of 73 000 tonnes corresponding to almost 6 % of the total food waste (Swedish Environmental Protection Agency 2022a).

Quantifications made in the Finish food service showed that around a fourth of all handled food was wasted, serving waste being the majority. In the study, only avoidable food waste was measured and the only liquid component included was milk (Katajajuuri *et al.* 2014). Similar results were obtained by Malefors *et al.* (2019) where a fifth of all served food was wasted in the food service entities of four European countries where data had been retrieved. The authors point out that the inclusion of liquid food components can vary between participants. In addition to this, studies show that serving waste in buffet settings contribute significantly to total food waste in food service sectors (Silvennoinen *et al.* 2015; Silvennoinen *et al.* 2019).



## 3.2 Liquid food waste levels

Studies in the food service sector where liquid food waste have been included are limited and vary in results and method. Ahmed *et al.* (2018) performed a study quantifying food waste, including liquids, in a university dining hall located in the United States. Around 19 % of the total waste consisted out of post-consumer liquid waste (beverages and soup). Another study by Sehnem *et al.* (2022), using a survey methodology in the Brazilian food service sector showed that 4 % of the total waste came from drinks or desserts.

In the context of liquid food waste in households the quantification research is, similarly to the food service sector, limited. A study by Swedish Environmental Protection Agency (2021) used kitchen diaries in 2050 households for four consecutive days to find out what food categories were wasted and to what extent. Around 190 000 tonnes of food and beverages was wasted through the sewage. This represents 23 % of households total food waste, according to estimates by Swedish Environmental Protection Agency (2022b). The food category most wasted was coffee or tea consisting of 45 % (Swedish Environmental Protection Agency 2021). A similar study was made by WRAP who quantified household waste in the United Kingdom. The results showed that 18% out of the total waste consisted of drinks where 57 % was characterised as avoidable or possibly avoidable (WRAP 2013).

The use of different scopes in previous research and the limited definitions provided of what food categories and waste streams have been included, make it difficult to compare the results. However, previous research indicate that liquid food waste occurs and that more research is needed to identify its proportions.

## 3.3 Causes of food waste in the food service sector

To prevent food waste and develop waste preventing measures, one needs to understand the reasons for its generation. Causes related to food waste generation have been explored in the context of the food service sector with focus on solid food waste. However, identified causes are likely to be applicable also to liquid food waste.

Heikkilä *et al.* (2016) presents eight factors influencing food waste from a Finnish food service perspective. It is stated that the norms and values of society will affect behaviour of both consumers and staff that could lead to food waste in the food service sector. In addition to this, business concept, management as well as product development and procurement of a food service is influential. This can be related to how one chooses to serve the food (e.g., self-serving or over counter), how a business is operated (e.g., control systems and instructions) and product quality and existing resources. Professional competence connects to how one conducts the tasks related to for instance the handling of the food and the ability to

plan. Moreover, there is the aspect of visitors and competition. How guests perceive the food served will generate different quantities of waste. A dissatisfied guest is likely to visit competitors, causing difficulty in predicting the number of visitors. Lastly, communication within and outside the operating business will also affect food waste generation.

The causes identified by Heikkilä *et al.* (2016) are to some extent similar to the ones mentioned by Priefer *et al.* (2016) where serving style and offers, difficulty in predicting number of guests and legislation (societal values) are pointed out as reasons for food waste in the food service sector in Europe. Research conducted in school kitchens expresses how serving waste increases with overproduction (Steen *et al.* 2018). In addition to this, awareness of both food service staff and consumers is likely to affect food waste levels (Canali *et al.* 2017; Silvennoinen *et al.* 2019). A study by Sehnem *et al.* (2022) indicated that meeting consumer preference and having enough food in the operation is of high value for business owners.

In combination with each other, these factors will influence preparation, serving and consumer waste to different extent, most likely also in the context of liquid coffee waste.

## 4. Method and material

### 4.1 Definitions, scope and system boundaries

This study has applied both quantitative and qualitative methodologies. Liquid coffee waste has been quantified, using direct measurements in six participating entities. In complement to this, interviews with participating quantification entities as well as surveys with other food services were performed. The methods and the scope and system boundaries applied to answer the research questions of the study are described in Figure 3. The terminology used in this report is defined in Table 2.

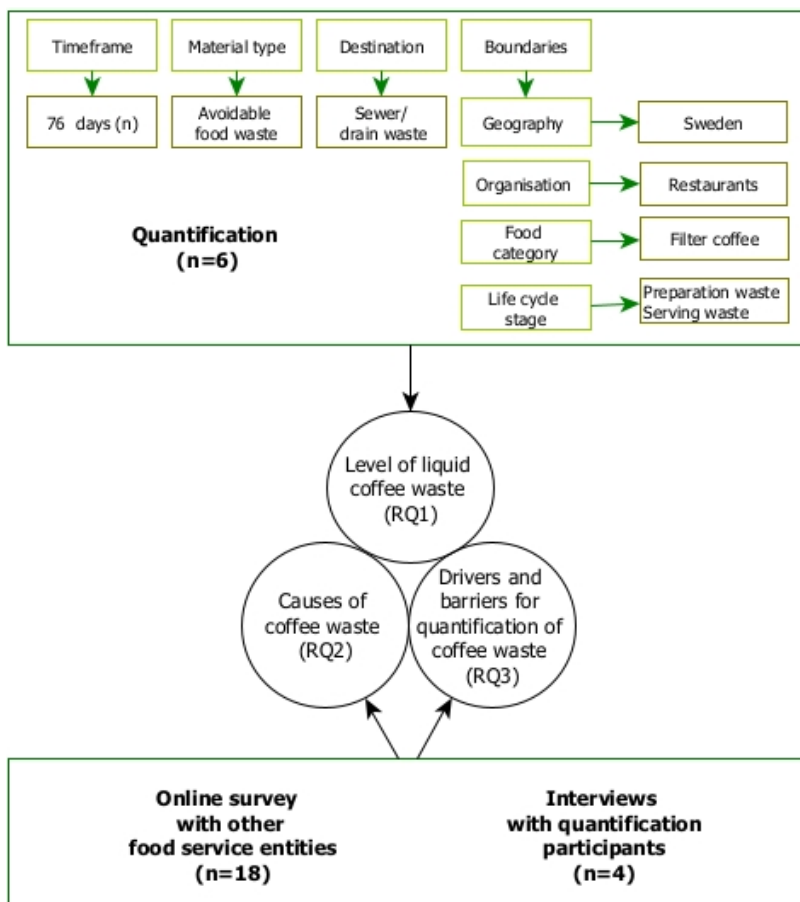


Figure 3. Methodology, scope and system boundaries of the study.

Table 2. Definitions applied in this study.

<b>Terminology</b>	<b>Definition</b>
Food service sector	Public or private companies serving food and drinks to guests outside the home. (For quantification only restaurants are included.)
Entity	Establishment serving food or drinks to guests outside the home.
Filter coffee	Coffee beverage made using drip filter.
Preparation waste	Produced filter coffee that cannot be served due to quality deficits and is therefore discarded.
Serving waste	Produced filter coffee intended to be served (without quality deficits), that is not served and therefor discarded. Coffee is considered to be served when it is poured into a cup.
Consumer waste	Produced filter coffee served to guest that is not consumed and therefor discarded (excluded from quantification).
Liquid coffee waste	Preparation waste and serving waste

## 4.2 Data collection

The recruitment of participants focused on businesses in the food service sector serving filter coffee to guests. Cafés, restaurants, conference sites and hotels were recruited randomly according to geographical convenience in Sweden.

The potential participants were contacted with information about the project via e-mail and the opportunity to report their interest in participating. A reminder of the project was sent out to each entity. Information about the entities interested in participating were collected by visits at the sites, via phone, email or an online form, involving scope of the organisation (serving style, meal offers, number of employees etc.) and the prerequisite for quantifying coffee waste (material, timeframe, etc.) In total 201 entities were contacted in five different cities in Sweden. 56 turned down the offer to participate and 139 did not respond. In the end, six restaurants took part in the quantifications and four out of these in follow up interviews. In Table 3 the participating entities are presented.

In additions to this, an anonymous online survey was sent out via e-mail to the entities who did not answer or turned down the offer to participate (n=195). Reminders were sent out twice. Survey participants had the opportunity to leave their contact information if they had interest in participating in follow up interviews. 18 entities completed the survey. None of the respondents choose to leave their contact information for a follow up interview.

Table 3. Participating food service entities and their characteristics. \* indicates participation in interview.

Entity	Quantification days	Business type	Guests/day (average)	No. of employees
A*	22	Lunch restaurant with café in office building	63	2
B*	10	Lunch restaurant for seniors	144	4
C*	19	Campus lunch restaurant with café	192	5
D*	10	Staff canteen with lunch & café	600	6
E	10	Campus café	622	3
F	5	Lunch restaurant with café in office building	548	7

#### 4.2.1 Quantification of liquid coffee waste

Direct measurements were performed by weighing liquid coffee waste in the six participating entities between October and December 2023. The variation in resources of the participants resulted in a different number of quantification days for each establishment, see Table 3. The participants were given instructions on how to conduct the quantification, printed and digital quantification sheets (Appendix 1) and weighing scale if lacking at the facility. Preparation waste and serving waste of coffee (see definitions in Table 2) were collected before discarded and weighed by the staff using digital scales in entity A to E on a daily basis (exception for entity B who measured volume of waste in litres). The waste quantities together with information about daily produced amounts of coffee and total number of guests were noted in the sheet. In entity F, the measurement was performed by the author of this study to be used as a verifying result. The author obtained information about produced amounts of coffee and total number of guests from the food service but conducted the weighing of coffee waste personally.

##### *Treatment of quantitative data*

In this study, one kilogram (kg) of liquid coffee is assumed to correspond to one litre (l) of liquid coffee. All information on the total produced amount of coffee is based on indicators on the filter coffee machines and have not been weighed.

The waste fractions were calculated in relation to waste per employee and waste in relation to total mass of coffee produced. The results from the daily coffee waste quantifications are presented as descriptive statistics encompassing the mean and a

confidence interval of 95%. A filter criterion was used for presenting statistics where only days where the quantification sheet was fully noted (produced amounts of coffee, number of guests, amount of waste), were included in the results. Applying this filter criterion resulted in the exclusion of one quantification day (entity C, day 7).

#### 4.2.2 Upscaling of coffee waste to a national level

The quantification results were scaled up to estimate the yearly level of liquid coffee waste in Swedish restaurants according to Equation 1 and Equation 2. Two different factors were used for scaling up to be able to compare the different outcomes. To apply the yearly level of liquid coffee waste in relation to total level of food waste in the Swedish food service sector Equation 3 was used. The parameters for the equations are explained in Table 4.

*Equation 1*

$$\begin{aligned} & \text{daily average coffee waste entity}^{-1} \\ & * \text{No. of entities serving coffee} \\ & * \text{days open year}^{-1} \end{aligned}$$

*Equation 2*

$$\begin{aligned} & \text{daily average coffee waste employee}^{-1} \\ & * \text{No. of employes in Swedish restaurants} \\ & * \text{days open year}^{-1} \end{aligned}$$

*Equation 3*

$$\frac{\text{annual coffee waste}}{(\text{annual coffee waste} + \text{annual solid food waste})}$$

*Table 4. Parameters for up-scaling of quantification and its definitions.*

<b>Parameter</b>	<b>Definition</b>
Daily average coffee waste entity <sup>-1</sup>	The quantified average of liquid coffee waste per day and entity.
No. of entities serving coffee	Number of entities in Sweden with restaurant (SNI 56100) as primary aim according to the company register of Statistics Sweden (n=28 651).
Days open per year	Assumed that all entities are open five days per week (n=260).
Daily average coffee waste employee <sup>-1</sup>	The quantified average of liquid coffee waste per day and employee.
No. of employees in Swedish restaurants	Number of employees in Swedish restaurants 2021 (SNI 56100) according to Statistics Sweden (2023c) (n=92 695).
Annual solid food waste (tonnes)	Annual mass of solid food waste in Sweden based on the estimates from year 2020 by Swedish Environmental Protection Agency (2022b) (n=65 000)

Due to it being difficult to obtain data on number of employees for only staff canteens, only the number of restaurants and employees of these have been used as a factor, even though the sample also includes one staff canteen. This entity is in this study considered as a part of the sub- sector restaurants.

Since liquid coffee waste contains high levels of water, the results were also converted into mass of coffee ground powder wasted. To convert the level of liquid coffee waste into mass of coffee powder used to produce the beverage, it was assumed that one kg of liquid coffee (same as one litre of liquid coffee) required 60 grams of coffee powder.

#### 4.2.3 Qualitative approach for understanding causes of waste and barriers and drivers for quantification

As a complement to the quantifications, semi- structured interviews with the participants were performed to understand causes of coffee waste and barriers and drivers for coffee waste quantification. The interviews consisted out of 10 open ended questions (Appendix 2) that aimed to provide with answers regarding motives for participating, causes and perception on the problematics of coffee waste and the view on the identified coffee waste levels of the entity. The interviews were conducted after the quantifications had been performed with the contact person for the project in four of the entities, in person or in written form via e-mail.

The online survey contained open-ended and multiple-choice questions (Appendix 3) regarding the reasons for not participating, what could motivate quantification of coffee waste and the view on coffee waste and its causes, in the entities as well as in general. Note that one survey answer can represent the answers from several entities due to the contact person being the same when entities are part of the same company. Therefor the response rate could potentially be higher. The survey was distributed in October 2023 through Netigate and was open for a total of 50 days.

##### *Treatment of qualitative data*

All answers retrieved from the semi-structured interviews and the online survey were analysed and firstly categorised into either cause of liquid coffee waste, barrier for quantification of coffee waste or driver for quantification of coffee waste. Secondly, the responses of each category were thematised in groups with common denominators, and their frequency of each response noted. The themes were summarised in a figure and divided into the areas: management, resources and behaviour. No distinction between preparation, serving or consumer waste was made in the interviews or surveys but treated coffee waste in general.

## 5. Results

### 5.1 Level of liquid coffee waste in participating entities

The quantifications performed for a total of 76 days show that serving waste of coffee is on average 3.26 kg per day and entity with a 95 % confidence interval (2.52, 4.00). When examining the amount of wasted coffee in relation to the amount of produced coffee, the average wasted volume was 10.26 % per day, as illustrated in Figure 4. If the values are placed in relation to number of employees in each entity it corresponds to 0.72 kg per employee and day (95 % CI: 0.57, 0.88). Preparation waste was non-existent during the quantification period in all entities.

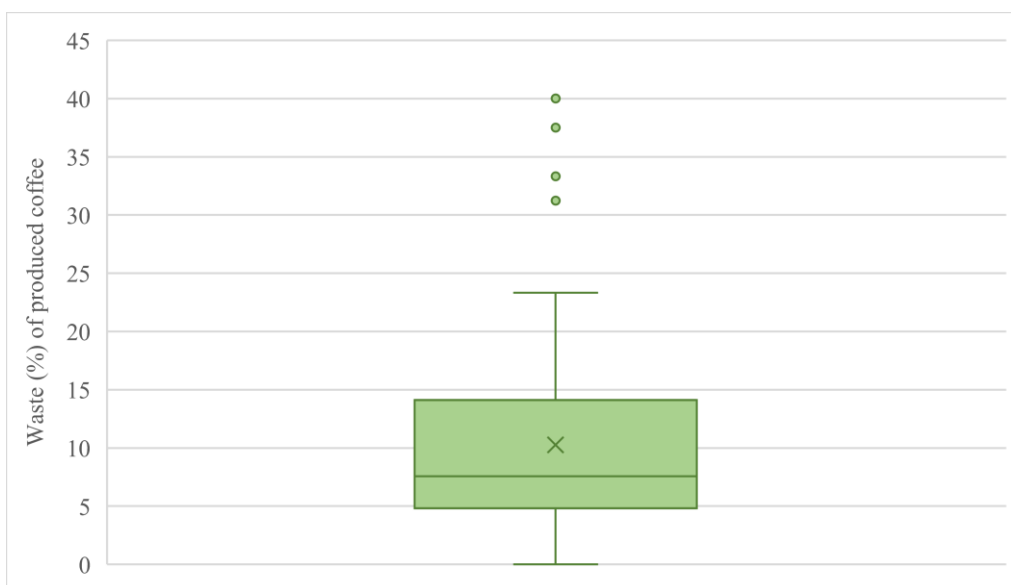


Figure 4. Boxplot displaying waste of liquid coffee in relation to total mass of produced coffee (%) in participating entities (box limits indicate 25<sup>th</sup> and 75<sup>th</sup> percentile: cross indicates mean: line in box indicates median: whiskers indicate minimum and maximum value apart from upper extreme values indicated with points).



As illustrated in Figure 5 waste levels vary within the entity as well as when comparing them to each other. Values between 0 % and 40 % have been quantified. The differences of production and waste within and between the entities is further illustrated in Figure 6. Production levels vary between 2 and 130 kg per day and coffee waste levels between 0 and 13 kg per day.

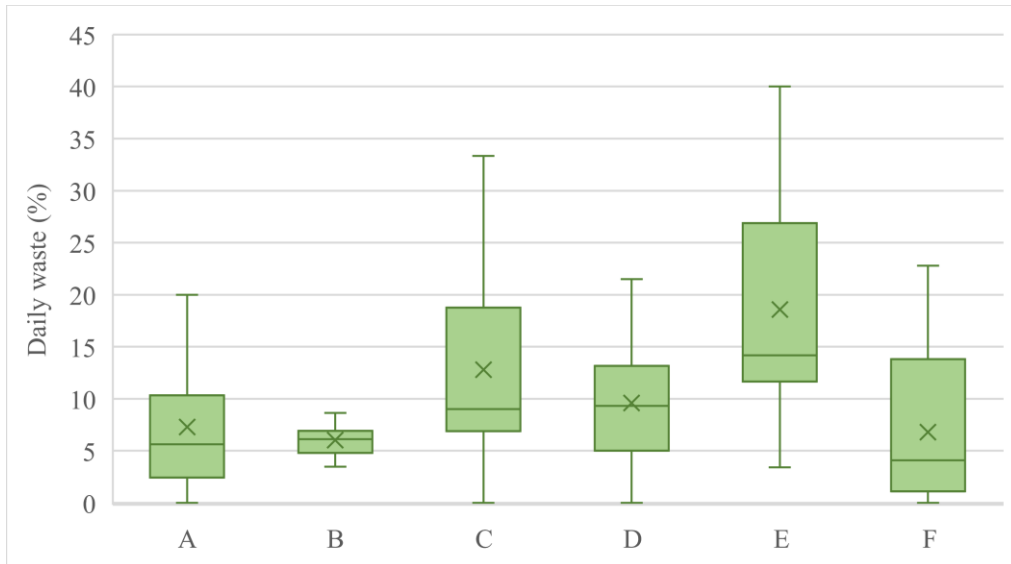


Figure 5. Boxplot displaying waste of liquid coffee in relation to total mass of produced coffee (%) per entity (box limits indicate 25<sup>th</sup> and 75<sup>th</sup> percentile: cross indicates mean: line in box indicates median: whiskers indicate minimum and maximum value).

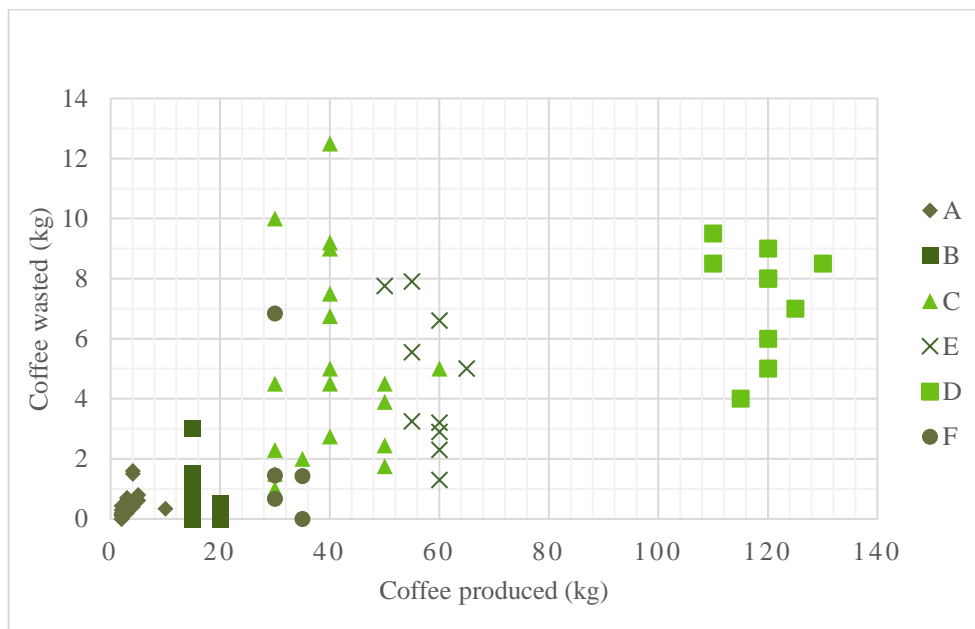


Figure 6. Level of liquid coffee production and waste per entity (A-F) for each quantification day. Each point indicates the level of waste (y axis) and production (x axis). One point can represent several days if same values have been obtained more than once.

## 5.2 Level of liquid coffee waste in Swedish restaurants

Based on the waste levels from the 76 quantification days in six entities the yearly serving waste of liquid coffee in Swedish restaurants corresponds to approximately 25 000 tonnes when scaled up to the number of restaurants, see Table 5. If the upscaling factor of number of employees is used the serving waste corresponds to around 17 000 tonnes per year. Applying this level of coffee waste in relation to solid food waste in the Swedish food service sector, using number of employees as a factor, 21% is liquid coffee waste.

*Table 5. Serving waste of coffee in Swedish restaurants.*

	Based on no. of restaurants	Based on no. of employees
Yearly liquid coffee waste (tonnes)	<b>24 285</b>	<b>17353</b>
Yearly waste of coffee ground powder (tonnes)	<b>1 457</b>	<b>1 041</b>
Yearly liquid coffee waste in relation to total mass of food waste in the Swedish food service sector (%)	<b>27</b>	<b>21</b>
Yearly waste of coffee ground powder in relation to total mass of food waste in the Swedish food service sector (%)	<b>2</b>	<b>2</b>

## 5.3 Causes of liquid coffee waste and drivers and barriers for quantification

The identified causes of liquid coffee waste as well as the barriers and drivers for quantifying coffee waste are based on the perception of respondents in this study. In Table 6 ,Table 7 and Table 8 these parameters are presented in themes where the summarised version of responses is presented in order of frequency.

### 5.3.1 Causes of liquid coffee waste

Overproduction of coffee is seen as a major contributor of waste, as seen in Table 6. The reason for overproducing is due to the entity fearing to run out of coffee and not knowing how much will be consumed during the day. The variance in guest attendance and the difficulty in predicting consumption plays a role here, according to the interview and surveys results.

Table 6. Causes of liquid coffee waste based on the perception of survey and interview respondents.

<b>Theme</b>	<b>Response</b>	<b>Interview (n=4)</b>	<b>Survey (n=18)</b>	<b>Total (n=22)</b>
<b>Production strategies</b>				<b>14</b>
	<i>Overproducing when fearing to run out of coffee</i>	2	3	
	<i>Overproducing for catering and conferences when you don't know how much will be consumed and you can't monitor it</i>	-	4	
	<i>There must be coffee to offer</i>	1	2	
	<i>Too time consuming to brew half amounts when needing to measure coffee powder</i>	1	-	
	<i>Coffee loses its taste after some time and new must be made</i>	-	1	
<b>Difficulty in predicting consumption</b>				<b>6</b>
	<i>Difficult to know how much coffee is needed</i>	2	2	
	<i>Variation in workload and number of guests</i>	-	2	
<b>Lack of resources</b>				<b>5</b>
	<i>Lack of attention on customer flow and time to analyse it</i>	2	-	
	<i>Lots to do and lack of time to focus on the coffee</i>	2	-	
	<i>No opportunity to brew half amounts of coffee due to the type of coffee machine</i>	1	-	
<b>Business offer</b>				<b>3</b>
	<i>Coffee is included in meal/uncharged</i>	1	1	
	<i>Difficult to know how much coffee is needed when offering refill</i>	1	-	
<b>Guest consumption pattern</b>				<b>2</b>
	<i>Guests taking more than they want</i>	-	2	

Moreover, the lack of time for analysing the customer flow and brewing smaller batches creates coffee waste. How consumers act is mentioned as one aspect causing consumers waste, by serving themselves more than they will drink. Coffee waste is also generated due to it loosing quality and is replaced by freshly brewed coffee.

Additionally, there is the aspect of entities not knowing how much will get consumed when coffee is offered included in the price of a meal or when free refill of coffee is offered, resulting in overproduction. One interview respondent stated:

“We offer coffee with free refill which makes it more difficult to predict. One doesn’t know how much will be consumed. Ten sold coffees could be 20 cups. “

Entities overproducing is also related to the aspect of consumer and production behaviour where coffee is seen as something that always should be accessible. Another interview respondent expresses the following:

“It is seen as a right to consume huge amounts of coffee. It is a balance between running out of coffee or having too much left at the end of the day”.

### 5.3.2 Barriers and drivers for quantifying liquid coffee waste

The responses from the surveys indicated that 11 out of 18 entities measure some kind of solid food waste with the motives to minimise food waste and to keep track on costs and sales. 11 respondents also expressed that coffee waste occur in their entity. Additionally, 13 respondents answered that they consider coffee waste an important or partly important issue. The ones who expressed the contrary, stated that they had no or little coffee waste or that it was not perceived as problematic. Two of the interview participants stated that their entity measures solid food waste on a regular basis. All the interviewed considered the coffee waste quantification to be relatively simple and two expressed they performed it independently with little involvement of other team members, due to it being seen as difficult to involve others.

When it comes to the barriers that could potentially hinder entities from quantifying coffee waste the lack of time is distinct, as seen in Table 7. Additionally, it is expressed by respondents how teams at workplaces not being structured enough to introduce new work activities. There is also the aspect of people not viewing the problem being vast enough and that change is difficult to achieve. Entities considering their waste levels not being large enough to quantify, non- existent or that they already are aware of their coffee waste levels is another barrier identified. In two of the survey answers, it was stated that the reason for not participating was that they use automatic coffee machines resulting in no waste and no motive for quantification.

When it comes to the drivers that could potentially motivate entities to perform coffee waste quantifications, the economic savings that reduced waste could give is evident, as seen in Table 8. Furthermore, most of the participants expressed that their interest for the topic was the reason for participating in the quantification. However, only one entity stated that they would continue the quantifications.

Moreover, it is conveyed in the interviews and surveys how company or industry standards would contribute to quantifications being performed. Guests asking for waste prevention work regarding coffee could also motivate businesses. In addition to this, respondents expressed how environmental aspects and not wasting food is important and a way to save on resources. For instance, less waste will result in less work to get rid of the waste. Finally, one entity believes that quantification results could be of value for the organisation.

Table 7. Barriers for quantifying liquid coffee waste based on the perception of survey and interview respondents.

<b>Theme</b>	<b>Response</b>	<b>Interview (n=4)</b>	<b>Survey (n=18)</b>	<b>Total (n=22)</b>
<b>Lack of resources</b>				<b>20</b>
	<i>Don't have time to quantify coffee</i>	3	16	
	<i>Cost of staff to perform quantification</i>	-	1	
	<i>It is unreasonable and difficult to quantify consumer waste</i>	-	1	
<b>Considers the waste to be known, low or non-existent</b>				<b>7</b>
	<i>Already know how much is wasted</i>	2	1	
	<i>Have low level of coffee waste and see no point in quantifying</i>	-	2	
	<i>Have small coffee production and see no point in quantifying</i>	-	1	
	<i>Low waste due to serving waste being re-used</i>	-	1	
<b>Lack of credence in problem and possibility to change</b>				<b>7</b>
	<i>Difficult to do something about coffee waste.</i>	1	2	
	<i>Perceived as a small problem</i>	1	1	
	<i>Results perceived as not important enough</i>	-	1	
	<i>Coffee waste is unavoidable.</i>	-	1	
<b>Team structure</b>				<b>3</b>
	<i>Different staff make it hard to perform quantifications</i>	1	1	
	<i>Lack of staff to be able to perform quantification</i>	-	1	

Table 8. Drivers for quantifying liquid coffee waste based on the perception of survey and interview respondents.

<b>Theme</b>	<b>Response</b>	<b>Interview (n=4)</b>	<b>Survey (n=18)</b>	<b>Total (n=22)</b>
<b>Possible cost savings</b>				<b>10</b>
	<i>Less waste saves money</i>	1	9	
<b>Awareness</b>				<b>9</b>
	<i>Environmental aspects</i>	-	3	
	<i>Intrested in sustainability and waste prevention</i>	3	-	
	<i>Feels sad to waste food</i>	-	2	
	<i>Can make use of quantification results</i>	1	-	
<b>Demand from organisation or industry</b>				<b>3</b>
	<i>Demand from company or industry</i>	1	2	
<b>Improved resource efficiency</b>				<b>3</b>
	<i>Less waste to discard means less work</i>	2	-	
	<i>Save on resources</i>	-	1	
<b>Demand from guest</b>				<b>1</b>
	<i>Demand from guest to prevent coffee waste</i>	1	-	

The results from the interviews and surveys are summarised and illustrated in Figure 7. Each horizontal column illustrates each category (cause of liquid coffee waste, barrier for quantification and driver for quantification) whilst the vertical columns illustrate areas of origin (management, resources and behaviour). Each section in the columns represent the identified themes.

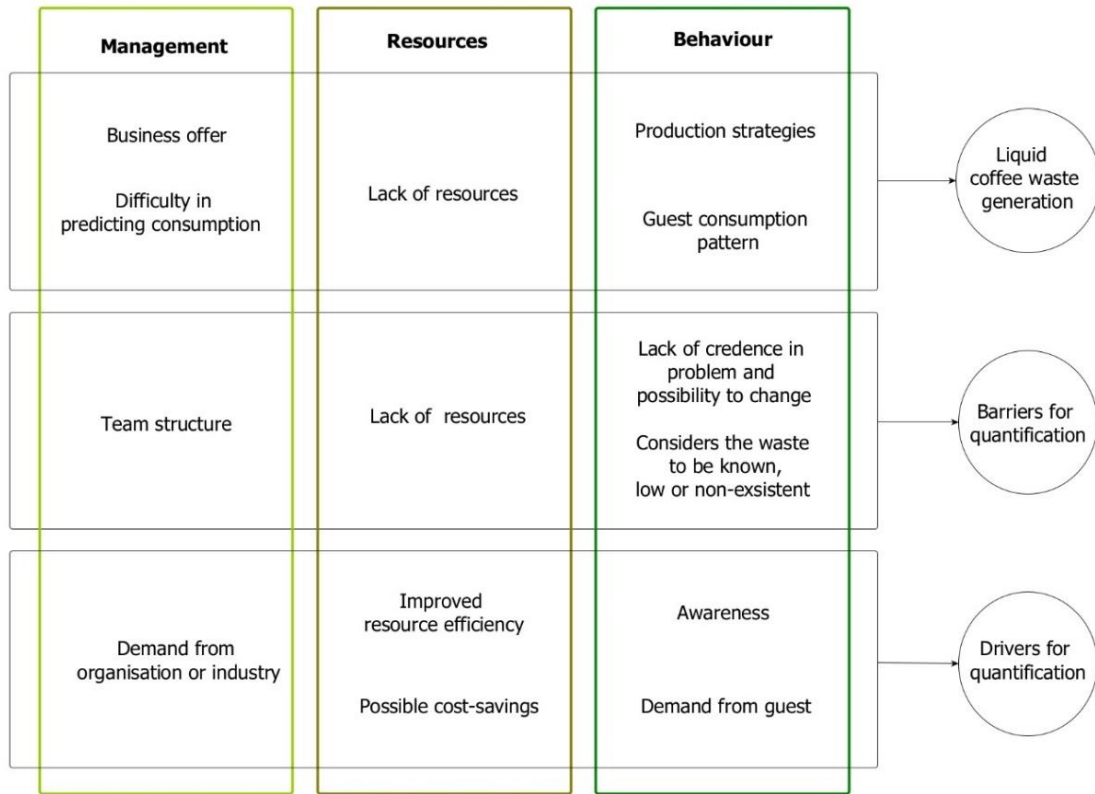


Figure 7. Causes of liquid coffee waste and drivers and barriers for liquid coffee waste quantification based on the findings of interviews and surveys.

## 6. Analysis

### 6.1 Level of liquid coffee waste

This study shows that in the six participating entities serving waste of coffee consists of around 3 kg per day and food service or 10 % of the total mass of coffee produced in the entities, indicating that there is a daily overproduction. This correlates with the findings of Steen *et al.* (2018) who concluded that overproduction correlates with serving waste levels. Due to this study only including one food category and other studies including different fractions and categories, its results are difficult to put in relation to other findings of liquid food waste in the food service sector.

When scaling up the quantification results to know the yearly level of serving waste in Swedish restaurants the estimate is 25 000 tonnes of liquid coffee when basing it on number of restaurants. However, if the factor number of employees is used, the result is noticeably lower, around 17 000 tonnes. These results not only indicate that an additional amount of food waste has been identified in this sector but also how influential the method for scaling up data are. Both factors used in this study and the outcomes of these, adds a new parameter to previous estimates on food waste by Swedish Environmental Protection Agency (2022b) of 65 000 tonnes. If the identified serving waste of coffee is included in this estimate, it would correspond to 21 % of total food waste using the factor of number of employees, same factor that has been used in the estimates by the Swedish Environmental Protection Agency. This could indicate that by excluding liquid foods from estimates and quantifications, risks missing areas where high levels of waste are generated.

Even though the share of liquid coffee waste gets substantially lower when converting it to amount of used product, it still points to the fact that one individual food category can have a large contribution to food waste generation. Additionally, the usage of water to make filter coffee is likewise an input, defined as food, wasted if liquid coffee is that should not be diminished.

In this study only the fractions preparation waste and serving waste was included. Preparation waste of coffee is non-occurring in the entities and could be assumed to be so also in the entire food service sector due to coffee being a rather



simple product to prepare. Attempts were made to also quantify consumer waste, waste from the guest's coffee cup. Participants were suggested to collect the consumer coffee waste when retrieving dishes from serving areas or by using separate bins for coffee waste by dish stations. However, entities found it difficult to implement this quantification due to lack of space, high workload, high levels of take away and disbelief that guests would follow information on where to place the coffee that had not been consumed. The surveys and interviews indicated that staff experience the guest's behaviour as a possible generator to consumer waste when they serve themselves more than they will drink. It is therefore probable that consumer waste occurs and that the total level of liquid coffee waste (including both serving and consumer waste) is substantially higher than the one identified in this study making prevention measures and quantification aimed also for consumer waste relevant.

Additionally, only parts of the food service sector (restaurants) have been included in this study, indicating that the coffee waste generated in the food service sector is likely to be higher.

## 6.2 Preventing liquid coffee waste

Understanding the causes of coffee waste will facilitate development of measures for prevention. The identified causes of coffee waste in this study (including consumer waste), see top section of Figure 7, are to some extent similar to the ones found in previous studies. How coffee is offered, how an entity is managed in terms of team structure, routines and planning are factors leading to waste, identified in this study as well as by Heikkilä *et al.* (2016). In the same study, the norms of society are pointed out as a factor. In this study this is displayed through the norm of consuming coffee and for entities to offer it, affecting behaviour of food waste generators, both food services and consumers. Moreover, visitors and competition affect waste levels by entities aiming to always have coffee eligible and the difficulty to predict the number of guests, the demand for coffee and the consumption, leading to entities overproducing to secure supply. This correlates with the findings of Sehnem *et al.* (2022) where having enough food is shown to be of high importance for entities and is in this study displayed through entities always seeking to have coffee to offer.

To prevent coffee waste, quantification of its levels are necessary. Considering the low interest in participating in quantifications of coffee waste that has been shown in this study, the barriers for quantification are larger than the drivers. The two lower sections in Figure 7 (seen in section 5.3.2) represents the drivers and barriers for quantification of liquid coffee waste but could potentially be applicable for liquid food waste in general.

In the sections below, suggestions of measures are discussed in connection to how causes of coffee waste and barriers for quantification can be minimised as well as how drivers can be enhanced with the purpose to facilitate quantification of liquid food waste and consequently preventing food waste generation. These are discussed for each area respectively.

## 6.2.1 Management

Since causes of liquid coffee waste and drivers and barriers for quantification in the food service sector can partially be related to how a food service is managed, measures in this area are relevant for achieving waste prevention.

### *Business offer alternations*

Alternating the business offers of entities, controlled by management, is a potential way to reduce coffee waste. For instance, by not offering coffee included in meals, as refills or un-charged for guests the behaviour of consumers is likely to change by guests only getting coffee when desired and not because it is seen as beneficial. The alternative to offer lunch prices with and without coffee will make it possible for entities to distinguish the number of coffee drinkers to higher extent. This will lead to more accurate numbers in the registers of businesses on how many coffees are consumed. Alternating the business offer for coffee could reduce overconsumption, hence overproduction and in the end also waste.

Additionally, alternating how coffee is served, is likely to affect consumption patterns. As shown by Silvennoinen *et al.* (2015); Silvennoinen *et al.* (2019) serving waste is a large contributor to food waste when an entity uses buffet serving. Serving coffee over counter, and charging for coffee separately, could be an effective way of monitoring the consumption and demand more efficiently and for the entity to get a better understanding of how many guests are drinking coffee. This has been unknown for most entities in this study and could potentially make it easier to predict guest attendance for specifically for the coffee offer and hence produce coffee according to demand. However, studies exploring correlation between serving style and food waste focuses on solid food waste and therefore more research on this correlation for liquid food needs to be made to assure appropriate serving styles.

### *Establishing routines for improved time management and quantification*

A lack of resources is in this study shown to be a cause of waste and a reason for quantifications not being performed. The entities difficulty in predicting number of guests, coffee demand and consumption and its variation in combination with the lack of time to analyse this leads to waste. Forecasting how many coffee guests the business will have, is likely to be simplified if alternations in coffee offer are made, as mentioned above. Additionally, team structure in entities is seen as a

barrier for performing quantifications. Large teams, team members being replaced often or the lack of team members, results in not having enough resources.

By establishing routines that make work duties and responsibilities clear and time-efficient, time can be set aside for waste prevention such as more accurate production strategies, forecasting demand and for performing quantifications regularly. Exchange of knowledge, tools and strategies between individual companies, industry organisations or educational institutions is one way to provide food services with tools that can help achieve this.

Quantification methods that are easy to implement, and part of daily routines are of importance. Implementing quantifications of liquid food waste is likely to be easier if a restaurant already has routines for measuring solid food waste. Quantification can be seen as a type of waste prevention measure. Combining measures with quantification in food services is important for the effectiveness of measures to be evaluated.

#### *Increased inclusion of liquid food waste in policies, certifications and education*

Respondents express how they will not start quantifying unless it is required from higher sources of management or bodies within food service industry. Organisations, global and national, putting pressure on management of companies, that further pressure management of individual entities and team members of these could be necessary to facilitate quantification and prevention work. It is of relevance for organisations and companies to start incorporating more aspects of food waste prevention work in policies, also including liquid food waste. Making use of different certifications assuring food waste prevention work could potentially motivate companies to increase this effort, when it can also be used as a marketing tool. The potential of governmental policies and if this could increase quantification also for liquid food waste is another aspect relevant to explore.

Different forms of educational organs could include aspects such as quantification work, food waste prevention (including liquid food) and management strategies related to this in their curriculums. This is of extra importance in various food service educations. This could provide current and future teams to have the means to include these aspects in daily work to a higher degree.

## 6.2.2 Resources

The causes of coffee waste and drivers and barriers for quantification can furthermore be connected to resources, and the lack or asset of these, affecting the ability businesses have to participate in waste prevention.

### *Emphasizing potential values of quantification*

The time required for quantifying coffee waste could potentially compensate for the values it provides, such as potential cost savings and increased resource efficiency. Cost- savings is a major driver for quantification according to the surveys. However, in the cases of the respondents, time restraints seem to have been more influential due to them not participating. More concrete information to entities on what the actual savings could be if waste was reduced in combination with the resource efficiency it can provide could possibly make this driver more influential. Highlighting the relatively low time input required together with the values waste prevention can provide is of relevance when proposing entities to quantify coffee waste.

### *Applying appropriate production techniques*

The surveys conducted in this study showed that some chose not to participate due to them using automatic coffee machines that produce coffee per cup resulting in no serving waste. The possibility of increasing the use of this type of production method is relevant to explore. For food services to consider what coffee production machines and sizes are most relevant for their individual business and possibly alternating these is of relevance to facilitate waste prevention of coffee.

## 6.2.3 Behaviour

The behaviour of both consumers and food services has in this study been shown to potentially cause waste of coffee, both serving and consumer waste. These are of relevance to acknowledge when proposing prevention measures for coffee waste.

### *Alternating consumer behaviour*

According to respondents of this study, the behaviour of guests affects coffee waste. In this study it is not explored if guests demand for coffee to be constantly accessible. However, if this is the case, there is a need for change in consumer behaviour. By using interventions aimed for guests, their consumption patterns are possible to change into more sustainable ones. Informative interventions pointing out the environmental impacts adjacent to the serving of coffee is one alternative. Furthermore, informing guests of their consumption pattern with reminders to only take as much as needed is of relevance. Additionally, interventions can also be less apparent for the consumer by alternating the coffee offer as previously mentioned.

By charging for coffee instead of offering it included in a meal could possibly affect behaviour without the guest reflecting on it. Making it more acceptable for entities to run out of food and beverages is a prerequisite for reducing overproduction. Using informational interventions as the ones mentioned above, could increase consumer awareness.

#### *Alternating production behaviour*

The production strategies that entities have can be related to the behaviour of team members. The view that there is a need for a constant access of coffee for guests, results in overproduction to secure supply throughout the day. In entities where waste is on a more constant level, simple alternations in production strategies could be made. As seen in entity B, waste levels are relatively constant and therefore the daily production could be reduced by the amount usually wasted.

To change overproduction behaviours, interventions aimed for team members and management of entities can be implemented. As found in the interviews and surveys, the economic loss of waste is expressed as a main driver for preventing it, making it possible for this to be an efficient intervention strategy. By stating the actual cost for the coffee waste, it is put in perspective for business owners, possibly motivating them to reduce it.

#### *Increasing awareness with education and campaigns*

Connected to the behaviour side of coffee waste generation, the view that the problem itself is not vast or changeable enough are seen as barriers for quantification in combination with entities feeling they have no or little waste or already know its extent. In this case, the relevance of performing quantifications to assure low waste levels over time need to be mediated to businesses and awareness for the matter need to be enhanced. This could be achieved for example by knowledge distribution of food waste in educations aimed for the food service sector, potentially creating future awareness within food services. Demand from guest to perform quantifications is found to be a driver in this study. For sustainability work to be requested by guests to higher extent, consumer's awareness for the matter need to be enhanced. By using for example societal information campaigns about sustainability and food waste the awareness could be increased. It is of importance that educations and campaign creators include also liquid food waste in their materials for this to work as a motive for food service sectors to quantify liquid food waste and for this waste stream not to be diminished.

#### 6.2.4 Assuring value of liquid waste prevention work

The suggested measures for reducing waste and increasing quantification in the context of coffee waste, will require resources of different forms. It is important to acknowledge what resources these measures require and if the measures provide enough value for it to be performed. A loss of profit could risk that food service establishments are less willing to implement prevention measures. For instance, interventions that lower demand and consumption could also affect incomes and profits. The risk that guests get dissatisfied by a changed offer, visit other entities or changes its demand to one less profitable are risks associated with this. Therefore, alternations that are accepted by guests and prevention strategies and tools that require as little resources as possible, and hence little cost, could be considered of higher relevance in the food service sector. As shown by Filimonau and De Coteau (2019), applying evidence-based forecasts for guest attendance and training teams to achieve this will require high initial cost. However, it is also stated that the savings it will provide are high. This could work as motives for implementing measures aimed to reduce coffee waste in combination with the contribution to mitigating environmental impacts from coffee consumption in the food service sector.

The quantification participants expressed that they choose to participate due to their interest in the area. However, only one participant stated that they would continue to quantify liquid coffee waste. The others stated it was too time consuming, even though the quantifications were stated to be perceived as relatively simple. In this case, the expressed views on quantification doesn't conform with behaviour. As stated by Filimonau and De Coteau (2019), managers willingness to perform food waste mitigation work is determined by how they perceive the values it can provide. In the context of this study, it is possible that the interest in the area is not valuable enough compared to the time quantifications will require. In similarity to this, the cost-savings that survey respondents express could motivate quantifications are likely to not be perceived as valuable enough for performing quantification. If this is the case, the values of quantification need to be further enhanced to increase quantification.

If this study would have been performed with focus on the entire liquid food waste stream, perhaps the findings would be different. Food services could potentially be more motivated to involve in liquid food waste mitigation when including a larger share of the food and beverages used in the food service making this prevention more influential on total food waste and its reduction potential.

## 7. Discussion

### 7.1 Limitations and generalisability

#### 7.1.1 Sample and representativeness

In this study, a larger sample would have facilitated for a more reliable result, more comparisons between entities and conclusion regarding the impact of business offer, serving style etc. on waste levels to be made. Though around 200 entities have been proposed to participate, a larger sample was in this study difficult to achieve. Moreover, time restraints of this project and the limitations of participating entities resulted in longer changes over time not being possible to follow and that only the fractions preparation and serving waste was included. Inclusion of consumer waste is likely to have generated different results were a higher level of total coffee waste in the food service sector is probable.

In addition to this, the attempt to scale up coffee waste levels to a national level are based on many assumptions and estimates and will therefor only serve as an indication of current levels. An alternation of these is likely to affect results. For example, the number of restaurants and employees of these has included both food services serving filter coffee and coffee from automatic machines, making this number less representable for filter coffee waste. However, locating a number that only represents the users of filter coffee have not been found and is likely to require a lot of effort.

Two different factors for scaling up the identified waste levels have been used to provide a broader insight in what the levels of coffee waste could be and to be able to compare the results to other quantifications in the food service, that often uses number of employees as a factor. When comparing the two results to each other, there is a difference in yearly level of serving waste, 25 000 tonnes and 17 000 tonnes. It shows how the alternation of assumptions can affect the results substantially and that these types of estimates only serve as an indicator on food waste levels. If food waste levels are to be compared to other quantification it is relevant to use similar factors for scaling up results for conclusions to be more reliable. In the case of this study, the outcomes of the variation in factors gives different results but are still within similar spans.

Furthermore, the six participating entities in this study is unlikely to be representative for all Swedish food services. A more varied sample where all subsectors in the food service are represented could generate different and more reliable results. Nonetheless, the survey respondents come from varied types of establishments and therefor the identified causes, drivers and barriers could be relevant views for other types of establishments in the food service sector. However, a larger number of respondents would have provided with conclusions with higher certainty.

### 7.1.2 Human error and selection bias

Moreover, the quantifications performed by the entities themselves have not been monitored by the author. There is always the risk of human error affecting the results. This risk has been minimised by conducting a verifying quantification that showed similar results in relation to the other participants.

Findings of this study indicated that that entities partially decided to participate due to their interest in sustainability aspects. The awareness of sustainability can influence production behaviour at each entity and possibly also their waste levels. This aspect has also been expressed by Canali *et al.* (2017) and Silvennoinen *et al.* (2019). Therefore, there is the risk that the sample is not representative for the Swedish food service sector. To overcome this selection bias, a larger sample were entities have different drivers for participating are of relevance. This can be achieved by implementing policies that require different entities to perform quantification. Furthermore, each contact person for participating entities does not necessarily represent the understanding of the entire entity. There is a risk that food services that would be interested in participating not doing so, due to the view of the contact person. The respondents of the surveys and interviews does not either necessarily correspond to the views of the entire entity.

Recruiting of participants and distribution of surveys were conducted via e-mail. Even though reminders were sent out there is a risk that not all entities received the information and that more entities were interested in participating. Additionally, it is possible that other recruitment methods could have been more successful, however the one applied in this study was seen as most relevant for the basis of this study.

## 7.2 Future research

### 7.2.1 Inclusion of liquid food waste

In this case study, the focus has been on coffee as a single food category. Quantification including the entire waste stream of liquids foods are relevant to



perform to gain a more accurate view on liquid food waste generation and its associated impacts. How will we know that we are achieving food waste reduction targets, if certain food categories or waste streams are excluded from quantification? If areas where food generation occurs are missed, it risks missing areas where waste preventing measures are required.

This study provides with a contribution to the field of liquid food waste and can serve as an example on how single food groups can contribute to large parts of total food waste generation. The result of this study indicates that coffee waste occurs to a relatively high degree in relation to total food waste in the Swedish food service sector. Further quantifications, both on coffee as a specific food category and total levels of liquid food waste, are needed to obtain clear data and to develop measures for reduction. Including larger samples and longer quantification periods will provide more certain conclusions and the ability to follow changes over time. Having clearly defined scopes, definitions and boundaries in future research is of importance for it to be comparable to other studies.

Additionally, in the context of coffee the extent of consumer waste needs to be further investigated to obtain a more accurate picture on total coffee waste levels. When doing so, a feasible quantification method for collecting consumer coffee waste in food service entities need to be established.

### 7.2.2 Potential for re-use of coffee

According to the food waste hierarchy (Papargyropoulou *et al.* 2014) liquid coffee waste should always be prevented. In the cases where this is not possible re-use is an alternative. The survey conducted in this study shows that some entities make use of coffee waste as an ingredient. However, it will be difficult to make use of all coffee waste this way. What other applications there are for coffee to be re-used or re-distributed are relevant to consider. Is it possible to re-use coffee within the entity by heating it up and serving it the next day? To explore the opportunities of re-using coffee, research in sensorics and consumer perception would be relevant to carry out and serve as a support for alternate coffee applications in the food service.

### 7.2.3 Success of measures and provided value

Further research on prevention measures is of relevance. For example, on how one can influence the consumption by alternating business offer. It is also relevant to explore what measures are successful and which ones are perceived as valuable enough to be implemented. In addition to this, the behaviour of consumers and teams need to be explored further to facilitate acceptance for food service entities to run out of food or beverages and for exploring consumer's acceptance for waste prevention measures. Further exploration of what can motivate quantification and what will make quantification valuable enough to perform is relevant.

## 8. Conclusions

This study has investigated serving waste levels of coffee in the Swedish food service sector as well as its potential causes. The motives for quantification of coffee waste have also been explored. The result of this study indicates that around 10% of the coffee produced in entities are wasted before being served to consumers. This corresponds to a national serving waste of around 17 000 tonnes or 25 000 tonnes per year (depending on assumptions applied) based on the quantification data retrieved from six food service entities during 76 quantification days.

The causes of liquid coffee waste, according to respondents of this study are related to business offer, difficulty in predicting consumption, guest consumption pattern and production strategies. Moreover, lack of resources such as time leads to a lack of planning and analysing current and future coffee demand are aspects generating coffee waste.

There are aspects hindering food service entities to perform coffee waste quantifications. These are connected to the team structure of an entity, lack of resources as well as lack of credence in the problem of coffee waste and its ability to be changed. In contrary there are aspects that motivate entities to quantify coffee waste. These are connected to demand from the organisation, industry or guests as well as the possible cost-savings and increased resource efficiency that can be achieved when waste is reduced. Additionally, personal interest and awareness can motivate entities to perform quantifications.

Due to the low and relatively unvaried sample in this study, it is not representable for the entire Swedish food service sector. Quantifications were a larger and more varied sample is included for a longer period is of relevance for future research. Nonetheless, the result of this study indicates that serving waste of coffee occurs to a relatively large extent and that further quantifications and waste preventing measures are needed to reduce coffee waste and consequently the impact the Swedish coffee consumption has. Higher inclusion of liquid food waste in quantifications are of relevance to identify waste generation areas in the food service and to further prevent food waste.

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## Popular science summary

Coffee is a popular food product, especially in Sweden, and is consumed in households, at work or in restaurants. There are around 30 000 restaurants in Sweden, most of them serving coffee. If all the coffee made in restaurants is not consumed, it will be thrown in the drain. The things required for making the coffee leads to different types of negative effects on the planet, for instance changing our climate. If the food we produce is not consumed, but thrown away, the damage on the planet could have been avoided. This is why wasting food always should be prevented.

Today, we don't know how much food is wasted through the drain because food waste measurements focus on food wasted in the garbage. Since Sweden has many restaurants where coffee is served, it is important to find out how much of this coffee is wasted and if it leads to damages on the planet that could be avoided. To answer this, coffee waste was measured in six Swedish restaurants. It turns out that around 3 litres of coffee per day is wasted in the drain by each restaurant. This means that 10 % of the brewed coffee is wasted. If we put this in perspective to the Swedish food service, this coffee waste would consist of a fifth of all food waste.

To minimise this amount of coffee waste it is important to know why it appears. By using interviews and surveys, causes for coffee waste were found. How a restaurant is managed and what they offer, what resources it has and how guests and food services behave will lead to waste. These are also aspects that results in restaurants not wanting to measure coffee waste. The money that restaurants could save could motivate them to start measuring or if it was required from the management or industry.

The coffee waste that has been identified in Swedish restaurants shows that it is important to start including food wasted in the drain in measurements to not risk missing areas where food waste could be avoided.

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Finally, I would like to express my appreciation to the participants of this project for dedicating their time to perform quantifications as well as participating in surveys and interviews.



# Appendix 1

## Quantification sheet (in Swedish)

Mättdag	Datum	Total producerad mängd (l eller kg)	Eventuellt produktionssvinn (kg)	Serveringssvinn (kg)	Total antal gäster/köp	Total antal bryggkaffe sålda	Total antal måltid med kaffe inkluderat	Eventuell kommentar
1								
2								
3								
4								
5								

## Appendix 2

### Interview material (in Swedish)

1. Varför valde ni att delta i mätningen?
2. Hur upplevde ni att mätningarna fungerade?
3. Hur upplevde ni resultatet av mätningarna?
4. Upplever ni det befintliga kaffesvinnet som problematiskt för er verksamhet?
5. Vad tror ni kaffesvinnet beror på inom er verksamhet?
6. Har ni ändrat ert arbetssätt sedan mätningarna påbörjades?
7. Hur tror ni kaffesvinnet kan minskas inom er verksamhet?
8. Kommer ni fortsätta mäta kaffesvinn?
9. Mäter ni annat matsvinn inom verksamheten?
10. Har ni något mer att tillägga?

## Appendix 3

### Survey material (in Swedish)

För en tid sen blev er verksamhet/verksamheter inbjudna att delta i en mätning av kaffesvinn. Ni valde att inte delta i detta, men får gärna fylla i detta korta formulär kring kaffesvinn. Formuläret är helt anonymt och består av några få frågor som tar 5–10 minuter att besvara. Vid frågor om formuläret eller projektet, vänligen kontakta:

Rosa Hellman  
rohe0002@stud.slu.se

Tack på förhand!

1. Varför valde ni att INTE delta i mätningen av kaffesvinn? Flera val kan göras.

Tidsbrist

För hög personalkostnad för att kunna genomföra.

Inget intresse av mätningen.

Har inte tagit del av informationen.

Annat, vänligen ange: \_\_\_\_\_

2. Vad skulle krävas för att er verksamhet skulle börja mäta mängden kaffesvinn? (Med kaffesvinn menas bryggkaffe som kastas för att det inte gått åt eller för att gästen inte druckit upp)

---

3. Mäter ni någon typ av matsvinn rutinmässigt i verksamheten?

JA

NEJ

4. Vilken typ av matsvinn mäter ni i verksamheten?

---

5.Varför mäter ni matsvinn inom verksamheten?

---

6.Upplever ni att kaffesvinn förekommer inom verksamheten? (Med kaffesvinn menas bryggkaffe som kastas för att det inte gått åt eller för att gästen inte druckit upp)

JA  
NEJ

7.Varför tror ni kaffesvinn förekommer inom verksamheten?

---

8.Varför förekommer inget kaffesvinn inom verksamheten?

---

9.Anser ni som verksamhet att kaffesvinn är en viktig fråga?

JA  
NEJ  
Delvis

10.Varför anser ni att kaffesvinn är en viktig fråga?

---

11.Varför anser ni att kaffesvinn INTE är en viktig fråga?

---

12. Har du något ytterligare du vill tillägga kring ämnet? Vänligen skriv detta nedan.

---

13. Om du har intresse av att delta i en kortare intervju på ämnet, vänligen fyll i dina kontaktuppgifter nedan. (Du anonymiseras i rapporten)

---

Tack för att du fyllt i detta formulär. Om du har frågor om projektet vänligen kontakta:

Rosa Hellman  
rohe0002@stud.slu.se

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