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Food Waste in Iceland

Methodological report

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UMHVERFISSTOFNUN

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Ágrip

(Abstract in Icelandic)

Matarsóun er málefni sem sífellt fær meiri athygli, ekki einungis hér á landi, heldur um öll Vesturlönd. Því hefur haldið fram að allt að þriðjungi þeirra matvæla sem framleidd eru í heiminum sé sóað og því er til mikils að vinna að taka á þessu vandamáli. Með því að draga úr matarsóun má nýta betur auðlindir og spara fé, auk þess sem fullyrða má að sóun matar leggi umtalsvert til losunar gróðurhúsalofttegunda, en gróðurhúsaáhrifin eru áskorun sem gervöll heimsbyggðin tekst nú á við. Á síðustu árum hefur verið gert átak í að mæla umfang matarsóunar, einkum í Evrópu, en það hafa ekki reynst auðveldar mælingar í framkvæmd og ennþá liggur ekki fyrir stöðluð aðferð við slíkar rannsóknir. Í þessari skýrslu eru lagðar fram niðurstöður úr fyrstu rannsókninni sem gerð hefur verið á umfangi matarsóunar hér á landi, sem nær til landsins alls og til hvort tveggja heimila og fyrirtækja.

Umhverfisstofnun vann rannsóknina árið 2016 og hlaut til þess fjárstuðning frá Evrópusambandinu og umhverfis– og auðlindaráðuneytinu, auk þess sem Hagstofa Íslands veitti faglega aðstoð. Rannsóknin var úrtaksrannsókn og skiptist í tvo hluta, annars vegar heimilishluta þar sem matarsóun á heimilum landsmanna var mæld og hins vegar fyrirtækjahluta þar sem matarsóun í tilteknum geirum atvinnulífsins var mæld. Í heimilishlutanum var tekið 1.036 heimila úrtak úr þjóðskrá og þátttakendur beðnir um að mæla og skrá þann mat sem þeir hentu og þá matarolíu og drykki sem þeir helltu í niðurföll. Skráningar bárust frá 123 heimilum. Í fyrirtækjahlutanum lenti 701 fyrirtæki í úrtaki, úr 17 mismunandi atvinnugreinaflokkum. Svör bárust frá 84 fyrirtækjum úr 12 atvinnugreinaflokkum. Þar sem gögn bárust frá svo fáum fyrirtækjum eru einungis fáein fyrirtæki á bakvið niðurstöðurnar í sumum atvinnugreinaflokkanna. Nauðsynlegt er að hafa það í huga þegar niðurstöðurnar eru skoðaðar.

Samkvæmt niðurstöðum úr heimilishluta rannsóknarinnar hendir hver íbúi hér á landi að meðaltali 23 kg af nýtanlegum mat á ári, 39 kg af ónýtanlegum mat og hellir niður 22 kg af matarolíu og fitu og 199 kg af drykkjum. Ekki er marktækur munur á sóun landsmanna eftir því hvort þeir búa á höfuðborgarsvæðinu eða á landsbyggðinni. Þar sem ennþá er ekki til stöðluð aðferð til að mæla matarsóun er samanburður á milli mismunandi rannsókna erfiður og reynist oft ómarktækur. Aðferðafræðin sem notuð er getur haft mikil áhrif á niðurstöður og jafnframt getur haft mikil áhrif hvort rannsóknirnar nái til drykkja og annarra vökva sem hellt er í niðurföll. Í forrannsókn á matarsóun Reykvíkinga, sem Landvernd gerði á síðasta ári, varð niðurstaðan að hver íbúi hendi 45 kg af nýtanlegum mat á ári (að frádregnum drykkjarvörum). Það er mun meira magn en þau 23 kg af nýtanlegum mat sem niðurstaðan varð í þeirri rannsókn sem hér er kynnt. Aftur á móti mældist drykkjarsóun 199 kg á íbúa nú, samanborið við rúmlega 3 kg á íbúa í rannsókn Landverndar. Í rannsókn Landverndar var ekki mælt hversu miklu af ónýtanlegum mat er hent. Ef horft er til annarra Evrópulanda kemur í ljós að sóun á nýtanlegum og ónýtanlegum mat er á svipuðu róli hér á landi, þ.e. ef niðurstöðurnar úr þessari rannsókn eru bornar saman við samantekt á matarsóun innan

Evrópusambandsins sem gerð var fyrr á þessu ári. Þar varð niðurstaðan að hver íbúi hendi á bilinu 70–84 kg á ári af nýtanlegum og ónýtanlegum mat á meðan niðurstöðurnar nú eru 62 kg. Ef horft er til drykkja er munurinn hins vegar meiri, en niðurstaðan nú varð að hver landsmaður helli niður 199 kg af drykkjum á ári á meðan magnið í evrópsku samantektinni reyndist rúmlega 15 kg á ári. Ef horft er til nágrannalanda þá reyndist sóun nýtanlegs matar í Finnlandi árið 2010 vera svipuð og niðurstöðurnar hér á landi gefa til kynna. Almennt má því segja að matarsóun frá heimilum á Íslandi sé að mestu sambærileg því sem gerist í öðrum löndum Evrópu.

Eins og áður segir reyndist svarhlutfall í fyrirtækjahlutanum lágt. Til að mynda fengust ekki gögn frá þeim fiskveiðifyrirtækjum, fiskvinnslufyrirtækjum og fyrirtækjum í mjólkuriðnaði sem lentu í úrtaki. Það skekkir óneitanlega samanburð við niðurstöður annarra landa þegar upplýsingar vantar frá svo stórum og mikilvægum atvinnugreinum. Samkvæmt niðurstöðum rannsóknarinnar reyndist veitingasala og –þjónusta (ÍSAT nr. 56) sá atvinnugreinaflokkur þar sem mesta magninu af mat er hent, eða rúmlega 40 þúsund tonnum á ári. Næstur á eftir kemur kjötiðnaður (10.1) með tæplega 30 þúsund tonn og þar á eftir smásöluverslun (47) með tæplega 4 þúsund tonn. Eins og fyrr segir er samanburður við niðurstöður annarra landa oft erfiður en samt sem áður er áhugavert að bera niðurstöðurnar úr þessari rannsókn saman við niðurstöður samantektar á matarsóun innan Evrópusambandsins, sem gerð var fyrr á þessu ári. Ef heildverslun og smásöluverslun (46 og 47) eru teknar saman í einn flokk þá kemur í ljós að svipuðu magni af mat er hent hér á landi af slíkum fyrirtækjum og gert er í sambærilegum fyrirtækjum í Evrópusambandslöndunum, eða um 9–13 kg á hvern íbúa á ári. Þess ber að geta að ágætis þátttaka var í rannsókninni í þessum flokki fyrirtækja. Frá frumframleiðslu (01-03) á Íslandi kemur mun minni matarúrgangur, eða 3 kg/íbúa samanborið við 18 kg/íbúa innan ESB, en þessi munur helgast a.m.k. að hluta til af skorti á gögnum frá íslenskum fiskveiðifyrirtækjum. Hins vegar er mun meiri mat hent við matvælaframleiðslu (10) og við rekstur gististaða og veitingarekstur (55 og 56) hér á landi heldur en annars staðar í Evrópu. Í fyrri flokknum er 98 kg/íbúa hent hér á landi á ári en 33 kg/íbúa í öðrum löndum og í þeim seinni er munurinn enn meiri, eða 122 kg/íbúa samanborið við 21 kg/íbúa. Þar vegur veitingareksturinn þyngst. Þann fyrirvara verður þó að setja við þennan samanburð að töluverðar óvissur eru í tölunum, hvort tveggja í niðurstöðum þessarar rannsóknar en einnig í erlendu tölunum. Í rannsókninni var einna best þátttaka frá eldhúsum og mötuneytum skóla (P), heilsustofnana (86) og hjúkrunarheimila (87). Ef þessi starfsemi er tekin saman reyndist matarsóunin vera 13 kg/íbúa á ári, sem er svipað magn og hjá heildverslun og smásöluverslun samanlagt. Niðurstaðan er því sú að þessi rannsókn dregur upp svipaða mynd af matarsóun frá atvinnurekstri eins og komið hefur fram í öðrum Evrópulöndum, þ.e. mesta sóunin er hjá veitingarekstri og matvælaframleiðslu.

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1 Introduction

The report discusses a research project on food waste in Iceland. The project was partially funded by the European Union under the FUSIONS programme, within the Seventh Framework programme (FP7), and situated at the Environment Agency of Iceland. The project started in February 2016 and ended with this report in October 2016. A temporary employee, Sociologist Margrét Einarsdóttir, was recruited to implement the research and analyse the data, but Guðmundur B. Ingvarsson, advisor at the Agency acted as a project manager. When needed, Statistics Iceland provided professional assistance to the project.

The results indicate that Icelandic households waste substantial amount of food, or that each individual wastes up to 23 kg of edible and 39 kg of inedible food, and pour down 22 kg of cooking oil and fat and 199 kg of liquid a year. This amounts to 283 kg of food and drink per person per year. In other words, annually Icelandic homes waste in total 7,649 tonnes of edible food, 13,024 tonnes of inedible food, 7,214 tonnes of cooking oil and fat, and 66,072 tons of drinks and other liquid food, or total annual waste of 93,959 tonnes. The figures are significantly higher than the 92 kg of food and drink per person per year that Stenmarck et al. (2016) estimated for the EU-28. The Icelandic figures on the waste of edible food are more in line with the results of Koivupuro et al. (2012) from Finland. Notably, however, research on food waste are still at an early stage and caution should be taken when comparing results.

The results on the food waste of Icelandic companies are somewhat limited because of lack of data. Therefore, figures on the waste within fishing, fish processing, manufacture of dairy products and manufacture of beverages are lacking. The available figures amount to annual food waste of 83,240 tonnes, or 250 kg per person per year. Again, the figures are significantly higher than the estimate of Stenmarck et al. (2016) for the EU-28 of 81 kg per person per year, and where the whole food chain (except for households) is reached. It should be noticed that the food service sector is responsible for more than half of the Icelandic company food waste, and that this sector has expanded extensively in recent years in line with the extensive expansion of turism in the country. Also, again it should be emphasised that research on food waste are still at an early stage and caution should be taken when comparing results.

The report starts with an account of the objectives of the research, followed by a short discussion on the Icelandic context of the research, and definitions of relevant concepts. Then the methods of the household research and the presentation of it results are discussed, as well as the methods and results of the company research. The report ends with a discussion on any deviation from the objectives of the research and challenges encountered during its execution.

2 The objectives

The objective of the research project is to obtain detailed and reliable statistics on the amount of food waste in Iceland. More precisely, the objective is to examine where in the food supply and consumption chain food waste is generated, and to obtain information on the types of food waste from the whole 'food use hierarchy'. As such, the focus of the research is on the complete food supply and consumption chain, from manufacturers to consumers, and the aim is to broke the statistics down exactly in line with the EU food waste 'plug-in', as described by Schrör (2013). Also, the aim is to break the statistics further down into edible and inedible food waste, as well as to examine urban vs. rural difference in household food waste.

The methodology and methods of food waste research are still at an early stage, and when the methodology for this research was designed, systematic methods for collection of statistical data still to be fully developed. For example, the FUSIONS food waste quantification manual (Tostivint et al., 2016) had not been published. Also, definitions of relevant concepts are still in progress. The research project contributes to that development by collecting detailed statistics on food waste in Iceland, based on randomly selected samples from the whole food supply and consumption chain.

In accordance with the objective of collecting information on food waste from the whole food use hierarchy, the research was multipartite. Firstly, the focus was both on households and on enterprises, secondly, regarding the enterprises, the focus was on the manufacture of food, on the wholesale and retail of food, as well as on the food service. A tailor-made survey was prepared for each category and the participants were asked to weigh and file the amounts of food waste they dispose of over a period of one week into an on-line web portal.

3 The Icelandic context

Iceland is an island country, and geographically isolated. The country has the smallest population of the Nordic countries, 332,529 inhabitants in the beginning of 2016 (Statistics Iceland, 2016), although its geographic size is considerable, or 103,125 km². Hence, the country is sparsely populated, or 3.2 inhabitants per km². The majority of the population, or 213,402 (64.2%), lives in the capital area,[1] the rest, or 119,127 (35.8%) in the countryside. The population of the largest town outside the capital area, Akureyri, is 18,294.

Experience shows that response rate has been relatively high in quantitative research in Iceland. Therefore, beforehand, it was expected that quite high response rate would be reached in the

[1] The capital area includes the municipalities of: Reykjavík (the capital); Kópavogur; Seltjarnarnes; Garðabær; Hafnarfjörður; and Mosfellsbær.

research, although it was also recognised that low response rate was the main risk factor of the research.

4 Definitions of concepts

There has been a lack of consistency of definition of food waste in statistics and research, and a clear definition of the concept of food waste therefore still needed in each case of food waste research (Östergren et al., n.d.).

The current research relies on Östergren et al. (n.d.) definition of food:

- 'Food means any substance or product, whether processed, partially processed or unprocessed, intended to be, or reasonably expected to be eaten by humans.' (Östergren et al., n.d., p. 20).

In the research, food is further divided into edible food and inedible food as follows:

- Edible food 'has or had the potential to be eaten by humans'. The definition 'recognizes food which is no longer considered edible (since e.g. it's moulded, rotten or the date has expired), but which has had the potential to be eaten, … even though it's not edible at the point of disposal' (Östergren et al., n.d., p. 22).
- Inedible food is the part of food that is not recognised as fit for human consumption, such as bones, eggshells, peels, coffee grounds, etc.

What is considered edible and what is considered inedible may vary between persons as well as between cultures. As the research depends on self-administrated surveys, it should be noted that the classification of edible and inedible food in the results is subjective rather than objective.

Participants were asked to report all food waste regardless of how the waste was treated. Therefore, food waste fed to animals is included in the research, unlike what is the case in the EU-28 estimate of food waste level where such waste is excluded, at least regarding households studies (Stenmarck et al., 2016, p. 24). Identical to the EU-28 estimate, data on food waste disposed of via the sewer was measured separately, but dissimilar to the EU-28 estimate cooking oil and fat was also separately measured.

In the report, the term urban refers to the capital area and the term rural to other parts of the country.

5 Methods of household research

5.1 Sample design

The sample design of the household research was one one-stage simple random sample without stratification. The sample units are families as defined by the Icelandic population register, and selected from that register. The lower age limit of the sample was 18 years, with no upper age limit.

The gross sample size was 1,036 families, set to meet demands for a confidence level of 99%, confidence interval of ±4%, for population of 185,569 families. That was the number of families in Iceland on 1 December 2015, according to Statistics Iceland.

5.2 Weighting and substitutions

The data was not weighted, adjusted to external data, nor any substitutions applied. Neither was the data adjusted to nonresponse. Although often applied in statistics, nonresponse adjustments have been criticised for assuming 'that those responding from a particular subgroup are about the same as those not responding on the variables the survey is trying to estimate' and it pointed out that this assumption is 'almost always untestable' (Fowler, 2014, p. 136). In light of limited existing results on household food waste, a nonresponse adjustment was not thought to increase the quality of the data.

5.3 Sampling errors: standard errors, and effective sample size

There were 1,036 households in the sample. In total, 13 of the households proved to be non-eligible (staying in institutions or emigrated), giving a net sample of 1,023 households.

The mean, the total member of observations and the standard errors for the food waste variables are shown in the results chapter (Table 4).

5.4 Non sampling errors

Errors other than sample errors can be divided into three categories: coverage errors, nonresponse errors and measurement errors.

5.4.1 Sampling frame and coverage errors

The sampling frame is the Icelandic national register. Eligible for the sample were all family numbers in the register of those aged 18 and older, and living in Iceland according to the register. Those registered at institutions were excluded from the sample.

The national register is updated continuously. However, it does not always contain correct information on changing of residence. People may move abroad or to an institution without giving information to

the national register. Therefore, the national register may over represents young people who tend to go abroad for their studies and older people who sometimes maintain a private address despite living in an institution. This possible coverage error was considered negligible and was not adjusted for.

5.4.2 Nonresponse errors

The average age of the respondents (51.4 years) was significantly higher than the average age of the non-respondents (47.3 years), t(1034) = -2.60, p =. 01, and those with higher income (monthly income ISK 701,000 or more) were more likely to respond than those with lower income (monthly income ISK 700,000 or less), $\chi^2(4, N=429)=23.01$, p=.00. Significant difference did not appear regarding gender nor residence (urban vs. rural).

Significant difference did not appear between the average number of household members of respondents' households (2.94) and non-respondents' households (3.0), t(595) = .38, p =. 71.

The bias was not countered for.

5.4.2.1 Achieved sample size and unit nonresponse

In total the achieved sample size was 123 households. As Table 1 shows the nonresponses occurred in two stages. The former stage occurred when consent for participation in the kitchen diaries was sought. In total 294 of the sampled families, or 28.7%, accepted to participate at this stage. The second stage of the non-response occurred during the filing of the kitchen diaries. In total, 171 families who had consented to participate failed to file the diaries, with the consequence of a final response rate of 12.0%. In other words, a unit nonresponse of 78.0%.

Table 1. Status of sampled families in the research, and in the kitchen diaries

Status in sample	N (%)	Status in kitchen diaries	N (%)
Agreed to participate	294 (28.7)	Participated in	123 (12.0%)
		Did not participate in	171 (16.7%)
Declined participation	478 (46.7)		
Declined because do not own a scale	21 (2.1)		
No telephone number	108 (10.6)		
At sea/temporary abroad	16 (1.6)		
Not reached by phone	94 (9.2)		
Not enough skill in Icelandic	12 (1.2)		
Total	1023 (100.0)		

5.4.2.2 Item nonresponse

It was assumed that participants of the kitchen diaries who did not report on some of the food waste types did indeed not waste any such type of food. Such missing values were therefore converted into zero values.

No imputations were applied.

5.5 Mode of data collection

5.5.1 Self-administrated, online kitchen diaries

The mode of data collection used in the household research was self-administrated, online kitchen diaries. The duration of registration was one week.

Various methods have been applied to measure food waste of households. Jörissen et al., (2015) divide the methods into two groups according to whether the data is collected by a third party or by the household members themselves. Both methods have their advantages and disadvantages (Jörissen et al., 2015; Williams et al., 2012).

The main advantage of data collection of a third party in food waste research is its accuracy and objectivity. The main disadvantage of such mode of data collection is however financial; it is expensive to provide an observer for each household taking part in the research unless it is restricted to just a few households. That financial threshold can be removed by asking the household members to collect the data. However, that means that the objectivity of the measurement is reduced. The simplest form

of such self-administrated survey is a questionnaire where the respondents are asked to estimate the weight of the food waste. However, experience shows that people tend to underestimate how much they waste when self-reporting (Beretta et al., 2013; Jörissen et al., 2015; Ventour, 2008). That disadvantage can be avoided by asking the respondents to weight the waste and file the results into a kitchen diary.

Some research on household food waste have applied self-administrated kitchen diaries, e. g. the Finnish Foodspill research (Silvennoinen et al., 2014; Koivupuro et al., 2012), the British WRAP studies (Ventour, 2008), and the Icelandic pilot study of Landvernd (Burgherr et al., 2015).

The pilot study of Landvernd was used as a starting point in the development of a kitchen diary for the current research. The exemplar of that kitchen diaries were the kitchen diaries developed by the British WRAP studies ('Love Food Hate Waste homepage', n.d.). In the Landvernd study each participating household was asked to hold a kitchen diary for one week into which all food and drink disposed was filed. Furthermore, the participant was asked to report the type of the disposed food, where the food was disposed of, as well as whether initially the food was edible or inedible.

For the current research, the kitchen diary form developed by Landvernd was tested by a group of 11 households. The test revealed the complexity of the diary which led to the risk of the participants not completing it. As the objectives of the research did not require as complex information as asked for in the Landvernd study, it was decided to simplify the form of the diary by deleting most questions on both types of food and disposal of food (Figure 1).

As digital technology has improved, the advances of online research have been recognised, and such research become more popular (Fowler, Jr., 2014; Fricker & Schonlau, 2002; Horevoorts et al., 2015). Figures show that in 2014 in total 97% of Icelanders used the internet regularly (the highest percentage of regular internet use in Europe) (https://hagstofa.is/media/43822/hag_150123.pdf, p. 1). Therefore, it was decided to offer an online kitchen diaries form. The online portal was designed by the IT unit at the Environment Agency of Iceland, and supported both personal computers and smartphones. The final form of the on-line kitchen diary is presented in Figure 1.Figure 1. Online kitchen diary form for households

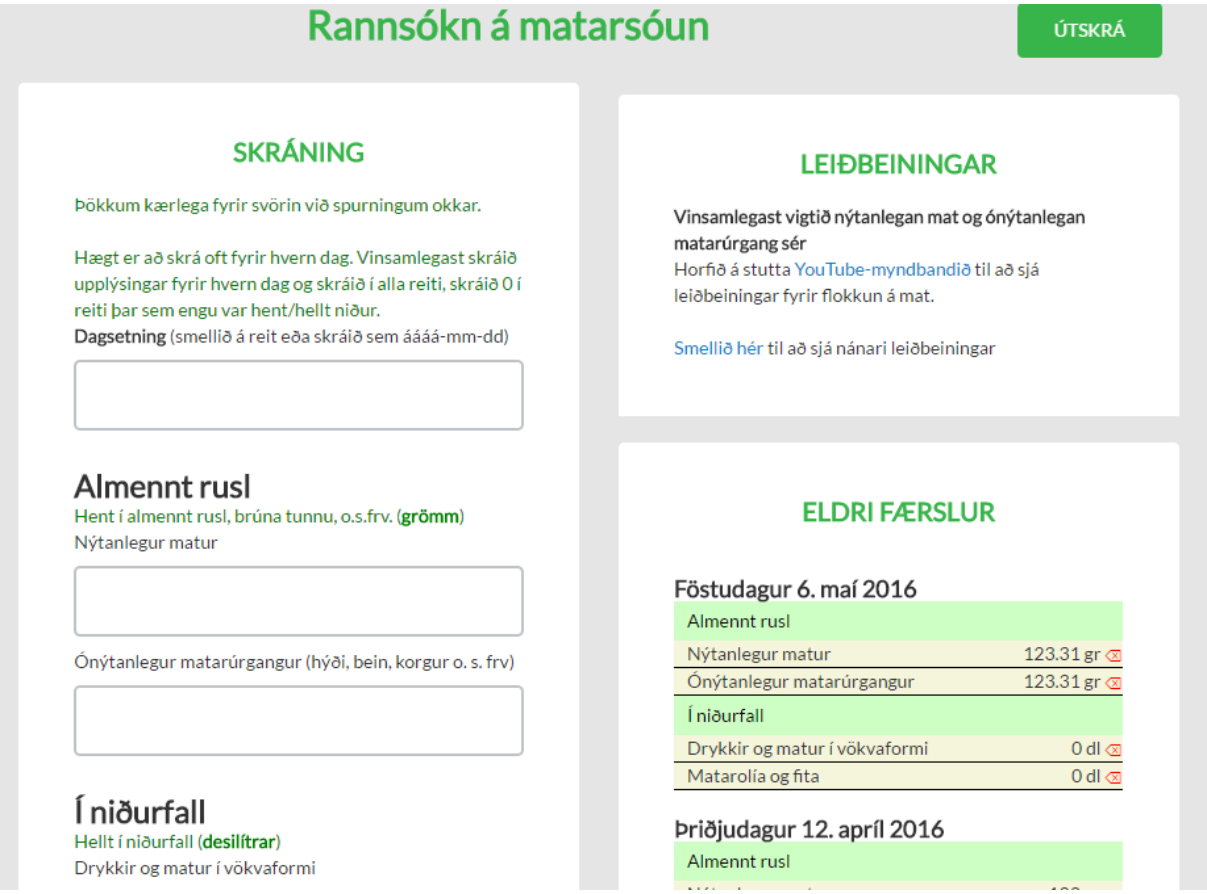

Figure 1. Online kitchen diary form for households

To overcome known disadvantages of online data collection a mixed-mode strategy was utilised (Fricker & Schonlau, 2002, p. 359). The contact strategy was limited to access by phone, but a mixed response mode of internet and mail was applied.

5.5.2 Mode of collection of participation consent

A consent to participation was collected by phone. Every person of the sample reached by phone was asked to answer three background questions on: the number of household members; the number of children in the household; and, the total income of the household. Background information on the age, the gender, and the residence of the persons of the sample was collected through the national register of Iceland.

Every respondent was then asked if he/she consented to participate in the kitchen diary logging. Those who agreed received a user name and a password into the kitchen diary web portal. Those who did not have access to a computer/internet connection were offered a kitchen diary form on paper by mail. The web portal allowed on-line check on the registrations. Those who had not registered on time

were reminded of the participation by email, by text messages, and by phone. The research was also introduced in Icelandic media to facilitate participation.

5.5.3 Measurement and processing errors

Measurement and processing errors can be classified into three categories: Design errors, interviewer errors, and processing errors.

5.5.3.1 Design errors

An immediate problem in the design of food waste research is that the collection of the data is quite time-consuming (Jörissen et al., 2015). The simplification of the kitchen diaries was a resort to reduce such time-consumption. Nevertheless, the demand of time and work the participants had to put into the registration could have led to nonresponses. In order to overcome such nonresponses, further developments of food waste research methods are needed.

The kitchen diaries were self-administrated, and a researcher not presented to control the quality of the measurements. The measurements are therefore subjective rather than objective. The method requires minimum calculation and writing skills in mathematics, which means that those without such skills might be undercovered (Fowler, Jr., 2014, p. 72). Also, the kitchen diaries were only in Icelandic which could have limited participation of immigrants. At the present, 7.96% of the Icelandic population has foreign citizenship (Statistics Iceland, 2016). In addition, the participants were not provided a scale. In total, 1.9% of the sample declined participation on the grounds that they did not own a scale.

Internet surveys have been criticised for not reaching those who do not have access to internet connection (e.g. Brick, 2011; Fowler, Jr., 2014). This limit was overcome in the research by: 1) using the National register as a sample frame and collecting email addresses by phone; 2) Offering those who do not use the internet to receive the kitchen diaries by post.

5.5.3.2 Interviewer errors and processing errors

Online data collection involves the danger of information losses because of technical failure. In this case, the data collection did not suffer from such failure. However, it is possible that some data was lost because some participants failed to save their reporting and/or that some participants did some sort of typing errors. On the other hand, online research has the advantages that information does not need to by manually filed into the statistics software, which both saves time and prevents misreading and typing errors on behalf of the researchers.

6 Results of household research

Although the households were asked to file their food waste for a whole week into the kitchen diary not all of them did so, some filed for a longer period and others for a shorter one (Table 2).

Table 2. Frequency of filing days for households

Number of filing days	Frequency (N)	Percentage (%)
1	14	11.4
2	1	0.8
3	5	4.1
4	6	4.9
5	6	4.9
6	15	12.2
7	56	45.5
8	14	11.4
9	1	0.8
10	1	0.8
11	2	1.6
14	1	0.8
36	1	0.8
Total	123	100

Therefore, it was necessary to calculate the food waste per household per day (Fw) for each type of food waste before further calculation:

Fw [g] = g [g]/N

g = Total food waste for food waste category

N = Number of filing days

6.1 Food waste per person per day

As expected, the number of household members varied, as Table 3 shows.

Table 3. Number of household members

Number of household members	N	Percentage
One member	17	13.8%
Two members	44	35.8%
Three members	19	15.4%
Four members	20	16.3%
Five members	19	15.4%
Six members	3	2.4%
Seven or more members	1	0.8%
Total	123	100%

The number of household members was used to calculate the person per day food waste (pwd) for each food waste type:

pwd [g] = Fw [g]/N

Fw = Food waste per household per day

N = Number of household members

The results on the average person per day waste of edible food, inedible food, cooking oil and liquid poured into sewages, as well as the standard deviation, and the standard error are presented in Table 4.

Table 4. The average person per day waste of edible food, inedible food, cooking oil and liquid into sewers

Type of food waste	N	Mean	SD	SE	Minimum value	Maximum value	Range
Edible food	123	63 g	65	6	0 g	365 g	365 g
Inedible food	123	107 g	105	9	0 g	524 g	524 g
Cooking oil	123	0.6 dl	3.1	0.3	0.0 dl	27.5 dl	27.5 dl
Liquid	123	5.4 dl	14.6	1.3	0.0 dl	86.7 dl	86.7 dl

Table 4 shows that on average 63 g of edible food, 107 g of inedible food, 0.6 dl of cooking oil and fat, and 5.4 dl of drinks and food in liquid form are wasted per person per day in Iceland.

The ranges of the values are substantial within all food waste types. For one thing, within all types, some households reported no waste, and, hence, in all instances the minimum value for individual per day waste is zero. For another thing, in all instances the maximum values are considerably high. That could reflect some process errors, although such errors are difficult to detect as maximum value for food waste per person per day cannot be assumed.

6.1.1 Differences between urban and rural areas

One of the purposes of the research was to examine whether a difference in household food waste occurs between urban and rural areas in Iceland.

A test of normality was applied to examine whether the food waste variables were normally distributed, and whether to use a parametric or non-parametric test to examine the residence difference (Table 5).

Table 5. Tests of normality for person per day waste of edible food, inedible food, cooking oil and liquid, by residence

Type of food waste	Residence	Test of Normality
Liquid into sewage	Urban	D(68) = .392. p = .000
	Rural	D(55) = .344. p = .000
Cooking oil	Urban	D(68) = .421. p = .000
	Rural	D(55) = .411. p = .000
Edible food	Urban	D(68) = .146. p = .001
	Rural	D(55) = .171. p = .000
Inedible food	Urban	D(68) = .155. p = .000
	Rural	D(55) = .189. p = .000

As the food waste variables were significantly non-normal in both the urban and the rural group the non-parametric Mann-Whitney test was applied to test whether differences between residence exists (see Table 6).

Table 6. Average person per day waste of edible food, inedible food, cooking oil and liquid, by residence

Type of food waste	Residence	N	Mean	SD	SE	Test of significance (U)
Edible food	Urban	68	54 g	51	6	= 1641.00.
	Rural	55	74 g	78	11	p = .512
Inedible food	Urban	68	94 g	85	10	= 1741.00.
	Rural	55	123 g	124	17	p = .244
Cooking oil	Urban	68	1.0 dl	4.0	0.5	= 1766.00.
	Rural	55	0.2 dl	0.7	0.1	p = .518
Liquid	Urban	68	6.8 dl	17.6	2.1	= 1762.50.
	Rural	55	3.8 dl	9.5	1.3	p = .581

Table 6 reveals substantial variation in individual per day waste of edible food, inedible food, cooking oil, and liquid poured into sewages in both urban and rural areas. Also, the table shows some residence differences in the average waste in all food waste types. However, those average differences are not statistically significant, and are therefore not included into further calculation.

6.2 Food waste per person per week

Household food waste is often measured as per person per week (Jörissen et al.. 2015). For the purpose of comparisons, the results on household food waste per person per week are therefore presented in Table 7.

The waste per person per week (pww) was calculated by multiplying the person per day waste (pdw) by seven:

pww [g] = pwd [g] * 7

Table 7. The average individual per week waste of edible food, inedible food, cooking oil, and liquid into sewers

Type of food waste	N	Mean
Edible food	123	441 g
Inedible food	123	751 g
Cooking oil	123	4.5 dl
Liquid	123	38.1 dl

6.3 Annual food waste per person

Household food waste has also been measured as kilograms of food waste per person per year (e.g. Stenmarck et al., 2016).

The waste of edible and inedible food per person per year (pwy) is calculated as follows:

pwy [kg] = (pwd [g] * 365.25)/1000

Initially, the waste of cooking oil/fat was measured in decilitres. Therefore, the average density of cooking oil (92.8 g/dl) had to be taken into account when calculating the waste in kilograms pear person per year:

pwy (kg) = ((pwd [dl]*92.8[g/dl])* 365.25)/1000

In the calculation of the waste of liquid per person per year (pwy) it is assumed that one litre equals one kilogram:

pwy (kg) = (pwd [dl] * 365.25)/10

The results are illustrated in Table 8.

Table 8. The average annual waste per person of edible food, inedible food, cooking oil and liquid into sewers

Type of food waste	N	Mean (kg)
Edible food	123	23
Inedible food	123	39
Cooking oil	123	22
Liquid	123	199

6.4 Annual food waste of households in Iceland

On 1 January 2016 the population of Iceland (P) was 332,529 according to Statistics Iceland.

The annual waste of edible and of inedible food (afw) in Iceland is measured in tonnes, and was calculated as follows:

afw [tonnes] = (pwd [g] *365.25*P)/1.000.000

The annual waste of cooking oil and fat (afw) in Iceland is measured in tonnes, and was calculated as follows:

afw [tonnes] = (pwd [dl] *92.8 [g/dl]*365.25*P)/1.000.000

The annual waste of liquid was calculated as follows:

afw [tonnes] = (pwd [dl] *365.25*P)/10.000

The results of the calculations of the annual food waste in Iceland are illustrated in Table 9.

Table 9. The annual waste per person of edible food, inedible food, cooking oil, and liquid into sewers

Type of food waste	N	Annual waste (tonnes)
Edible food	123	7649
Inedible food	123	13024
Cooking oil	123	7214
Liquid	123	66072

6.5 Summary of results on household food waste

The results on household food waste in Iceland are summed up in Table 10.

Table 10. Summary of results on household food waste in Iceland

Type of food waste	Person per day food waste	Person per week food waste	Person per year food waste (kg)	Annual food waste in Iceland (tonnes)
Edible food	63 g	441 g	23	7649
Inedible food	107 g	751g	39	13024
Cooking oil	0.6 dl	4.5 dl	22	7214
Liquid	5.4 dl	38.1 dl	199	66072
Total			283	93959

The results reveal substantial food waste within Icelandic households. Regarding edible food, each individual wastes 63 g a day, which sums up to 23 kg a year, or annual waste of 7,649 tonnes in total. The figures on the inedible food that are disposed of are higher; 107 g a day, or 39 kg a year, and total annual waste of 13,024 tonnes. Each individual throws away 0.6 dl of cooking oil and fat and 5.4 dl of drinks and food in a liquid form per day, or annually 22 and 199 kg respectively. That amounts to that Icelandic households pour down 7,214 tonnes of cooking oil and fat, and 66,072 tons of drinks and other liquid food a year. In total, 283 kg of food and drink is disposed of per person per year, or 93,959 tonnes in total.

6.6 Comparison with other results on food waste

The results of present studies on household food waste vary considerably. As such, Jörissen's et al. (2015) review on European studies reveals a range from 153 g – 1500 g per person per week. It can be assumed that the differences can partly be explained by different definitions of food waste. The results on the waste of edible food in Iceland are somewhat higher than the results of Koivupuro et al. (2012) on edible food waste in Finland of 442 g per person per week when it has been taken into consideration that milk (in liquid form) was included in the Finnish study. On the other hand, the results are considerably lower than the results of Icelandic pilot study of Landvernd (Burgherr et al., 2015) of 920 g per person per week, but considerably higher that the estimate of the authors of the FUSIONS projects of 92 ± 9 kg per person per year within the EU-28. Drinks and food in liquid form are included in both studies.

7 Methodology of company research

7.1 Sample design

Effective sample size planning requires access to data of a similar nature in order to estimate the number of sample units needed for accurate estimates. Due to the lack of data on food waste among enterprises in Iceland the sample size had to be determined by using other, less preferable methods. Based on similar sample surveys among enterprises conducted in Iceland for the purpose of official statistical production, a sample size of 700 enterprises was determined adequate, with the assumption (again based on other similar surveys) that the final number of responses would be around 500.

The sample was selected using a simple random stratified sample design. The strata were based on the NACE categorization identified in the EU plug-in for food waste statistics (Schrör, 2013), as well as on the turnover of each enterprise, splitting each NACE category into high and low turnover groups, making the total number of strata 42. NACE categories of the EU plug-in with no economic activities in Iceland were erased from the sample frame. Subcategories of the included NACE categories that apparently do not deal in food were also deleted from the sample frame. The included NACE categories and the inclusion of their subcategories are listed in Table 11.

Table 11. The NACE categories included in the company sample frame, and the inclusion of their subcategories

NACE category	Inclusion of subcategories
01 Agriculture	Fully included
03 Fishing	Fully included
10.1 Meat processing	Fully included
10.2 Fish processing	Fully included
10.3 Processing of fruit and vegetables	Fully included
10.4 Manufacture of oil and fat	Fully included
10.5 Manufacture of dairy products	Fully included
10.7 Manufacture of bakery and farinaceous products	Fully included
10.8 Manufacture of other food products	Fully included
11 Manufacture of beverages	Fully included
46 Wholesale trade	Subcategories assumed not to involve food excluded
47 Retail trade	Subcategories assumed not to involve food excluded
55 Accommodation	Subcategories assumed not to involve food excluded
56 Food and beverage service activities	Fully included
P Education	Students canteens included
86 Health	Patients canteens included
87 Nursing homes	Patients canteens included

The sample was selected from Statistics Iceland's business register, using optimal allocation, while keeping a minimum of 2 enterprises within each stratum – which was successful for every stratum, except one where the total number of enterprises in the population was 1.

Except from institutions at university level that were sampled as described above, educational institutions (NACE category P) were sampled additionally, as their coverage in the business registers is poor. That was also the case of health institutions (NACE category 86).

Information on existing preschools and primary schools in Iceland was gathered from the Association of Local Authorities, and information on existing secondary schools from the Ministry of Education. Based on that sample frame, 15% of the schools at each school level were selected into the sample.

Information on existing health institutions was gathered from the Ministry of Welfare. The institutions were split into high and low turnover groups as described above. In total, 15% of the lower turnover group was selected into the sample.

7.2 Weighting and substitutions

The data was weighted within each stratum. The high turnover group of each strata received to weight 1, whereas the weight of the low turnover group in each strata is the inverse number of turnover companies in that strata according to Statistics Iceland's business register as calculated in x, the NACE category design weight:

x = 1/N

N = number of low turnover companies in the relevant NACE

The weighting was adjusted to nonresponse (xx):

xx = x/rr

x = NACE category design weight

rr = response rate for each strata

No substitutions were applied.

7.3 Sampling errors: Standard errors and effective sample size

There were 701 companies in the sample. In total, 192 of the companies proved to be non-eligible (not involved in food, not in operation, or had officially quit all operation), giving a net sample of 509 companies (Table 12).

Table 12. Level of participation in company research

Level of participation	N	Percentage
Did not participate	426	60.8%
Filed into the diary web portal	78	11.1%
Provided available food waste data	6	0.9%
Company was not operating or not involved in food	191	27.2%
Total	701	100%

7.4 Non sampling errors

Errors other than sample errors can be divided into three categories: coverage errors; measurement and processing errors; and, nonresponse errors.

7.4.1 Sampling frame and coverage errors

The sampling frame is the Statistics Iceland's business register. Eligible for the sample were businesses in NACE categories assumed to be involved in food (see section 6.1). Education institutions and health institutions where selected separately as their coverage in the business registers is poor. The sample frames of those institutions where lists gathered from the Association of Local Authorities, the Ministry of Education and the Ministry of Welfare.

7.4.2 Measurement and processing errors

Measurement and processing errors can be classified into three categories: Design errors; interviewer errors; and, processing errors.

7.4.2.1 Design errors

As in the case of the household research, an immediate problem in the design of research of food waste in companies is that the filing is time-consuming on the behalf of the sampled companies. The demand of time and work from the participants could have led to nonresponses. In order to overcome such nonresponses, further developments of food waste research methods is needed. The company diaries were self-administrated, and a researcher not presented to control the quality of the measurements. The measurements are therefore subjective rather than objective. (Fowler, Jr., 2014, p. 72). However, unlike in the household research, companies were provided a scale if that facilitated their participation.

Internet surveys that focus on individuals have been criticised for not reaching those who do not have access to internet connection (e.g. Brick, 2011; Fowler, Jr., 2014). Such limitation should not be as demanding regarding company research. The execution of the company research revealed this to be

the case, although some sampled companies did not publish their email addresses online, and their email addresses had therefore to be collected by phone.

7.4.2.2 Interviewer errors and processing errors

Online data collection involves the danger of information losses because of technical failure. In this case, the data collection did not suffer from such failure. However, it is possible that some data was lost because some participants failed to save their reporting and/or that some participants did some sort of typing errors. On the other hand, online research has the advantages that information does not need to by manually filed into the statistics software, which both saves time and prevents misreading and typing errors on behalf of the researchers.

7.4.3 Nonresponse errors

Nonresponse errors were not accounted for.

7.4.3.1 Achieved sample size, and unit nonresponse

Achieved sample size was 510 companies, where 426 did not participate, 78 participated by filing data into the diary web portal and 6 participated by submitting already available data on food waste (Table 13).

7.4.3.2 Item nonresponse

It was assumed that those who did participate but did not report on some of the food waste types did not waste any such type of food. Such missing values were therefore converted into zero values.

No imputations were applied.

7.5 Mode of data collection

In the beginning, the intention was to collect the company data exclusively from self-reported food waste diaries. In practice, although revealing positive attitude towards the research, spokesmen of many of the sample's companies found such diaries to be time-consuming. However, some were willing to provide already available data on food waste. It was decided to accept those offers rather than getting no data. The disadvantage of such data is that in most instances it did not confirm to the break-down of the EU food waste plug-in. Consequently, the data in some of the NACE categories is not in accordance with that plug-in. Additionally, in fishing, fish processing, manufacture of dairy products and manufacture of beverages it was not possible to collect the minimum amount of data, and consequently, no statistics were produced for these categories.

The final participation in the research is showed in Table 13.

Table 13. Status of participation in the research

Status of participation	N	Percentage
Did not participate	426	83.5
Filed into the diary web portal	78	15.3
Provided available food waste data	6	1.2
Total	510	100

Table 14. Status of participation in the research by NACE code

NACE code	No participation	Filed into portal	Available food waste data	Total
01 Agriculture	71.4% (25)	28.6% (10)	0.0% (0)	100.0% (35)
03 Fishing	100.0% (66)	0.0% (0)	0.0% (0)	100.0% (66)
11 Manufacture of beverages	75.0% (3)	0.0% (0)	25.0% (1)	100.0% (4)
46 Wholesale trade	82.9% (63)	17.1% (13)	0.0% (0)	100.0% (76)
47 Retail trade	69.8% (44)	28.6% (18)	1.6% (1)	100.0% (63)
55 Accommodation	91.3% (21)	8.7% (2)	0.0% (0)	100.0% (23)
56 Food and beverage service activities	86.8% (33)	10.5% (4)	2.6% (1)	100.0% (38)
P Education	69.4% (50)	30.6% (22)	0.0%(0)	100.0% (72)
86 Health	0.0% (0)	50.0% (1)	50.0% (1)	100.0% (2)
87 Nursing homes	57.1% (4)	28.6% (2)	14.3% (1)	100.0% (7)
10.1 Meat processing	78.9% (15)	15.8% (3)	5.3% (1)	100.0% (19)
10.2 Fish processing	100.0% (77)	0.0% (0)	0.0% (0)	100.0% (77)
10.3 Processing of fruit and vegetables	83.3% (5)	16.7% (1)	0.0% (0)	100.0% (6)
10.4 Manufacture of oil and fat	66.7% (2)	33.3% (1)	0.0% (0)	100.0% (3)
10.5 Manufacture of dairy products	100.0% (3)	0.0% (0)	0.0% (0)	100.0% (0)
10.7 Manufacture of bakery and farinaceous products	87.5% (7)	12.5% (1)	0.0% (0)	100.0% (8)
10.8 Manufacture of other food products	100.0% (8)	0.0% (0)	0.0% (0)	100.0% (8)
Total	83.5% (426)	15.3% (78)	1.2% (6)	100.0% (510)

7.5.1 Self-administrated, online company food waste diaries

There is a lack of detailed description of the methods used for collecting data on the amount of food waste in companies, at least regarding descriptions written in English or Scandinavian languages. An exception is the Finnish Foodspill research were some description on the methods are to be found (Katajajuuri, Silvennoinen, Hartikainen, Heikkilä, & Reinikainen, 2014; Silvennoinen et al., 2012; Silvennoinen et al., 2015). A notice was taken of that description, but otherwise the data collection methods had to be developed without relying on existing research. The development of the company data relied on the EU food waste plug-in, and an account was taken of the household data collection.

As regarding the household data collection, a self-administrated, online food waste diary form was developed. As the EU food waste plug-in defines different food waste categories for different NACE codes, a specific form was developed for each code.

An example of the on-line food waste diary form for companies is shown in Figure 2.

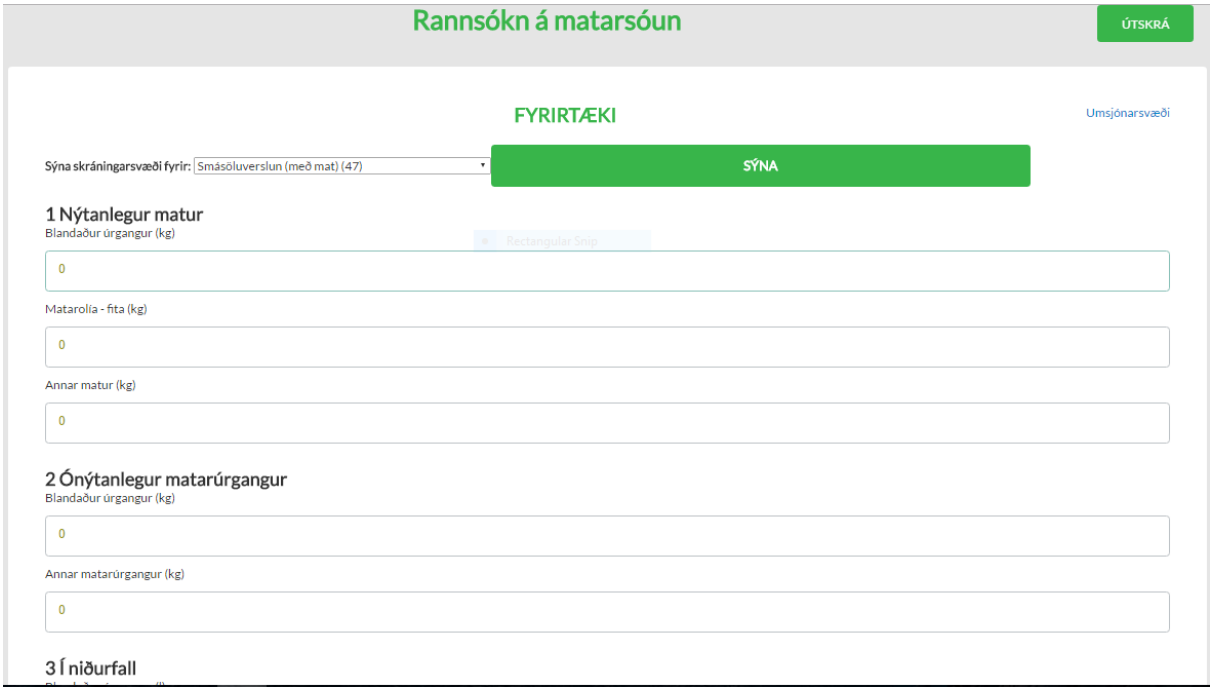

Figure 2. Online company food waste diary form

7.5.2 Mode of collection of participation consent

The sampled companies were contacted by email in cases where an email address was available on the internet. Otherwise the companies were contacted by phone, the research introduced and an email address collected. Regarding the companies in the high turnover groups an effort was put into reaching the relevant contact person.

Those who agreed to participate received a user name and a password for the company diary web portal. Those who did not have access to a computer/internet connection were offered a diary form on paper by mail (which one company accepted). The web portal allowed for online check on the registrations. Companies which had not filed the diary on time nor offered data the company already had available were reminded of the participation by email and by phone. Lack of time was a common reason given for non-participation.

8 Results of company research

The companies were asked to file their food waste for a whole week into the web-portal. However, some filed for a shorter period and other for a longer period, as Table 15 shows.

Table 15. Frequency of filing days for companies

Number of filing days	Frequency (N)	Percentage (%)
1	14	17.9%
2	4	5.1%
3	2	2.6%
4	6	7.7%
5	21	26.9%
6	9	11.5%
7	17	21.8%
8	3	3.8%
9	1	1.3%
14	1	1.3%
Total	78	100

In order to produce a standardized weekly food waste (swfw) data the following calculation was conducted:

swfw =(Kg [kg]/ N) * 7

Kg = Total food waste for food waste category

N = Number of filing days

The swfw for each NACE category was weighted as described in section 7.2 before the annual food waste in tonnes (afwt) was calculated:

afwt = (swfw*52)/1000

The results on the annual food waste for each NACE category is presented below. In accordance with the aim of the research, the results are broken into relevant waste categories of the EU food waste plug-in, as well as into edible and inedible food waste.

8.1 Agriculture (01)

The results on the annual edible and inedible food waste within agriculture in Iceland are shown in Table 16.

Table 16. Annual food waste in agriculture, by edibility

Waste code	Food waste category	Edible food waste (tonnes)	Inedible food waste (tonnes)	Total (tonnes)
02 01 02	Animal-tissue	0.0	94.7	94.7
02 01 01	Sludges from washing and cleaning	0.0	0.0	0
02 01 03	Plant-tissue	8.1	546.9	555
02 03 04	Materials unsuitable for consumption or processing	-	0.0	0
02 01 99	Other food waste	245.2	187.0	432.2
Total		253.3	828.6	1081.9

8.2 Wholesale (46)

The results on the annual edible and inedible food waste within wholesale trade in Iceland are shown in Table 17.

Table 17. Annual food waste in wholesale, by edibility

Waste code	Food waste category	Edible food (tonnes)	Edible liquid into sewers	Inedible food (tonnes)	Total (tonnes)
20 03 01	Mixed municipal waste	0.41	0.00	715.44	715.85
20 01 25	Oil and fat	0.00	0.00	0.00	0
20 03 99	Other food waste	0.00	0.00	0.41	0.41
Total		0.41	0.00	715.85	716.26

8.3 Retail trade (47)

The results on the annual edible and inedible food waste within retail trade in Iceland are shown in **Error! Reference source not found.**.

Table 18. Annual food waste in retail, by edibility

Waste code	Food waste category	Edible food (tonnes)	Edible liquid into sewers (tonnes)	Inedible food (tonnes)	Total (tonnes)
20 03 01	Mixed municipal waste	1220.2	269.6	2093.0	3582.8
20 01 25	Oil and fat	26.0	12.5	0.0	38.5
20 03 99	Other food waste	65.3	33.7	28.7	127.7
Total		1311.5	315.8	2121.7	3749

8.4 Accommodation (55)

The results on the annual edible and inedible food waste in accommodation activities in Iceland are shown in Table 19.

Table 19. Annual food waste in accomodation, by edibility

Waste code	Food waste category	Edible food (tonnes)	Edible liquid into sewers	Inedible food (tonnes)	Total (tonnes)
20 01 08	Biodegradable kitchen and canteen waste	7.4	0	466.8	474.2
20 01 25	Oil and fat	0.0	0	0.0	0
20 03 01	Mixed municipal waste	0.0	0	0.0	0
20 03 99	Other food waste	0.0	0	0.0	0
Total		7.4	0	466.8	474.2

8.5 Food and beverage service activities (56)

The results on the annual edible and inedible food waste within food and beverage service activities in Iceland are shown in Table 20.

Table 20. Annual food waste in food and beverage service activities, by edibility

Waste code	Food waste category	Edible food (tonnes)	Edible liquid into sewers (tonnes)	Inedible food (tonnes)	Total (tonnes)
20 01 08	Biodegradable kitchen and canteen waste	15870.0	50.5	3867.3	19787.8
20 01 25	Oil and fat	1061.6	0	0.0	1061.6
20 03 01	Mixed municipal waste	12792.9	0	6613.5	19406.4
20 03 99	Other food waste	0.0	0	0.0	0
Total		29724.4	50.5	10480.9	40255.8

8.6 Education (P)

The results on the annual edible and inedible food waste within canteens in educational institutions in Iceland are shown in Table 21.

Table 21. Annual food waste within education, by edibility

Waste code	Food waste category	Edible food (tonnes)	Edible liquid into sewers (tonnes)	Inedible food (tonnes)	Total (tonnes)
20 01 08	Biodegradable kitchen and canteen waste	2137.9	976.6	402.2	3516.7
20 01 25	Oil and fat	10.5	87.7	0	98.2
20 03 01	Mixed municipal waste	251.0	2.4	118.3	371.7
20 03 99	Other food waste	28.7	0.2	2.6	31.5
Total		2428.1	1067.0	523.0	4018.1

8.7 Meat Processing (10.1)

The results on the annual edible and inedible food waste within meat processing in Iceland are shown in Table 22.

Table 22. Annual food waste in meat processing, by edibility

Waste code	Food waste category	Edible food waste (tonnes)	Inedible food waste (tonnes)	Oil and fat (tonnes)	Total (tonnes)
02 02 01	Sludges from washing and cleaning	5007.5	168.1	-	5175.6
02 01 02	Animal-tissue waste	0.0	1993.4	-	1993.4
02 02 03	Materials unsuitable for consumption or processing	0.0	16910.3	-	16910.3
02 01 99	Other food waste	851.7	2396.8	-	3248.5
20 01 25	From grease trap	-	-	2526.2	2526.2
Total		5859.2	21468.6		29854.0

8.8 Processing of fruit and vegetables (10.3)

The results on the annual edible and inedible food waste within processing of fruit and vegetables in Iceland are shown in Table 23.

Table 23. Annual food waste in processing of fruit and vegetables, by edibility

Waste code	Food waste category	Edible food waste (tonnes)	Inedible food waste (tonnes)	Total (tonnes)
02 03 01	Sludges from washing, cleaning, peeling etc.	3.6	7.3	10.9
02 03 02	Wastes from preserving agents	0.0	0.0	0.0
02 03 03	Wastes from solvent extraction	0.0	0.0	0.0
02 03 04	Materials unsuitable for consumption or processing	0.0	0.0	0.0
02 03 99	Other food waste	0	3.6	3.6
Total		3.6	10.9	14.6

8.9 Manufacture of oil and fat (10.4)

The results on the annual edible and inedible food waste within manufacturing of oil and fat in Iceland are shown in Table 24.

Table 24. Annual food waste in manufacture of oil and fat, by edibility

Waste code	Food waste category	Edible food (tonnes)	Inedible food (tonnes)	Oil and fat	Total (tonnes)
02 03 01	Sludges from washing, cleaning, peeling etc.	0.0	0.0	-	0.0
02 03 02	Wastes from preserving agents	-	0.0	-	0.0
02 03 03	Wastes from solvent extraction	-	0.0	-	0.0
02 03 04	Materials unsuitable for consumption or processing	-	0.0	-	0.0
02 03 99	Other food waste	0.0	0.0	-	0.0
From grease trap		-	-	19.3	19.3
Total		0.0	0.0	19.3	19.3

8.10 Manufacture of bakery and farinaceous products (10.7)

The results on the annual edible and inedible food waste within manufacture of bakery and farinaceous products in Iceland are shown in Table 25.

Table 25. Annual food waste in Manufacture of bakery and farinaceous products, by edibility

Waste code	Food waste category	Edible food waste (tonnes)	Inedible food waste (tonnes)	Total (tonnes)
02 06 02	Wastes from preserving agents	-	0.0	0.0
02 06 01	Materials unsuitable for consumption or processing	-	29.0	29.0
20 01 25	Oil and fat	43.7	0.0	43.7
02 06 99	Other food waste	2628.4	0.0	2628.4
Total		2672.1	29.0	2701.1

8.11 Manufacture of dairy products (10.5)

Statistics not calculated because of lack of data.

8.12 Manufacture of beverages (11)

Statistics not calculated because of lack of data. Only one participant submitted fragmented data he had available. It was not possible to calculate reliable statistics based on these data.

8.13 Fishing (03)

Statistics not calculated because of lack of data.

8.14 Fish processing (10.2)

Statistics not calculated because of lack of data.

8.15 Manufacture of other food products (10.8)

Statistics not calculated because of lack of data.

8.16 Health (86)

The method used to calculate the waste of food in health institutions deviates from the main method of the research. The National Hospital (LSH) is by far the largest health institution in the country, with

216,481 inpatient days per year out of 392,794 in total in the country. LSH provided annual figures on its food waste, based on regular measurements. Unfortunately, the figures are not divided by edibility, and total figures on food waste in health institutions in Iceland by edibility therefore lacking.

Only one of the smaller health institutions filed into a food waste diary. Based on this data the following method was used to calculate the total food waste in smaller health institutions in Iceland:

The food waste per inpatient day (fwi) was calculated:

$fwi = (Fw[kg]/N^1)/N^2$

Fw = food waste

N^1 = number of filing days

N^2 = number of inpatient days

Available information on total annual inpatient days at the smaller institutions was then used to calculate total annual food waste (Afw) in smaller heath institutions:

Afw [tonnes] = (fwi [kg]* taid)/1000

taid = total annual inpatient days at the smaller institutions

The results are presented in Table 26:

Table 26. Annual food waste in smaller health institution, by edibility

Edibility	Tonnes
Edible food waste	19.8
Inedible food waste	30.6
Total food waste	50.4

The total annual food waste in those smaller health institutions was then added to the annual food waste at LSH to calculate the total food waste in health institutions in Iceland. The results are presented in Table 27.

Table 27. Annual food waste in health institutions

Total food waste	170.4 tonnes

8.17 Nursing homes (87)

Nursing homes, NACE code 87, are not included in the EU food waste plug-in. As nursing homes are an important part of 24/7 healthcare it was considered relevant to include them into the research. However, the method used to calculate the waste of food in the nursing homes institutions deviates from the main method of the research. Also, the waste is only examined in relation to the edibility of the food, not in relation to food waste codes.

Two out of the seven nursing homes in the sample filed their diaries into the web-portal. In addition, one home provided available data on food waste in one of the nursing home's wards.

The resident per day food waste (rwd) was calculated:

rwd = Fw[kg]/N

Fw = food waste per day

N = number of filing days

Then the average resident per day food waste (arwd) was calculated:

arwd = rwd [kg]/N

N = number of nursing homes

The arwd was used to compute the total annual food waste (afw) in nursing homes:

afw [tonnes] = (arwd [kg] *N*365,25)/1000

N = Total number of residents in nursing homes in Iceland[2]

The results are presented in Table 28.

Table 28. Annual food waste in nursing homes, by edibility

Edibility	Tonnes
Edible food waste	120.8
Inedible food waste	65.0
Total food waste	185.8

[2] Source: Directorate of Health Iceland, http://www.landlaeknir.is/servlet/file/store93/item29751/Talnabrunnur_juni_2016.pdf

8.18 Summary of company results

The summary of the results of food waste in companies in Iceland is illustrated in Table 29.

Table 29. Summary of results on company food waste in Iceland

NACE code	Edible food (tonnes)	Inedible food (tonnes)	Liquid (tonnes)	Oil and fat (tonnes)	Total (tonnes)
Agriculture (01)	253.3	828.6	-	-	1081.9
Wholesale (46)	0.41	715.85	0.00	-	716.26
Retail (47)	1310.2	1875	217.4	-	3749
Accommodation (55)	7.4	466.8	0	-	474.2
Food and beverage service (56)	29724.4	10480.9	50.5	-	40255.8
Education (P)	2428.1	523.0	1067.0	-	4018.1
Meat processing (10.1)	5859.2	21468.6		2526.2	29854.0
Processing of fruit and vegetables (10.3)	3.6	10.9			14.6
Manufacture of oil and fat (10.4)				19.3	19.3
Manufacture of bakery and farinaceous products (10.7)	2672.1	29.0			2701.1
Health institutions (86)					170.4
Nursing homes (87)	120.8	65.0			185.8
Total	42380.8	36710.35	1433.3	2545.5	83240

It must be emphasised when the results of the company research are summed up that figures are missing from the NACE codes of fishing, fish processing, manufacture of dairy products, and of beverages. The available figures amount to annual food waste of 83,240 tonnes, or 250 kg per person per year. The figures are significantly higher than the estimate of Stenmarck, Jensen et al (2016) for the EU-28 of 81 kg per person per year, and where the whole food chain (except for households) is

reached. It should be noticed that the food service sector is responsible for more than half of the Icelandic company food waste, and that the sector has expanded extensively in recent years in line with the extensive expansion of turism in the country.

9 Deviation from objectives and problems encountered

As identified at the beginning of the report, the methodology and methods of food waste research are at an early stage, and still to be improved (e.g. Hanssen et al., 2016; Jörissen et al., 2015). Some challenges were faced during the implementation of both the household and the company parts of this research. These challenges will be discussed below, as well as the deviations from the original objectives that some of the problems elicited.

9.1 Problems encountered in household research

One-stage simple random sample without stratification is the ideal sampling method in statistic. In Iceland, the national registry allows for such sampling from the whole population, of which we took the advantage in the drawing of the household sample. Nevertheless, in practice, low response rate reduced the power of the sample design. The nonparticipation can be explained by more than one factor.

Research on household food waste of this kind - where households are asked to weigh and file the waste amounts - inevitably involves two stages of nonparticipation, firstly, at the stage of recruitment, and, secondly, at the stage of weighing and filing. Substantial nonresponse occurred at both stages with the consequences of the final response rate being much lower than expected beforehand. Similar two stages nonparticipation has been identified in other kinds of self-administrated research, for example, in household budget surveys. In further household food waste research, this problem of two stages nonparticipation must be addressed.

Also, self-administration research of this kind requires some time, and it seems that this time requirement, or time consumption, led to some nonparticipation, at least at the stage of filing. As such, phone calls to those who had accepted participation but not filed the kitchen diaries in time revealed that the respondents were usually positive towards the research in particular, as well as towards the concept of food waste in general, and that they wanted to participate in the research. Nevertheless, many claimed that they had some many chores to attend to that in the end they did not find the time to file the diaries. This time-consuming factor of the research might also have elicited nonresponse at the stage of recruitment of participants.

In light of this two stages nonresponse, it should be considered in future whether one-stage simple random sampling is the best sampling method of household food waste research, or whether other kind of sampling where more emphasis is placed on the recruitment (of course at the cost of statistical power) is more feasible. In such consideration, the option of mixed sampling methods should not be excluded.

A problem at the stage of filing and typing was also faced. The variance of the food waste data is substancial. However, it could not be assumed that outlaws in the data were due to typing errors, as food consumption and waste can vary considerably, both between different households and also within the household. This is mainly because of difference in size of households; wide range of the extent of food preperation; occational parties and invitations that requirers relatively large amounts of food; etc. Also, because of such assumed variation, it was not considered feasible to add a typing error check into the kitchen diaries web protal. However, that could be possible in the future when more statistics on household food waste has been gathered and better assessments of the extent of the food waste made from available data.

9.2 Problems encountered in company research

As in the household research, low participation rate was the greatest challenge of the company research. Although the rate varied between the NACE codes, in most instances it was lower than expected. The exception was canteens of preschools and primary schools, were the participation was acceptable in statistical terms. When contacted, many representatives of the selected companies stated that they simply did not have the time and resources to participate despite showing positive attitude towards the research, as well as towards the topic of food waste in general. This was especially common among representatives of companies in the accommodation and food and beverage service sectors. The recent blossoming of the tourism in Iceland could, at least partly, explain this lack of time. As such, in 2015 the number of tourists increased by 29.2% from the year before, and now it has been estimated that the further increase in 2016 will be 37%. In addition, it was surprising that as early as in May, when the largest part of the research was conducted, many staff members in the selected companies were already on summer holiday. Therefore, quite many company representatives argued that the autumn is more suitable time than the spring for research of this kind. This should be taken into account in future research.

Admittedly, from the point of view of waste management the EU-food waste plug-in is a practical took. However, it turned out that the thorough waste categorisation of the plug-in, based on the European Waste Catalogue, is not as practical in research. In addition to complicating the filing of the data and possibly increasing the nonparticipation, such thorough classification of the food waste lead to complicated analysis of the data which, in the end, might have reduced the validity of the results. This complication was amplified by asking the companies to provide information on their waste of edible food as well as inedible food, liquid poored into sewers, and of cooking oil and fat. In future research,

it should be considered whether such detailed information is indeed needed, and if not what kind of information is the most practical.

Although the Statistics Iceland's business register made a difference as a sample frame for the company research, it also had its limitations. For one thing, it turn out that the register was insufficient for selecting participants withinn education and health institutions (with the exception of nursing homes). For another thing, the NACE classification of the register is in some instances inaccurate, with the consequence that some companies drawn into the sample are in reality not in the food business or deal in any way with food. The number of such companies in the sample was amplified by the beforehand decision of including retail and wholesale companies registered as in 'miscellaneous operation' into the sample frame. It turned out that most did not deal with food in any way. It is advised to exclude such companies from the sample frame in future research.

9.3 Deviations from objectives

The implementation of the research deviated from its original objectives regarding three factors. Firstly, the period of the waste diaries was generally shorter than originally intented, or one week instead of two or three weeks. The decision to shorten the period was based on the experience of the pre-research of the household research, as well as on the practice in former research (e.g. Koivupuro et al, 2012).

Secondly, the implementation of the research deviated from its objectives regarding the collection of the company data. As such, in some instances use was made of already available data, as some of the selected companies were willing to provide such data but not willing, or able, to participate otherwise. This willingness of Icelandic companies to provide available food waste data should be taken into consideration in further research. It should be considered whether such methods of data collection should be applied solely within some of the NACE codes, especially in production and fishing.

Thirdly, it was originally the intention to break the statistics down into different waste treatment categories. To do so the most reliable way would have been to include the collection of such data through the food waste diaries the participants submitted. As has been stated before, low response rate was the greatest challenge of the reasearch. As such, the reasearchers had to weigh thoroughly all the parameters in the research against the possibility that they would contribute to low response rate. Acquiring data on different waste treatment categories was considered of less importance than data on the amounts, types and sources of the food waste. Therefore, such acquisition was omitted.

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Appendix I – Results in the plug-in

Here, the results of the research are displayed in line with the EU food waste plug-in. The NACE activities displayed are the ones that submitted sufficient data for reliable statistics to be calculated. Other activities are omitted.

Food waste in Iceland in 2016, from households and selected NACE activities

Attention! NOT ONLY SOLID WASTE - Liquid waste poured into sewers is included.			NACE activities and households													
EWC-Stat waste categories and breakdown into EWC categories		*All amounts are in tonnes.*	Agriculture	Meat processing	Processing of fruit and vegetables	Manufacture of oil and fat	Manufacture of bakery and farinaceous products	Wholesale trade	Retail trade	Accomodation	Food and beverage service activities	Education	Health	Nursing homes	Households	Total
			01	10.1	10.3	10.4	10.7	46	47	55	56	P	86	87	H	
09.1 Animal and mixed food waste																
	02 01 02	animal-tissue waste	95	1993												2088
	02 02 01	sludges from washing and cleaning		5176												5176
	02 02 02	animal-tissue waste														0
	02 02 03	materials unsuitable for consumption or processing		16910												16910
	02 03 02	wastes from preserving agents			0	0										0
	02 05 01	materials unsuitable for consumption or processing														0
	02 06 02	wastes from preserving agents					0									0
	19 08 09	grease and oil mixture from oil/water														0
	20 01 08	biodegradable kitchen and canteen waste								474	19788	3517	170	186		24135
	20 01 25	edible oil and fat		2526		19	44	0	39	0	1062	98			7214	11002
	02 01 99	wastes not otherwise specified	432	3249												3681
09.2 Vegetal wastes																0
	02 01 01	sludges from washing and cleaning	0													0
	02 01 03	plant-tissue waste	555													555
	02 01 07	wastes from forestry														0
	02 03 01	sludges from washing, cleaning, peeling, centrifuging and separation			11	0										11
	02 03 03	wastes from solvent extraction			0	0										0
	02 03 04	materials unsuitable for consumption or processing	0		0	0										0
	02 06 01	materials unsuitable for consumption or processing					29									29
	02 07 01	wastes from washing, cleaning and mechanical reduction of raw materials														0
	02 07 02	wastes from spirits distillation														0
	02 07 04	materials unsuitable for consumption or processing														0
	20 02 01	biodegradable waste														0
	02 03 99	wastes not otherwise specified			4	0										4
	02 06 99	wastes not otherwise specified					2628									2628
10.1 Household and similar wastes																0
	20 03 01	mixed municipal waste						716	3583	0	19406	372			86745	110822
	20 03 02	waste from markets														0
	20 03 07	bulky waste														0
	20 03 99	municipal wastes not otherwise specified						0	128	0	0	32				160
	20 03 03	street-cleaning residues														0
		Total	1082	29854	15	19	2701	716	3749	474	40256	4018	170	186	93959	177199

Appendix II – Metadata

1 Registration entry for subjects

1.1 Name

Food waste research

1.2 Subject area

Food waste

1.3 Responsible authority; office, division, person etc.

Gunnlaug Einarsdóttir
Director of Department of Sustainability
Environment Agency of Iceland

1.4 Purpose and history

The purpose is to gather information on food waste from the whole food use hierarchy in Iceland. The survey is the first of its kind in Iceland. The food waste statistics are broken down in line with the EU food waste plug-in. Otherwise, the methods of the survey are not comparable to other countries.

1.5 Users and application

The research provides information on the amount of food waste in Iceland with regard to both households and companies.

1.6 Sources

The food waste research is a sample research.

Sources can be divided into three categories: household food waste diaries, company food waste diaries, and available data from companies.

1.7 Legal bases for official statistics

Regulation (EC) No 2150/2002 of the European Parliament and of the Council of 25 November 2002 on waste statistics.

1.8 Response burden

Those in the sample can choose not to respond.

Respondents keep accurate food waste diary for one week. The response burden for participants is therefore some, although available data from companies can be used in some instances.

1.9 EEA and EU obligations

No formal treaties or rules.

2 Contents

2.1 Description of contents

The food waste surveys gives exact and itemized information on food waste of both households and companies in Iceland. The following can be found in the surveys:

- Annual food waste of household
- Annual food waste in production
- Annual food waste in wholesale and retail
- Annual food waste in food service

The annual food waste is divided into the EWC-Stat waste categories and categories based on the European Waste Catalogue.

Sample of households: The sample consisted of 1036 families chosen at random from family numbers in the National Register of Persons.

Data collection of households: Information on the amount of food the households waste.

Sample of companies: The sample consisted of 700 companies chosen at random from strata within the Statistics Iceland's business register. The strata were based on the NACE categorization identified in the EU plug-in for food waste statistics, as well as on the turnover of each enterprise, splitting each NACE category into high and low turnover groups, making the total number of strata 42.

Data collection of companies: Information on the amount of food wasted within each NACE category.

The food waste amount is also divided into the EWC-Stat waste categories and categories based on the European Waste Catalogue.

2.2 Statistical concepts

Research unit of household survey is households. The sample is drawn on a random basis from the National Registry of Persons. Family identity number of people aged 18-74 are chosen irrespective of residence or marital status. Participants are all those living in the household selected.

Research unit of company survey is companies.

Household: All individuals living under the same roof and running a common household while the survey was being carried out.

Company: Company units as defined in the Statistics Iceland's business register.

Food: Any substance or product, whether processed, partially processed or unprocessed, intended to be, or reasonably expected to be eaten by humans. Food is further divided into edible food and inedible food.

Edible food: Has, or had, the potential to be eaten by humans. The definition recognizes food which is no longer considered edible since it is moulded, rotten, the date has expired etc., but which has had the potential to be eaten even though it is not edible at the point of disposal.

Inedible food: The part of food that is not recognised as fit for human consumption, such as bones, eggshells, peels, coffee grounds, etc.

3 Time

3.1 Reference period

The research was cross-sectional.

3.2 Process time

The research was conducted in February to October, 2016, and the reference period is the year 2016.

3.3 Punctuality

Results are published according to grant agreement.

3.4 Frequency of releases

As the research was cross-sectional the results were only released once, in November 2016.

4 Reliability and security

4.1 Accuracy and reliability

The Food waste research is a sample survey and entail a degree of uncertainty because of the nature of sample surveys.

4.2 Sources of errors

Sampling errors. Every sample research entails a degree of uncertainty because of the sample not being an exact reflection of the entire registry or population. Because of the random nature of this uncertainty, it is possible to calculate the confidence limits for the numbers being estimated.

Coverage errors. In some cases the sampling frame does not reflect the actual population. Either there is over coverage when there are sample units in the frame that should be excluded or there is under coverage when there are sample units that ought to be assigned to the population but are not in the frame.

Non-response errors. In all surveys, results may represent errors because of non-response in the sample being unevenly distributed among groups. The main reasons for non-response are refusals, hindrances due to illness or disability, absence from home/work while the survey is proceeding, or a failure to find the residence or telephone number of those in the sample.

Interviewer and processing errors. The data was collected on-line. Online data collection involves the danger of information losses because of technical failure. It is also possible that some data was lost because some participants forgot to save their reporting and/or did some type errors.

Design errors. The filing of food waste is time consuming. The demand of time and work the participants had to put into the survey can led to nonresponses. The design required minimum calculation and writing skills in mathematics, which means that those without such skills might be undercovered. The surveys were only in Icelandic which could have limited participation of immigrants.

5 Comparison

5.1 Comparison between periods

The research is cross-sectional and conducted for the first time in Iceland. Therefore, results for comparison are not available.

5.2 Comparison with other statistics

The EU plug-in for food waste statistics was used as a reference for the surveys. A standardized EU procedure for food waste statistics is still in development, and, hence, the results are not fully comparable with other statistics on food waste within the EU.

5.3 Coherence between preliminary and final statistics

Preliminary statistics are not published.

6 Access to information

6.1 Forms of dissemination

News, released on the website of the Environment Agency of Iceland.

Statistics, categorised statistical web tables stored.

6.2 Basic data; storage and usability

The source material is stored in digital form by Statistics Iceland. No access is allowed to the data itself but it is possible to have it processed specially.

6.3 Reports

The results are explained in the report Food Waste in Iceland – Methodological report.

6.4 Other information

Further information is provided by:

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