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Exploring backgrounds for food waste in schools and kindergartens

Identification and quantification of factors influencing plate and serving waste

Hjördis Steen

ABSTRACT

Exploring backgrounds for food waste in schools and kindergartens – Identification and quantification of factors influencing plate and serving waste

Hjördis Steen

Although food waste is known to have a negative impact on the environment, little research about the causes for food waste in school and kindergarten kitchens has been made. In order to identify factors with a significant influence on food waste in schools and kindergartens, divided into plate and serving waste, correlation analysis was performed on quantitative factors. Among the factors that were analyzed, children's age ($n=35$, $p<0.001$, Kendall's rank correlation $\tau=0.44$), the number of semesters with food waste measurements ($n=151$, $p<0.05$, Kendall's rank correlation $\tau=0.15$) and portion size as an indicator for overproduction ($n=97$, $p<0.01$, Spearman's rank correlation $\rho=0.28$) were significantly increasing plate waste. Serving waste was significantly increased by portion size ($n=97$, $p<0.0001$, Spearman's rank correlation $\rho=0.42$) and was generally higher in satellite units than in production units ($n=142$, $p<0.05$, Pearson's product-moment correlation $r=0.19$).

Multiple linear regression models were developed to quantify the factors' impact on plate, serving and total waste. While possible causes for serving waste should be further researched, the model for plate waste explained over 70 % of the variation in plate waste in schools and kindergartens.

Due to the correlation between children's age and plate waste, schools with students in higher grades could introduce more structured lunch breaks in order to reduce their plate waste. Furthermore, plate waste could be reduced if students are constantly aware of the food waste issue. Schools and kindergartens should also improve the grounds for the planning of their food production to reduce their portion sizes.

Keywords: plate waste, serving waste, food waste, public kitchen, correlation analysis, school kitchen, model

Department of Energy and Technology, Swedish University of Agricultural Sciences, Lennart Hjelms väg 9, SE-750 07 Uppsala, Sweden
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REFERAT

Vad ligger bakom matsvinnet i skolor och förskolor? – Identifiering och kvantifiering av faktorer som påverkar tallriks- och serveringssvinn
Hjördis Steen

På grund av den överflödiga resursförbrukningen som uppstår genom svinn av livsmedel har matsvinn de senaste åren uppmärksammats som ett miljöproblem. Än så länge har få studier berört orsakerna för matsvinn i skolor och förskolor. Denna studie syftar till att kartlägga och kvantifiera olika faktorers inverkan på matsvinn i skolor och förskolor. Det totala matsvinnet delades upp i tallriks- och serveringssvinn. Enligt statistisk korrelationsanalys, som utfördes i programmet R, ökade tallrikssvinnet signifikant med barnens ålder ($n=35$, $p<0.001$, Kendalls korrelationsmetod $tau=0.44$), antalet mätterminer ($n=151$, $p<0.05$, Kendalls korrelationsmetod $tau=0.15$) och portionsstorlek som indikator för överflödig matproduktion ($n=97$, $p<0.01$, Spearmans korrelationsmetod $rho=0.28$). Serveringssvinnet var allmänt högre i mottagningskök än i tillagningskök ($n=142$, $p<0.05$, Pearsons korrelationsmetod $r=0.19$). Serveringssvinnet ökade dessutom signifikant med portionsstorleken ($n=97$, $p<0.0001$, Spearmans korrelationsmetod $rho=0.42$).

För att kvantifiera faktorernas inverkan på matsvinnet togs tre modeller fram med hjälp av multipel linjär regression. Modellen för serveringssvinn visade att fler faktorer återstår att undersökas för att förklara orsakerna för serveringssvinn i skolor och förskolor. Över 70 % av tallrikssvinnet i skolor och förskolor kunde däremot förklaras med modellen för tallrikssvinn. Modellen för tallrikssvinn visade att elevernas ålder, antalet mätterminer, antalet inskrivna elever och samverkan mellan portionsstorlek och antalet platser i matsalen per elev tillsammans förklarar variationen i tallrikssvinn på skolor och förskolor.

För att effektivt minska både serverings- och tallrikssvinn på deras enheter bör skolor och förskolor förbättra sina planeringsunderlag. Med bättre planeringsgrunder skulle överproduktionen av mat kunna reduceras, genom vilket framför allt mottagningskökens serveringssvinn skulle minska. Korrelationen mellan tallrikssvinn och ålder visar att skolor med äldre elever bör införa mer strukturerade lunchraster och skapa en lugnare lunchatmosfär. Både skolor och förskolor bör löpande påminna sina elever om matsvinnsproblemet för att minska sitt tallrikssvinn.

Nyckelord: tallrikssvinn, serveringssvinn, matsvinn, storkök, korrelationsanalys, skolkök, modell

Institutionen för energi och teknik, Sveriges lantbruksuniversitet, Lennart Hjelms väg 9, SE-750 07 Uppsala, Sverige
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PREFACE

This study represents the final project of 30 credits of the Master of Science program in Water and Environmental Engineering at Uppsala University and the Swedish University of Agricultural Sciences. This project was supervised by Mattias Eriksson and the subject reviewer was Elin Röös, both employed at the Department of Energy and Technology at the Swedish University of Agricultural Sciences. Examiner was Anna Sjöblom, employed at the Department of Earth Sciences at Uppsala University.

I would like to cordially thank Anna Sjöblom, Elin Röös and especially Mattias Eriksson for their support and review of my work. Further, I would like to express my gratitude to Christopher Malefors, Jesper Björkman and Matomatic AB for support and data and Mikael Andersson Franko for answers to my questions. Likewise, I thank all schools and kindergartens and the municipalities Falun, Malmö, Sala and Uppsala that responded to my questions and helped me build a solid ground for my analysis.

Last, but definitely not least, I would like to cordially thank my mother Martina, my father Uwe, my sister Amelie and my brother Kjelli for their support throughout my life and their guidance, which brought me where I am today; and Sebastian for all support during the last three years. I am grateful and lucky to have all of you in my life!

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POPULÄRVETENSKAPLIG SAMMANFATTNING

En torr brödskiva här, en gulprickig banan där. Varje dag slänger vi mat av olika anledningar. Frukt och grönsaker som ser gamla ut, mängden fil som vi inte lyckas pressa ut ur paketet, prästosten som har gått över bäst-före-datum och gårdagens pasta som helt enkelt inte verkar lika god som då.

Att vi kastar så många livsmedel är ett stort miljöproblem. Matproduktion kräver vatten, markyta och ekonomiska resurser. Mejeri-, fisk- och köttprodukter orsakar den största förbrukningen av resurser bland livsmedlen, då djuren i sin tur behöver föda, betesmark och ofta hålls friska med läkemedel. Grönsaker och frukt skyddas i många fall med pesticider som vid regnväder kan sköljas ner till grundvattnet och förgifta dricksvattnet. Matproduktionen bidrar dessutom starkt till utsläppet av växthusgaser, exempelvis genom gödsling och transporter.

Matsvinn definieras i denna studie som alla ät- och drickbara produkter som var avsedda för mänsklig förbrukning när de producerades och som inte kom till användning. Genom att minska vårt matsvinn med bara 50 % skulle vi, utan att vara hungriga, kunna spara en stor andel vatten- och markresurser. Andelen mark- och vattenresurser som skulle sparas motsvarar den mängd resurser som i dagsläget krävs för att producera mat till över 60 miljoner människor.

Svenska storkök, som finns i skolor, förskolor och äldreboenden, kastar sammanlagt dubbelt så stora mängder livsmedel som svenska matbutiker. Trots detta faktum har endast ett fåtal studier berört ämnet matsvinn i storkök. För att undersöka hur matsvinnet från lunchmåltiden i skol- och förskolekök uppstår och vilka åtgärder som skulle kunna vidtas för att effektivt minska matsvinnet har denna studie genomförts. I studien har skolor och förskolor i kommunerna Falun, Malmö, Sala och Uppsala deltagit. Det totala matsvinnet delades upp i tallriks- och serveringssvinn. Tallrikssvinn uppstår när elever skrapar ner rester från sina tallrikar efter måltiden. Serveringssvinn är all mat som slängs i köket eller blir över på serveringsfaten som ställs fram åt eleverna i matsalen. I medel hade skolorna 25 g tallrikssvinn för varje elev, vilket motsvarar vikten av två köttbullar eller en hel tallrik med bladsallad. Serveringssvinnet per elev var i medel ungefär 40 g. Detta innebär att en genomsnittlig skola eller förskola sammanlagt slänger mat vars vikt motsvarar fyra köttbullar eller nästan tre tallrikar med bladsallad för varje elev under en lunchmåltid.

Statistiska korrelationsanalyser genomfördes för att hitta orsakerna till matsvinnet i svenska skolor och förskolor. Resultaten från den statistiska undersökningen visade att tallrikssvinnet ökar med elevernas ålder. Orsaken till detta är förmodligen att yngre elever och förskoleelever ofta äter i sällskap av sina lärare och har mer strukturerade lunchraster än eleverna i högre årskurser. Bland annat förekommer ”tysta minuter”, under vilka eleverna har lugn och ro för att äta sin lunch. Skolor med elever i högre årskurser bör därför skapa mer struktur i sina lunchraster eller införa ”pedagogiska luncher”, där eleverna äter i sällskap och vid samma bord som sin lärare, för att minska sitt tallrikssvinn. Om eleverna äter i sina klassrum eller i en separat matsal påverkar däremot inte matsvinnet.

Den statistiska analysen visade också att tallrikssvinnet ökar ju oftare respektive skola eller förskola mäter sitt matsvinn. En möjlig orsak för detta fenomen är att eleverna efter ett fåtal mätningar vänjer sig vid mätningarna och tappar intresse för ämnet matsvinn. Vid första mätningen brukar de flesta skolor och förskolor ha tävlingar om att minska sitt matsvinn eller dela ut särskild information om matsvinnsproblemet till eleverna. För att bibehålla effekten från den första mätningen bör skolor och förskolor kontinuerligt påminna sina elever om matsvinnsproblemet. I vissa skolor används ”matsvinnstavlor” där det dagliga matsvinnet antecknas och jämförs med pengasumman som skulle kunna sparas in om matsvinnet förhindrades. För yngre elever skulle matsvinnet kunna jämföras med glasstrutar som skulle kunna köpas eller djur som skulle kunna räddas om matsvinnet minskade.

Både serverings- och tallrikssvinnet visade sig öka när portionsstorleken ökade. Portionsstorleken beräknas som mängden mat per elev. I samband med dålig planering ökar portionsstorleken eftersom köken i många fall räknar med ett för stort antal ätande. Många skolor uppgav att köket för sent eller inte alls fick information om det dagliga antalet ätande i deras matsal. Antalet ätande kan skilja sig mycket i exempelvis influensaperioder eller om en klass ska på utflykt och eleverna har med sig egen matsäck. Bättre planering inför mattillagningen skulle därför kunna minska matsvinnet och onödiga kostnader avsevärt. En bättre planering av antalet ätande per dag skulle framför allt i mottagningskök ha en stor effekt på matsvinnet, då mottagningskök till skillnad från tillagningskök oftast inte har möjligheter att lagra överbliven mat och integrera den i nya maträtter. En dålig uppskattning av antalet ätande har därför stor påverkan på matsvinnsmängden i ett mottagningskök, men också tillagningskök skulle tjäna på att förbättra sin matplanering.

Enligt studien kan den största delen av tallrikssvinnet som uppstår i skolor och förskolor förklaras med de ovan nämnda orsakerna, medan det förmodligen finns ytterligare orsaker som ligger till grund för serveringssvinnet och återstår att undersökas i framtida studier. Det är bland annat tänkbart att serveringssvinnet påverkas av organisatoriska faktorer som personalens arbetstid och möjligheter att påverka mattillagningen. Stress och relationen mellan personal och elev skulle också kunna påverka matsvinnet, likaså personalens kunskap om matsvinn och olika strategier för att minska matsvinnet. Sammanfattningsvis skulle skolor och förskolor kunna bidra till att minska matsvinnsproblemet avsevärt genom enkla åtgärder och på så sätt spara vatten, markyta och pengar. Avgörande är att problemet uppmärksammas av ledningen och eleverna informeras om matsvinnets betydelse.

GLOSSARY

Competitive food items	Food products that can be purchased besides the meal options offered for lunch in school or kindergarten kitchens, food products competing with the food offered by public kitchens
Diners	People eating in a dining facility, their number often being in line with the number of portions that are served
Edible material	Food parts that can be eaten without leaving any waste behind, such as a peeled banana, a slice of bread or a sausage
Food supply chain	Food items way from their origin to their consumer, including an agricultural stage, an industrial stage, a distribution stage and a consumption stage
Inedible material	Food parts that are included in food products but cannot be eaten, such as banana peel, bones or eggshell
Post-harvest material	Material used for food production after the agricultural stage in the food supply chain, e.g. crops
Pre-harvest material	Material used for food production before entering the agricultural stage in the food supply chain, e.g. seeds

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1 INTRODUCTION

In order to decrease food waste and save land, water and economic resources, further knowledge about the issue is required (Thyberg and Tonjes, 2015). The focus of this study lies on the consumption stage, as a great share of the food waste is generated during this stage (FAO, 2013). Schools and kindergartens ("preschools") account for a huge amount of the food waste generated during the consumption stage in Sweden and are therefore examined, although the contribution is lower compared to the food waste generated by households (Elander, 2016).

1.1 DEFINITION OF FOOD WASTE

According to Eriksson (2015), multiple definitions for food waste have been developed. The distinctions between different definitions consider distinguished stages of the food supply chain and different products, such as liquid or solid waste and pre-harvest and post-harvest material (Eriksson, 2015).

The disunity concerning the definition of food waste results in difficulties when comparing different studies that include multiple stages of the food supply chain. Therefore, food waste is here defined as the disposal of all material, edible and inedible, that was intended for the food supply chain (Östergren et al., 2014).

1.2 FOOD WASTAGE AND ITS NEGATIVE IMPACTS GLOBALLY

All in all, the Food and Agricultural Organization FAO (2013) estimates that 1.3 Gtonnes of edible food are lost or wasted along the food supply chain each year, which answers to one third of all food that is produced for human consumption. The highest level of food waste occurs during the stage of agricultural production followed by the postharvest handling and storage stage and the consumption stage with over 300 million tonnes of wastage. Moreover, the consumption stage contributes with 37 % to the total carbon footprint generated along the food supply chain, due to food wastage of 3.3 Gtonnes CO_2 equivalents. Thus, the consumption stage represents the greatest share of the carbon footprint along the food supply chain. Annually, the production and post-handling of food that is later wasted together require around 30 % of the world's agricultural area. The blue water footprint caused by agricultural products for food waste answers to 250 km^3 of groundwater and surface resources. (FAO, 2013)

Although the agricultural stage has the biggest impact on the environment among all stages in the food supply chain, food consumption has a huge impact on the environment through the energy used for production, packaging, transportation and cooking among others (Schott and Cánovas, 2015). By preventing 1 kg of food waste, up to 29 kg of emitted CO_2 could be saved, depending on the type of food wasted (Eriksson et al., 2015). In addition to decreased greenhouse gas emissions, a 50 % reduction in food wastage in developed countries is estimated to result in lowering the global water footprint by 59 Gm^3 according to calculations by Munesue et al. (2014). Furthermore, over 60 million people could be nourished as a result of a 50 % reduction. Generally, food waste prevention would save natural resources and diminish negative effects on the environment caused by agricultural economy (Munesue et al., 2014). Knowledge about the implications of food waste and its prevention should be an "urgent priority" according to Thyberg and Tonjes (2015).

1.3 FOOD WASTE IN PUBLIC KITCHEN UNITS

Public kitchen units stand for a great share of the food waste generated during the consumption stage and are only outreached by households. In total, 70,000 tonnes of food waste were estimated to have been generated in Sweden's public kitchen units during 2014, which is more than twice as much as the waste from food stores. Among all public facilities, schools and preschools stood for most of the waste (67 %) followed by elderly care homes (24 %). (Elander, 2016)

So far, only a few studies have focused on food waste generated in public serving units. Eriksson et al. (2017) quantified the food waste from 30 public kitchen units in the Swedish municipality Sala with regard to plate waste and serving waste. The results show that elderly care homes had the highest waste per portion (90 g) followed by schools (79 g) and preschools (51 g). In general, 23 % of the food served in Sala's public kitchen units was wasted, with 64 % serving and 33 % plate waste. Production units had significantly lower waste than satellite units that receive food produced in another facility and often have few possibilities for cooling and storage of food leftovers. Preschools had significantly lower waste than schools. Still, a great variation between kitchens of the same type was discovered. (Eriksson et al., 2017)

A quantification of the food waste in an American elementary school was made by Byker et al. (2014), based on a short measurement of five days. The findings show that food waste is lowest on Tuesdays and highest on Mondays. It is mentioned that portion sizes, noise levels, time available for food consumption and children's age should be examined as factors correlating with food waste in schools.

Some other attempts to explain the drivers for food waste in educational establishments have been made, whereas most of them relied on surveys or had the purpose of ensuring that pupils received enough nutritional values through their school lunches. Kinasz et al. (2015) developed a checklist for the prevention of food waste based on the vote of experts, but also states that more research is necessary to identify the factors controlling the generation of food waste. In addition to factors concerning the management in the service sector, dining ambiance and knowledge about the diners were mentioned as potential factors influencing food waste in public facilities.

In order to decrease plate waste and under the objective to improve children's nutritional intake during school lunches, Ishdorj et al. (2015) analyzed different pairings of dishes, including potato products, meat products and vegetables. Even though different pairings of vegetables and other products were found to result in different amounts of plate waste, it remained uncertain whether the pairing was a direct or an indirect driver for plate waste.

According to a group of university students that participated in a survey, other factors influencing plate and serving waste in educational establishments may be the availability of competitive food offers, students' emotional and physical condition, the popularity of the meals served, portion sizes, the distance between dining hall and lecture hall and awareness of food waste as an issue. (Painter et al., 2016)

Whitehair et al. (2013) tried to examine whether the food waste in universities was reduced if students received information about food waste. A reduction by 15 % was found after messages about food waste were given out to the students. However, only 40 % of the students agreed to participate in the study and let their trays get weighed. The findings of Kuo and Shih (2016) suggest that gender differences might be a factor influencing plate waste, as female plate waste in universities was found to be significantly higher than male plate waste. A significant decrease in plate waste was also found when trays were removed in a university dining hall (Thiagarajah and Getty, 2013).

Statistical approaches examining the drivers for food waste in school kitchens show that plate waste increased when sixth graders purchased food outside the dining hall, referred to as competitive food items (Marlette et al, 2005). A study by Niaki et al. (2017) detected that children's age is an important factor influencing food waste behaviour in schools which should be taken into account when examining the drivers for plate waste in school kitchens. According to the study, children attending kindergarten (often referred to as "preschool") had significantly higher plate waste than children in higher grades. Then again, it is mentioned that the youngest participants in the study had lunch two hours earlier than the oldest participants. Differences in lunch break procedures should therefore be examined as a factor coupled to food waste behaviour (Niaki et al., 2017). As an example, food waste decreased with about 10 % when elementary school children in grades 1 to 3 had recess before eating lunch (Getlinger et al., 1996).

1.4 PURPOSE

The purpose was to gain deepened knowledge about the factors influencing food waste in schools and kindergartens under the objective of identifying and analyzing these factors. Another goal was to investigate and model the influence of factors that were significantly related to food waste to create a ground for effective provisions against food waste in schools and kindergartens.

2 MATERIALS AND METHOD

2.1 SELECTION OF PARAMETERS

In literature, diverse parameters have been mentioned or examined as factors that have, or might have, an influence on the food waste generated in schools, kindergartens and universities. Then again, no study was found to have quantified the impact from these parameters on the food waste generation. The data used for analysis in this study is bigger than the data used in previous studies focusing on backgrounds for food waste in educational establishments.

In order to receive significant results that are not based on qualitative surveys, and to avoid results biased by the public view on school meals, only parameters that could be quantified were used for analysis (Persson Osowski, 2012). Some parameters were therefore grouped into indicators for which quantification was possible. (Table 1)

Other parameters that might have influence but were not considered for analysis are weekdays (Byker et al., 2014; Eriksson et al., 2017), pairings of meals (Ishdorj et al., 2015), popularity of meals (Painter et al., 2016), availability of competitive food items (Marlette et al., 2015; Painter et al., 2016) and the children's gender (Kuo and Shih, 2016). These factors were either difficult to quantify or not enough information was available for a statistical analysis.

Table 1 Parameters that have or might have an influence on food waste generated in educational establishments according to literature; hypotheses concerning the parameters and possibilities to quantify the parameter

Parameter	Hypothesis according to literature	Quantification
Children's age or differentiation between schools and kindergartens	Food waste increases with age. (Byker et al., 2014; Eriksson et al., 2017; Niaki et al., 2017)	Grades could be used as a quantitative indicator for the children's age.
Type of kitchen	Production units generate lower food waste than satellite units. (Eriksson et al., 2017)	The factor could be examined in a bivariate analysis.
Portion sizes	Possible factor influencing food waste (Byker et al., 2014; Painter et al., 2016)	Portion sizes were given in grams and therefore quantitative. The factor could be used as an indicator for overproduction and improvable management.
Dining ambiance, noise level and students' physical or emotional condition	A calm ambiance in the dining hall reduces food waste. (Naturvårdsverket, 2009; Byker et al., 2014; Kinasz et al., 2015; Painter et al., 2016)	Dining ambiance, noise level and conditions evoking stress were assumed to be indicated by the dining hall capacity and crowdedness, which could be quantified as the number of seats in the dining space.
Time available for lunch and point of time at which lunch is served	To decrease food waste, children should have enough time to eat during their lunch break. (Getlinger et al., 1996; Naturvårdsverket, 2009; Byker et al., 2014; Niaki et al., 2017)	Lunch time was assumed to be indicated by the dining space capacity in relation to the number of diners, which could be quantified using the number of seats in the dining space and the number of diners.
Management factors and knowledge of diners	Possible factor influencing food waste (Kinasz et al., 2015)	Some management factors and the knowledge of diners were assumed to be indicated by the number of staff members in the dining facility, which was a quantitative measure.
Awareness of food waste as an issue	Possible factor influencing food waste (Whitehair et al., 2013; Painter et al., 2016)	Awareness of food waste as an issue was assumed to be indicated by whether education or information about food waste was given to staff members and children. The factor could then have been examined in a bivariate analysis.
Trays in the dining system	A system without trays decreases plate waste. (Thiagarajah and Getty, 2013)	The factor could have been examined in a bivariate analysis.
Distance between classroom and dining space	Possible factor influencing food waste (Painter et al., 2016)	The distance could be quantified as different categorical groups.

2.2 AREA OF STUDY

Food waste data was available for the municipalities Sala, Uppsala, Falun and Malmö in Sweden, which represent both urban and more rural areas with different numbers of citizens.

The municipality of Sala is located in Västmanland county in the middle of Sweden and has approximately 22,000 inhabitants (SCB, 2016). Food waste measurements were available for 30 kitchen units of which four prepared food for elderly care homes and the remaining 26 prepared food for schools or kindergartens (Sala municipality, 2016; Table 9, Appendix 7.3).

Uppsala is with around 215,000 inhabitants Sweden's fourth biggest municipality (SCB, 2016) located 70 km north of Stockholm. The city has around 100 kindergarten kitchens and 58 school kitchens (Uppsala municipality, 2017). Food waste measurements were available for 54 of these kitchens (Table 9, Appendix 7.3).

Falun, the biggest municipality in Dalarna, has approximately 58,000 inhabitants (SCB, 2016) and about 100 kindergarten and school kitchens (Falun municipality, 2017). Food waste measurements were available for 8 school kitchens (Table 9, Appendix 7.3).

Malmö is with around 330,000 inhabitants Sweden's third biggest city and located on the south-west coast of the country (SCB, 2016). Of over 200 kindergarten and school kitchens in the municipality of Malmö (Malmö city, 2017), food waste measurements were available for 91 kindergarten and school kitchens (Table 9, Appendix 7.3).

2.3 FOOD WASTE MEASUREMENTS

Food waste measurements were available for 183 kindergarten and school kitchens in the four municipalities Sala, Uppsala, Falun and Malmö.

Matomatic AB (2017) has developed a platform where information about the food waste measurements reported by kitchen head chefs is structured. The only meal for which food waste measurements are available on the platform at this point is lunch, even though some public kitchen units also offer breakfast, smaller meals or dinner. The results from the measurements are categorized as plate and serving waste.
Plate waste is defined as all waste scraped from plates which were handed out to the diners, including inedible parts such as bones or peel. In addition to the weighed plate waste, the number of plates handed in as dishes are counted and used to define the number of portions served per day. (Eriksson et al., 2016)

Serving waste is defined as all food waste generated throughout the preparation and serving process in both kitchen and dining hall, as well as left-overs from the serving trays. Inedible parts that are discarded during the preparation process are not included. Serving waste is often estimated to be a multiple weight of one serving tray that is weighed at the beginning of the measurement.

Some municipalities report a third category "other waste" referring to food waste generated through storage or another source that the category "serving waste" is not inclusive of. However, this category tends to be insignificantly small compared to the other two. Serving waste tends to weigh twice as much as the plate waste in different school and kindergarten kitchens. (Eriksson et al., 2016)

In order to develop comparable values, the variables "total waste per portion, "plate waste per portion" and "serving waste per portion" were introduced per day, week and semester for each school. The total waste per portion is defined as the sum of both serving and plate waste per portion. These comparable values were calculated dividing the reported food waste by the number of portions. All incomplete measurements were excluded from the calculation. In addition to the three food waste quantities, background data about the number of semesters with food waste measurements, portion size and type of kitchen were collected from Matomatic's platform. (Matomatic AB, 2017)

As the reported measurements differed in frequency, count and span of time between different kitchen units, the average over all semesters included in each kitchen's reported measurements was used as a comparable measure for analysis. Food waste variables included in the analysis were "total waste per portion" in grams, "serving waste per portion" in grams and "plate waste per portion" in grams (Figure 1).

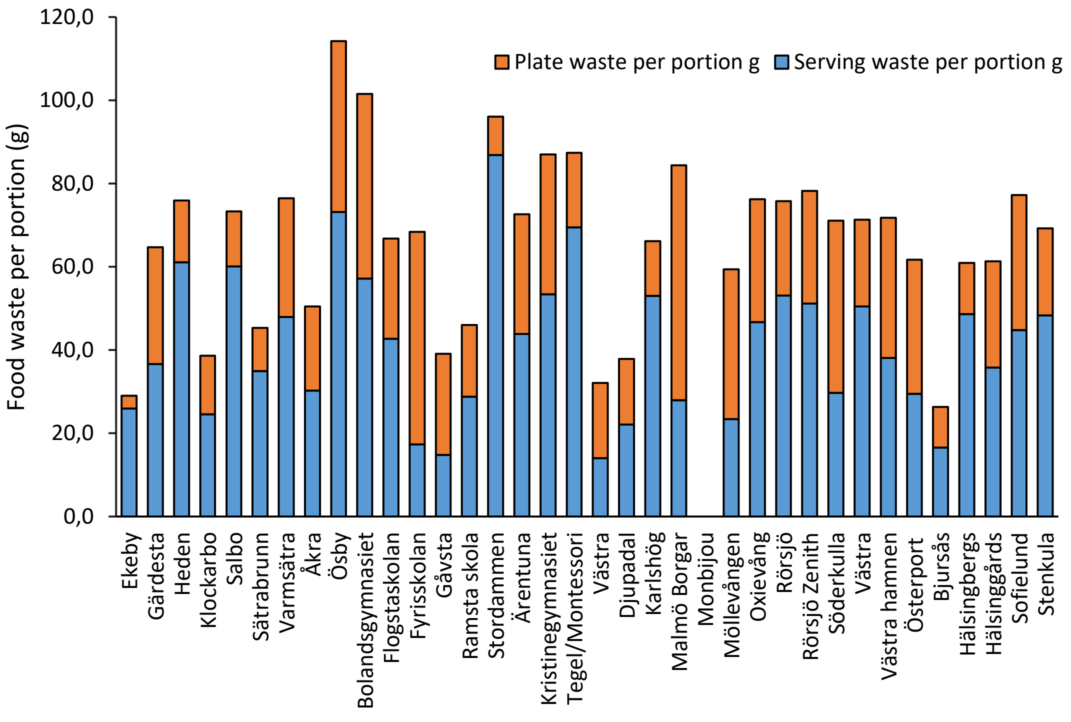

Figure 1 Food waste quantities included in analysis; serving waste per portion (g) and plate waste per portion (g) for the 36 kitchen units that responded to this study's questionnaire (section 2.4). Plate waste tends to be a third of the total waste.

2.4 COLLECTED BACKGROUND DATA

In order to collect information about different kindergartens' and schools' dining systems in the municipalities of Uppsala, Falun, Sala and Malmö, ten questions were sent out to the kitchen head chefs that were responsible for kitchens where food waste measurements were available. The written questionnaire was expanded by an oral questionnaire by telephone for some of the kitchens that did not reply to the written questionnaire. (Appendix 7.2)

In total, 36 kindergarten and school kitchens responded to the questionnaire. Most of the answers were received during the first two weeks after the questionnaire was sent out, whereas the oral questionnaire by telephone took place three weeks thereafter. (Table 9, Appendix 7.3)

The information that was collected through the kitchen head chefs consisted of quantitative data including number of students, dining space capacity, grades, number of meal options, number of employees, number of female and male employees and distance between dining space and classroom (Table 2).

As the answers to the question whether information about food waste was given to children and staff differed and contained unacceptable uncertainty, this information was not considered as a factor for analysis. To the question whether there was a booking system to predict the number of diners, all kitchens replied that the calculation of the number of diners was based on the number of students registered at the school. In most cases, the kitchen depends on notification if students are unable to attend lunch in the dining hall, though kitchens often are notified late or not at all.

According to the municipalities' responsible persons, none of the dining halls had a serving system with trays. Whether a trayless system results in less food waste could therefore not be examined. (Personal communication: Falun, Malmö, Sala and Uppsala municipality (2017))

In addition to the 36 responses to the questionnaire, the number of students was available for all educational establishments in Uppsala except for high schools (Personal communication: Uppsala municipality (2017)). Furthermore, information about the type of kitchen (satellite or production units) was given for 100 of the 180 kitchens that had reported food waste measurements.

Table 2 Information included in the analysis and collected from the kitchen head chefs in the municipalities Sala, Uppsala, Falun and Malmö; description of the data by definition, type of data and estimated uncertainty

Category	**Definition**	**Type of data**	**Estimated uncertainty**
Number of students	Number of students registered at the school in December 2016	Accurate or rounded number (truncation by 5 students)	±10 students (including truncation and variation over time)
Number of employees	Number of employees working in the school kitchen in January and February 2017	Accurate number	±1 (due to variation over time)
Number of female and male employees	Number of employees working in the school kitchen in January and February 2017 divided into male and female employees	Accurate number	±1 (due to variation over time)
Grades	Grades represented in the school	Grades as a span of numbers, i.e. 1 - 9 or KG for kindergarten with children aged 1 to 5	0
Dining hall capacity	Number of seats available for diners in the dining hall	Accurate or rounded number (truncation by 5 seats) or category “in classroom” when the school does not have a dining hall and the children eat in their classrooms	±5 (due to truncation)
Distance between dining space and classroom	Distance between dining space and classroom	Either as distance in meters, as a description including whether the dining hall is in the same building as the classrooms or not or category “in classroom” when the school does not have a dining hall and the children eat in their classrooms	Distance in meters: ±50 m (due to different classrooms and visual estimation errors) Building: none Category “in classroom”: none
Number of meal options	Number of meal options that was intended by the kitchen staff	Accurate number or as a span, i.e. 2 - 3	Daily variation included in the span of numbers, thus, no uncertainty in the information given

2.5 METHOD - CORRELATION ANALYSIS

Statistical correlation analysis was used in order to examine the relationship between the factors listed in Table 1 and food waste that was generated in kindergartens and schools.

In general, correlation analysis uses hypothesis testing to determine how one variable is affected by another. The null hypothesis states that there is no significant correlation between the two tested variables. If the calculated p-value is lower than the assigned significance level, the null hypothesis can be rejected and the two tested variables are influencing each other. (Helsel and Hirsch, 2002)
The significance level for this study was set to be 0.05, which means that at least 95 % of the tested data sample accord to the correlation found when the null hypothesis is rejected.

The correlation between two variables can either be positive, meaning that one variable increases as the other increases, or negative, meaning that one variable decreases when the other increases. According to Helsel and Hirsch (2002), the three most common methods for correlation analysis are Pearson's r, Spearman's rho and Kendall's tau. All three methods return a correlation coefficient between -1 and 1, indicating the correlation strength. As the correlation coefficients r, rho and tau are calculated differently, the correlation strength is measured on a different scale depending on the method. It is therefore difficult to compare the strengths of correlations with different correlation coefficients. An overall standard says that a correlation coefficient between ±0.1 and ±0.3 indicates a weak relationship, a correlation coefficient between ±0.3 and ±0.5 indicates a moderate relationship and a correlation coefficient higher than 0.5 or lower than -0.5 indicates a strong relationship. (Field et al., 2012)

2.5.1 Pearson's product-moment correlation r

Pearson's r is the most commonly used method for correlation analysis and requires a normally distributed data sample. An exception can be made if one of the tested variables is bivariate and the second variable follows a normal distribution. Elsewise, the method requires that the observed variables are linearly dependent and fulfill the conditions of interval or ratio data. (Field et al., 2012)

Outliers, which can be detected in a boxplot, must be excluded from the analysis as the method is not resistant to outliers (Helsel and Hirsch, 2002).

2.5.2 Spearman's rank correlation rho

Spearman's rho uses a weighed rank test and requires a monotonic relationship between the two tested variables (Helsel and Hirsch, 2002). As the method depends on a rank test, the data sample is not required to be normally distributed. According to Field et al. (2012), Spearman's rho is not suitable for data samples containing less than 20 data points or data that do not fulfill the conditions to be ordinal.

2.5.3 Kendall's rank correlation tau

In contrast to Pearson's r and Spearman's rho, Kendall's tau is resistant to outliers as the method is based on a simple rank sum test. Still, the method asks for a monotonic relationship between the observed variables (Helsel and Hirsch, 2002). The method can handle ties in the data sample and does not require the tested variables to be normally distributed. Kendall's tau is suitable for smaller sample sizes, especially if the sample contains many ties. (Field et al., 2012)

2.5.4 Correlation analysis using R

R is a program with a big variety of built-in functions to compute statistical measures and to perform statistical analysis (The R Foundation, 2017). Correlation analysis was performed by writing and using a customized function "corranalyze" in R, which examines if the given data samples are normally distributed according to the Shapiro-Wilk test (Royston, 1991), creates a scatterplot to visualize the relationship between the tested variables and then decides on a suitable method before performing correlation analysis. (Appendix 7.4)

2.6 EXAMINED PARAMETERS

The following parameters were analyzed in R to determine whether there was a significant correlation between the suggested drivers for food waste in Table 1 and the food waste generated in Swedish kindergartens and schools. Correlations were examined between the parameters, total waste per portion, serving waste per portion and plate waste per portion. A graphical analysis was manually performed on scatterplots before each correlation test to ensure that only monotonic patterns appeared in the sample examined.

In preparation for multiple linear regression and to develop an overview over the parameters interaction with each other, a correlation matrix was created using the built-in function "cor" in R. To ensure that the results were not biased by ties or outliers in the data sample, the method was specified as "Kendall's rank correlation". The established correlation matrix contained all correlation coefficients between the parameters tested.

2.6.1 Number of students

The "number of students" was defined as the number of students registered at the school or kindergarten in December 2016. With a sample size of 72 data points and a discrete range of 27 to 1200 students, the data did not contain many ties compared to the sample size. As the data sample's distribution was non-normal (Shapiro-Wilk test, $n=72$, $p<0.05$). Spearman's rank correlation rho was chosen to be the most suitable method.

2.6.2 Span of grades

"Span of grades" is defined as the number of grades represented in a school. Kindergarten counts as one single grade, since children in kindergarten have the same routines and share the same location despite their different ages (1 to 5 years).
The data sample had a discrete range from 1 to 13 different grades and contained 35 data points. As the data was normally distributed (Shapiro-Wilk test, $n=35$, $p>0.05$), Pearson's product-moment correlation r was chosen to be the most suitable method.

2.6.3 Comparable age

In order to develop a relative measure to compare the students age, the "comparable age" was calculated and defined as the sum of all grades represented at a school or kindergarten divided by the span of grades. Some schools included a kindergarten class. To calculate the sum of all grades represented, each grade had a number between 1 and 15 assigned to it, 1 being the representable number for a kindergarten class and 15 to represent the last year of high school. The number 2 represented "class zero", also named "preschool class".

The data sample had a discrete range from 1 to 13 and consisted of 35 data points. As the data was non-normally distributed (Shapiro-Wilk test, $n=35$, $p<0.05$) and contained many ties compared to the sample size, Kendall's rank correlation tau was chosen to be the most suitable method.

2.6.4 Number of employees

The "number of employees" is defined as the number of persons working in the dining system's kitchen in January and February 2017. The data sample contained 35 data points with a discrete range from 1 to 11 employees and contained many ties compared to the sample size. As the data was non-normally distributed (Shapiro-Wilk test, $n=35$, $p<0.05$), Kendall's rank correlation tau was chosen as the most suitable method.

2.6.5 Employed men (percentage)

The percentage of employed men was calculated by dividing the number of male kitchen employees by the total number of kitchen employees and multiplying the resulting number by 100. The kitchen staff is most commonly dominated by women and men were therefore chosen as the observant gender percentage. The data sample contained 35 data points on a continuous range from 0 to 100 %. As the data was non-normally distributed (Shapiro-Wilk test, $n=35$, $p<0.05$) and some ties occurred, Kendall's rank correlation was chosen to be the most suitable method.

2.6.6 Employees per student

"Employees per student" was introduced to develop a comparable measure, since it is likely that the number of employees grows with an increased number of students. The measure was computed by dividing the number of employees by the number of students and multiplying the resulting number by 1000 to enhance the scale. The data sample contained 35 data points on a continuous range from 4.55 to 37.04. Visualization by boxplot showed the presence of one outlier. As the data was non-normally distributed (Shapiro-Wilk test, n=35, $p<0.05$) and did not contain any ties, Spearman's rank correlation rho was chosen to be the most suitable method. This method is resistant to outliers.

2.6.7 Type of dining space

"Type of dining space" was grouped into two categories. Schools in which the students ate lunch in their classrooms were assigned to be category 1 and schools that offered a dining hall separated from the classrooms were assigned to be category 0. The data sample was therefore bivariate and contained 36 data points. As waste per portion, serving waste per portion and plate waste per portion were found to be normally distributed (Shapiro-Wilk test, n=36, $p>0.05$), Pearson's product-moment correlation was chosen to be the most suitable method.

2.6.8 Distance between dining space and classroom

The "distance between dining space and classroom" was grouped into three different categories. The resulting data sample contained 34 data points on an ordinal scale with the following categories:

1 – No distance between dining space and classroom, meaning that students eat in their classrooms;

2 – The dining hall is located in the same building as or lies within 100 m from the classrooms;

3 – The dining hall and the classrooms are located in separate buildings or lie further than 100 m apart.

As the data sample included many ties due to the categorization, Kendall's rank correlation tau was chosen to be the most suitable method.

2.6.9 Number of seats in dining space

"Number of seats in dining space" is defined as the total number of chairs in the dining space. For schools without a separate dining hall, the number of seats was estimated to equal the number of students per class. According to (Skolverket, 2014) the average Swedish class size answers to 19 students and one teacher, resulting in 20 seats per dining space.

The data sample consisted of 35 data points on a discrete range from 20 to 485 seats. As the data was non-normally distributed (Shapiro-Wilk test, n=35, $p<0.05$) and contained ties, Kendall's rank correlation tau was chosen as the most suitable method.

2.6.10 Seats per student

"Seats per student" was introduced to develop a comparable measure, since it is likely that the dining space capacity grows with an increased number of students. The measure was computed by dividing the number of seats in dining space by the number of students.

The data sample consisted of 35 data points on a continuous range from 0.213 to 1.136. As data contained ties and was non-normally distributed (Shapiro-Wilk test, n=35, p<0.05), Kendall's rank correlation tau was chosen to be the most suitable method.

2.6.11 Variety of meal options

"Variety of meal options" is a measure that indicates how high the flexibility in a kitchen is to change the menu. A bigger span could for instance give the kitchen possibilities to include left-overs in new dishes. As an example, a dining system that reported a usual number of 3 to 6 meal options had a variety of 4 meal options.

The data sample consisted of 33 data points on a discrete range from 1 to 4. As the data contained many ties and was non-normally distributed (Shapiro-Wilk test, n=33, p<0.05), Kendall's rank correlation tau was chosen to be the most suitable method.

2.6.12 Comparable number of dishes

"Comparable number of dishes" is a measure of the total number of meal options that are generally offered at a school. The measure was calculated as an average over the number of meal options offered in each dining system. As an example, a school with a span of 2 to 3 meal options had a comparable number of 2.5 dishes.

The resulting data sample consisted of 33 data points on a continuous range from 1 to 4.5. As the data was non-normally distributed (Shapiro-Wilk test, n=33, p<0.05) and contained ties, Kendall's rank correlation was chosen to be the most suitable method.

2.6.13 Number of semesters with food waste measurements

The number of semesters in which food waste measurements had taken place varied between 1 to 8 semesters for the different dining systems. As the data sample was non-normally distributed (Shapiro-Wilk test, n=151, p<0.05) and contained many ties compared to the sample size of 151 data points, Kendall's rank correlation tau was chosen to be the most suitable method.

2.6.14 Type of kitchen

"Type of kitchen" was distinguished to be either 0 for production units or 1 for satellite units resulting in a bivariate data sample with 142 data points. As waste per portion, serving waste per portion and plate waste per portion were normally distributed (Shapiro-Wilk test, n=142, p>0.05), Pearson's product-moment correlation r was chosen to be the most suitable method.

2.6.15 Portion size

"Portion size" (g) was calculated as the total amount of served food divided by the number of portions served. The data sample consisted of 97 data points on a continuous range from 182.7 to 725 g and contained two outliers at 583.6 g and 725 g. As the data was non-normally distributed (Shapiro-Wilk test, n=97, $p<0.05$), Spearman's rank correlation rho was chosen to be the most suitable method. The method is resistant to outliers.

2.7 METHOD - MULTIPLE LINEAR REGRESSION

2.7.1 Model equation

In order to quantify the significantly influencing factors' impact on food waste, a multiple linear regression model was developed for each food waste quantity. According to Uyanik and Güler (2013), the advantage of using a multiple linear regression model instead of diverse correlations is the ability to quantify the totalized effect from relevant factors on the model outcome.

In general, a multiple linear regression model includes an intercept (c_0), model coefficients (c_0, c_1, c_2, …, c_n) and two or more explanatory variables (x_1, x_2, …, x_n) that together explain the variation in the response variable (y). In most cases, some unexplained noise remains, often referred to as the error (ε) in the model. (Eq. 1; Helsel and Hirsch, 2002)

$$y = c_0 + c_1 * x_1 + c_2 * x_2 + \cdots + c_n * x_n + \varepsilon \qquad (1)$$

If the model outcome is likely to depend on two factors' interaction, an interaction term (x_1*x_2) can be added to the general model equation (Eq. 2; Helsel and Hirsch, 2002).

$$y = c_0 + c_1 * x_1 + c_2 * x_2 + \cdots + c_n * x_n + a_1 * x_1 * x_2 + \cdots + \varepsilon \qquad (2)$$

R's built-in commando "lm" was used to perform the modeling.

2.7.2 Assumptions and choice of explanatory variables

With respect to the results from the correlation analysis, a number of multiple linear regression models based on different factor constellations were tested for each food waste quantity. According to Field et al. (2012), the choice of explanatory variables should be based on theoretical reasons. Only factors that were significantly correlated ($p<0.05$) or almost significantly correlated ($p<0.1$) with food waste were therefore used for developing the model.

Furthermore, the model outcome should be linearly dependent on all explanatory variables included in the model (Field et al., 2012). The explanatory variables should be independent and randomly distributed, while the response variable is assumed to be normally distributed (Uyanik and Güler, 2013).

In order to be able to generalize the multiple linear regression model beyond the data used for model development, the residuals should be normally distributed and not show any specific pattern (Field et al., 2012).

Since the food waste quantities plate waste per portion, serving waste per portion and total waste per portion were normally distributed (Shapiro-Wilk test, n=35, p>0.05), three different multiple linear regression models with food waste quantities as response variables could be developed. Graphical analysis assured that the assumption about linearity held for all explanatory variables included in the models. To avoid biased models, outliers were removed from the data used for modeling (Uyanik and Güler, 2013) and factors that were likely to cause multi-collinearity (tau>0.6 according to correlation matrix) were eliminated before the model development (Helsel and Hirsch, 2002; Field et al., 2012).

2.7.3 Validation and choice of model

Backwards elimination was used to choose the best performing multiple linear regression model. All explanatory variables significantly or almost significantly correlated to the food waste quantity were included in the model. Explanatory variables that were not significant for the model outcome (p>0.05) were eliminated step by step until all included explanatory variables significantly influenced the variation in the response variable (p<0.05). (Helsel and Hirsch, 2002)

To improve the model performance, different interaction terms were then added through backwards elimination. The best performing model was chosen with respect to the coefficient of determination, R^2, and the number of explanatory variables. According to Helsel and Hirsch (2002), a good model explains as much of the variation in the response variables with as few explanatory variables as possible. As the R^2-value naturally increases with each explanatory variable included in the model, the adjusted R^2-value, which is considerate of the number of explanatory variables, was used to determine the best performing model (Helsel and Hirsch, 2002).

To ensure that the assumptions of linearity, normality and independence held for the chosen models, a graphical analysis was performed on a residual and a quantile-quantile plot (Field et al., 2012).

3 RESULTS

3.1 CORRELATION ANALYSIS

A schematic model (Figure 2) summarizes the findings from the correlation analysis. The factors “number of employees”, “number of seats in dining space” and “number of students” strongly influence each other (tau>0.7).

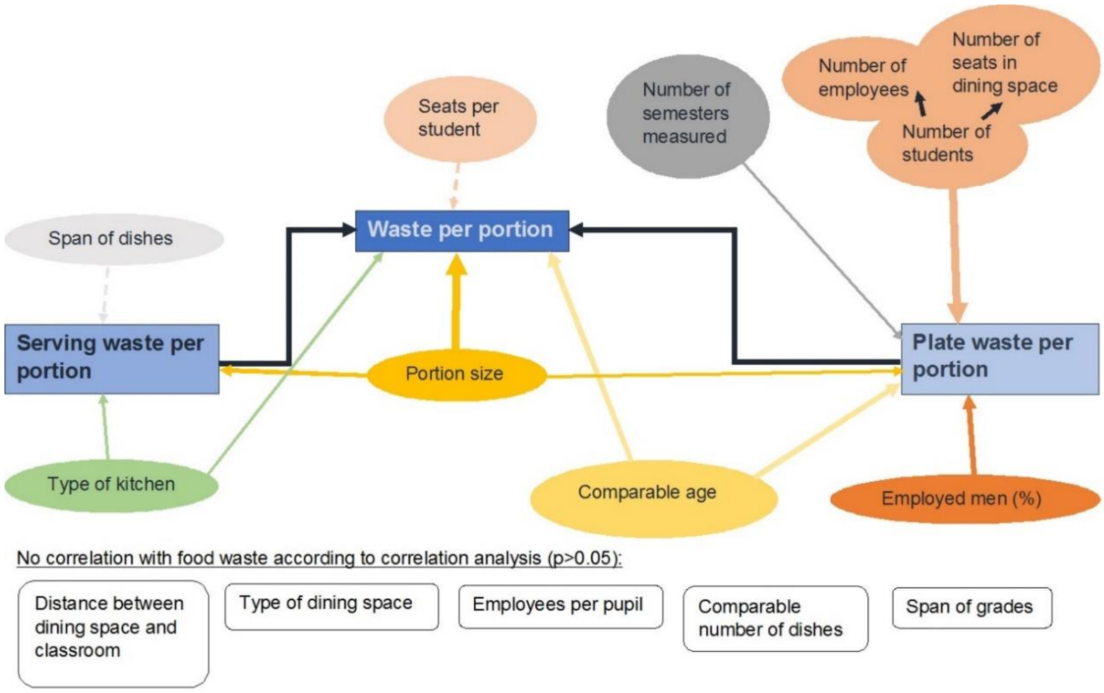

Figure 2 Schematic model over the interaction between factors and their influence on food waste quantities. The total waste per portion is the sum of both serving and plate waste per portion. The boldness of the arrows indicates the strength of the correlation. Dashed arrows indicate that the factor is significantly correlated to the corresponding food waste quantity with a different significance level ($p<0.1$). Factors that were not correlated to any food waste quantity are listed below the schematic model.

3.1.1 Correlations with plate waste per portion

Plate waste per portion was strongly positively correlated with the number of students, moderately positively correlated with comparable age, the number of employees, the percentage of employed men and number of seats in dining space, and weakly positively correlated with the number of semesters measured and portion size (Table 3 and Figure 3-9).

Table 3 Significant correlations with plate waste per portion; method, number of data points n, p-value and the strength of the correlation according to the correlation coefficient

Factor	Method	n	p-value	Correlation strength
Number of students	Spearman	72	<0.0001	rho=0.52
Comparable age	Kendall	35	<0.001	tau=0.44
Number of semesters measured	Kendall	151	<0.05	tau=0.15
Number of employees	Kendall	35	<0.001	tau=0.45
Employed men (percentage)	Kendall	35	<0.05	tau=0.31
Portion size	Spearman	97	<0.01	rho=0.28
Number of seats in dining space	Kendall	35	<0.01	tau=0.36

The factors "number of employees" and "number of seats in dining space" were strongly positively influenced by "number of students" (tau>0.7). (Figure 2)

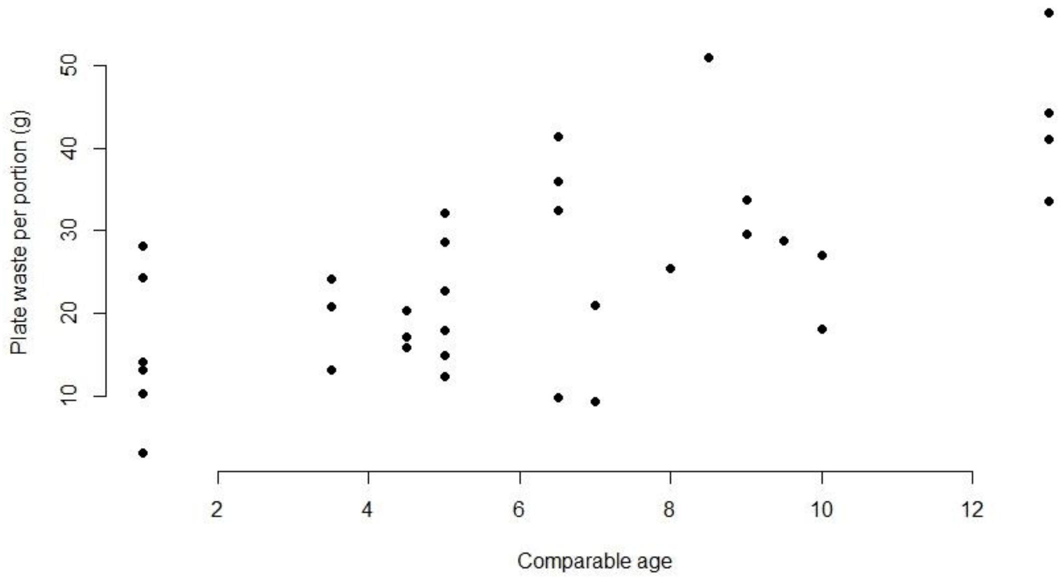

Figure 3 Scatterplot over the relationship between plate waste per portion (g) on the vertical axis and comparable age on the horizontal axis (n=35, p<0.001, tau=0.44).

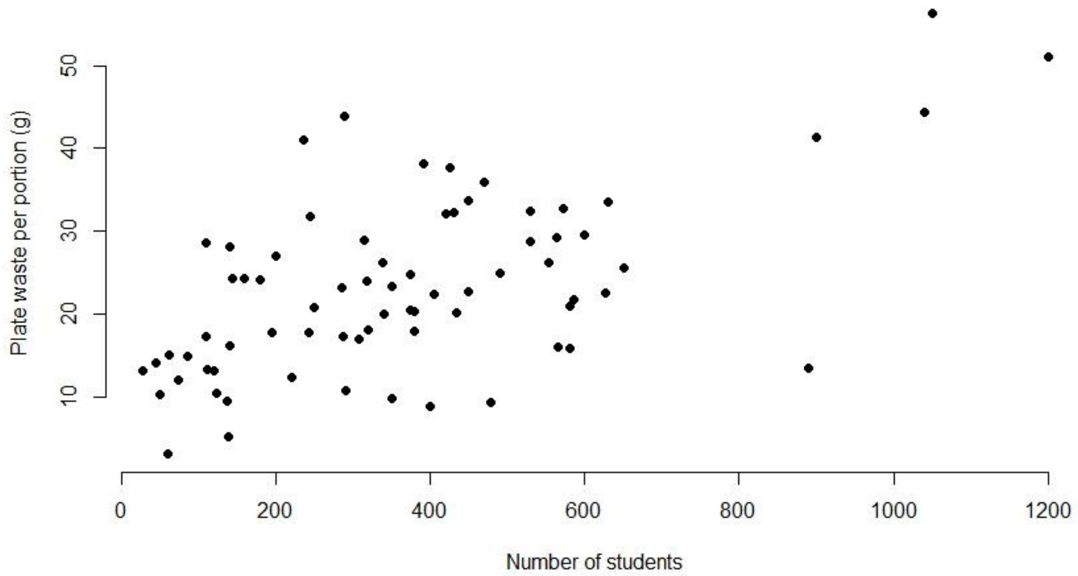

Figure 4 Scatterplot over the relationship between plate waste per portion (g) on the vertical axis and number of students registered at the school on the horizontal axis (n=72, p<0.0001, rho=0.52).

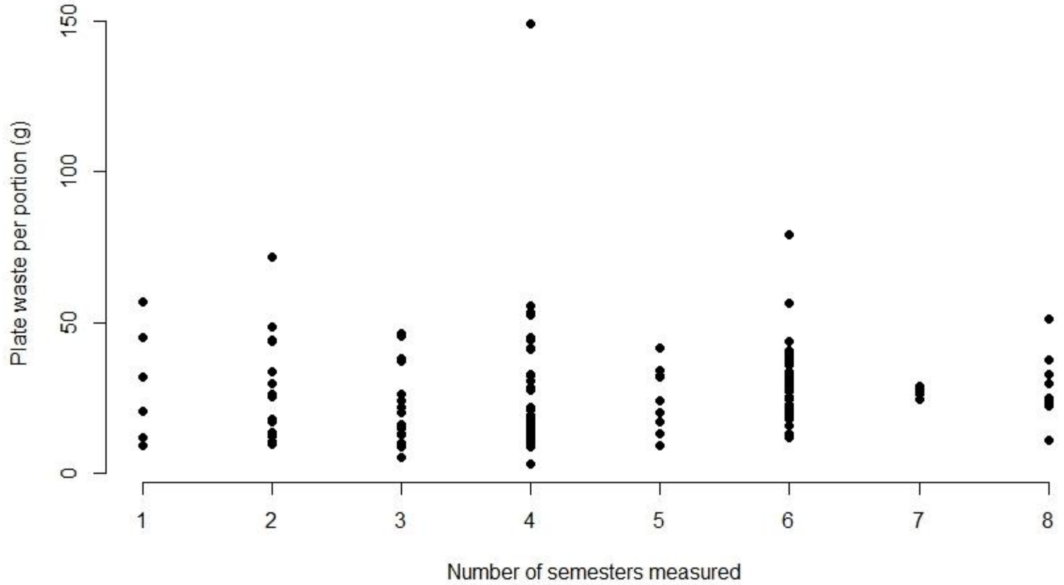

Figure 5 Scatterplot over the relationship between plate waste per portion (g) on the vertical axis and number of semesters with food waste measurements on the horizontal axis (n=151, p<0.05, tau=0.15).

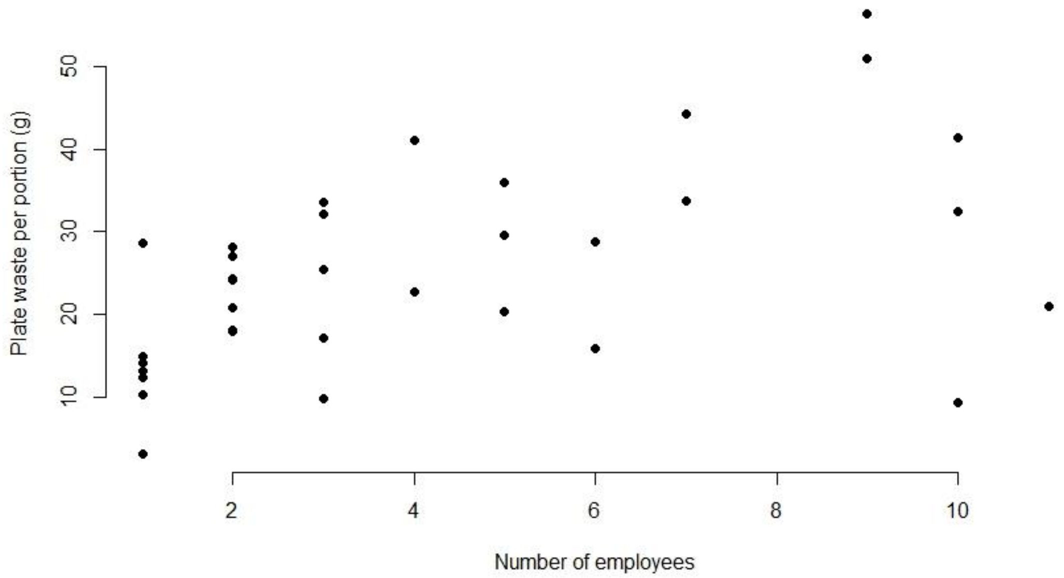

Figure 6 Scatterplot over the relationship between plate waste per portion (g) on the vertical axis and number of employees in the dining facility on the horizontal axis (n=35, $p<0.001$, tau=0.45).

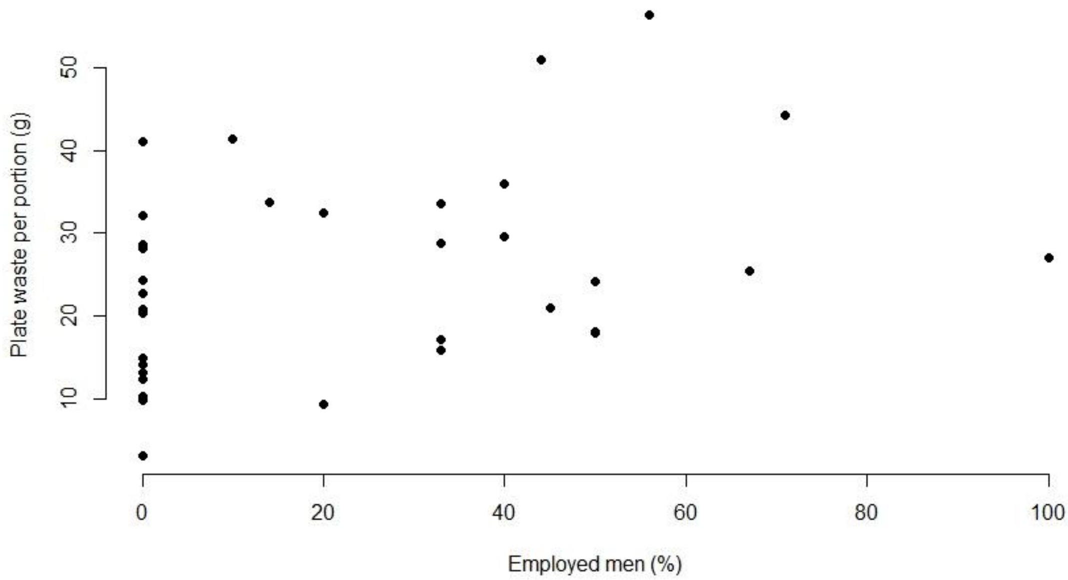

Figure 7 Scatterplot over the relationship between plate waste per portion (g) on the vertical axis and percentage of employed men in the dining facility on the horizontal axis (n=35, $p<0.05$, tau=0.31).

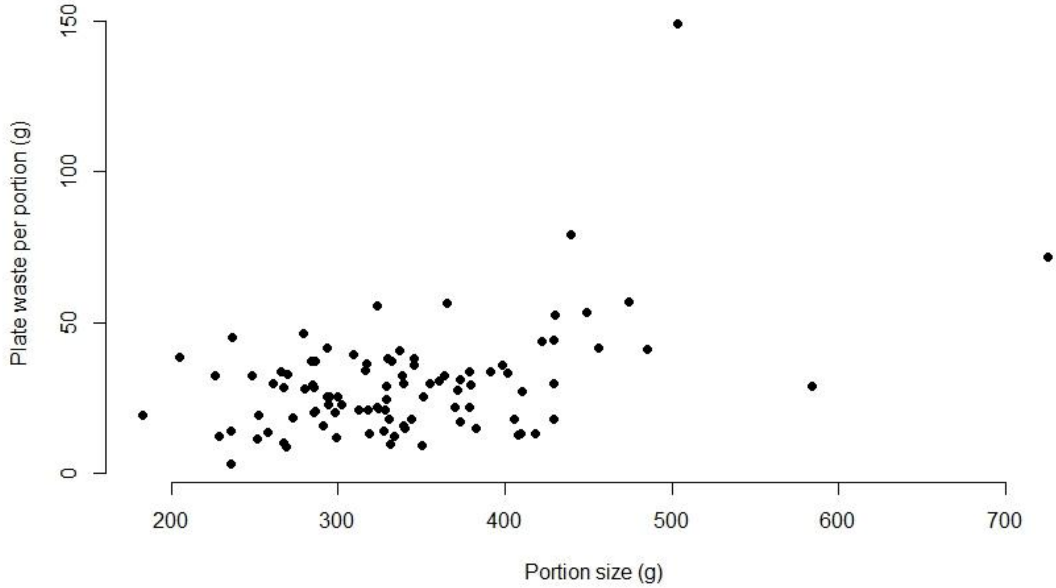

Figure 8 Scatterplot over the relationship between plate waste per portion (g) on the vertical axis and average portion size (g) calculated as total amount of served food divided by the number of portions served on the horizontal axis (n=97, p<0.01, rho=0.28).

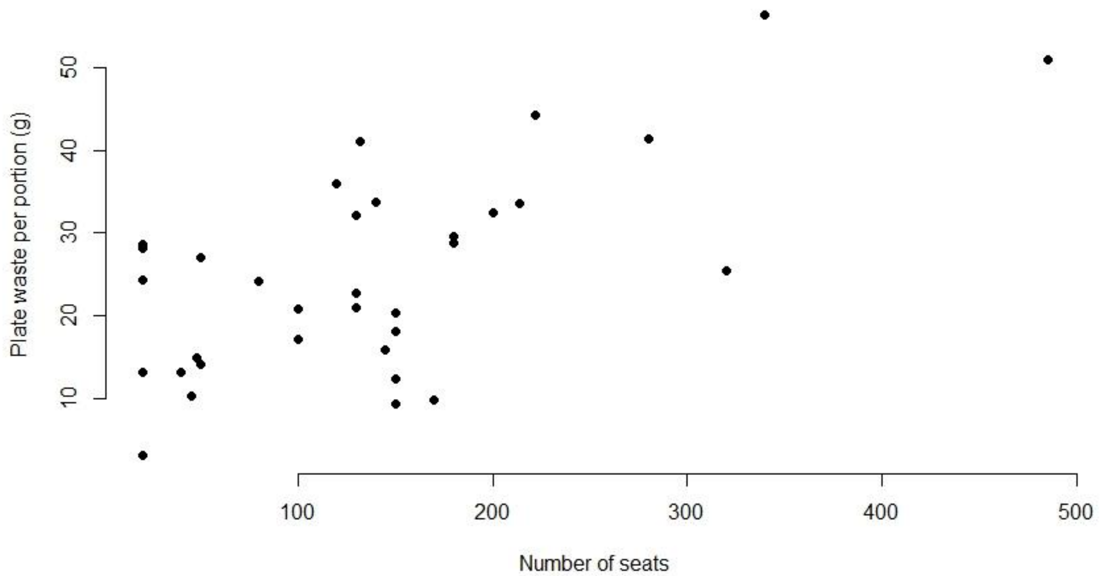

Figure 9 Scatterplot over the relationship between plate waste per portion (g) on the vertical axis and number of seats in dining space on the horizontal axis (n=35, p<0.01, tau=0.36).

3.1.2 Correlations with serving waste per portion

Serving waste per portion was moderately positively correlated to portion size. Satellite units had significantly higher serving waste than production units. (Table 4 and Figure 10 and 12)

Table 4 Significant correlations with serving waste per portion; method, number of data points n, p-value and the strength of the correlation according to the correlation coefficient

Factor	Method	n	p-value	Correlation strength
Portion size	Spearman	97	<0.0001	rho=0.42
Type of kitchen	Pearson	142	<0.05	r=0.19

In addition to these two factors, Kendall's rank correlation indicated a weak negative correlation between serving waste per portion and the variety of meal options (n=33, p=0.07, tau=-0.26; Figure 11).

Portion size, variety of meal options and type of kitchen were only weakly influenced by some of the other factors that were examined and could therefore be used to explain serving waste per portion (Figure 2).

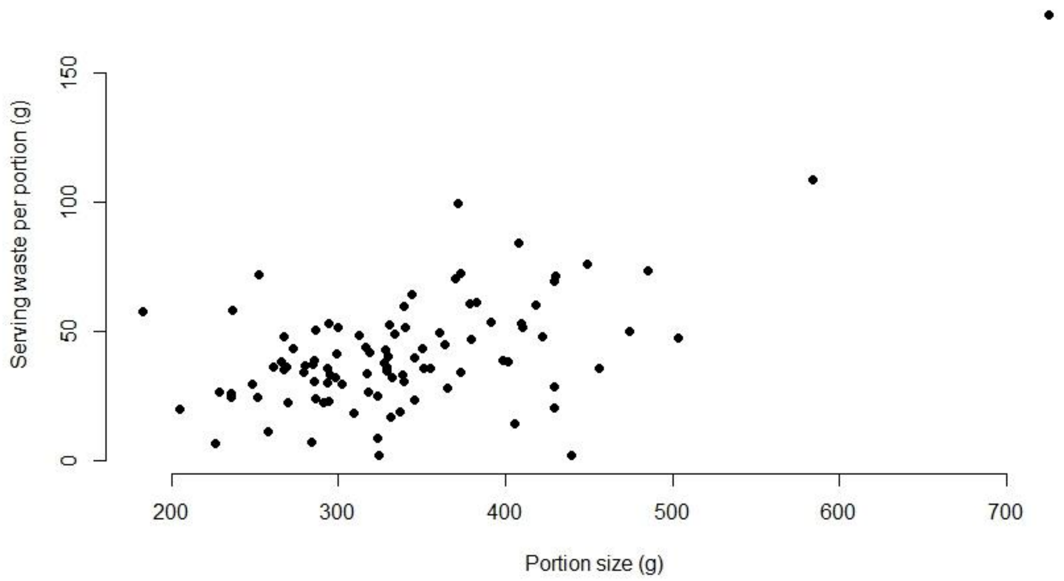

Figure 10 Scatterplot over the relationship between serving waste per portion (g) on the vertical axis and average portion size (g) calculated as total amount of served food divided by the number of portions served on the horizontal axis (n=97, p<0.0001, rho=0.42).

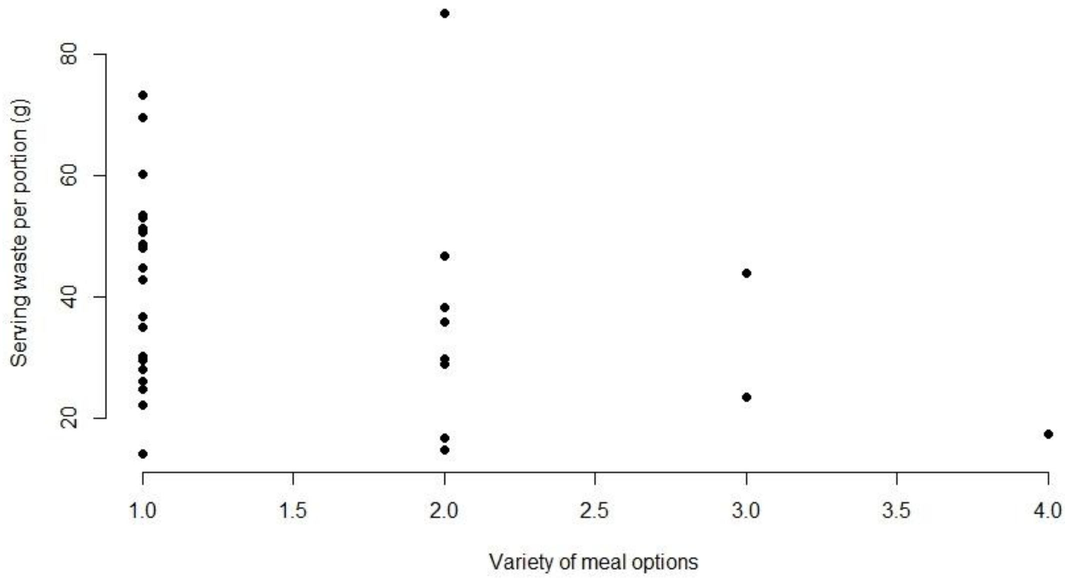

Figure 11 Scatterplot over the relationship between serving waste per portion (g) on the vertical axis and variety of meal options on the horizontal axis and (n=33, p=0.07, tau=-0.26). Most of the observed facilities offer a fixed number of meal options (1.0 on the horizontal axis).

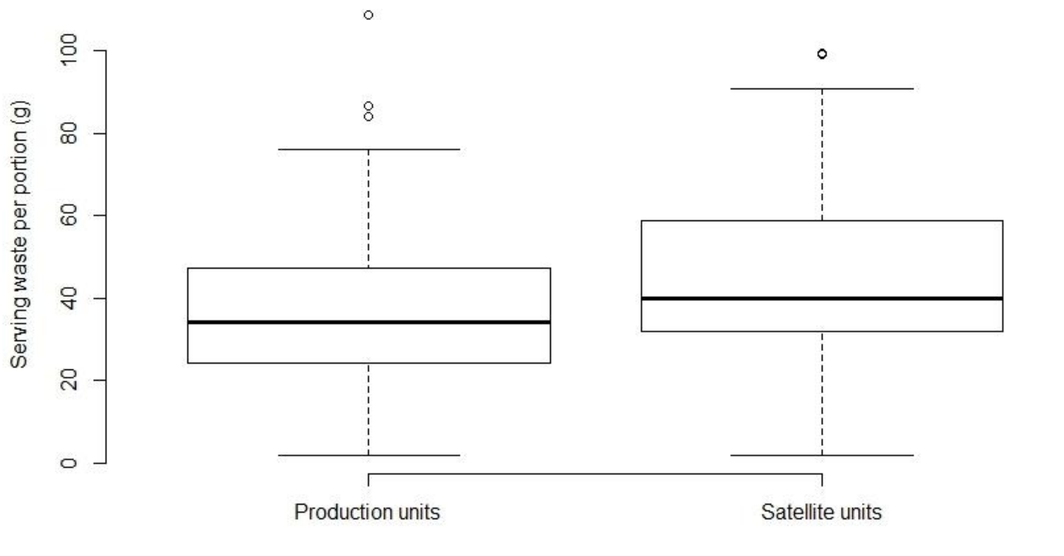

Figure 12 Boxplot comparing serving waste per portion in production and satellite units; the vertical axis presents the serving waste per portion (g); the bold lines in the boxes represent the mean over the data for each kitchen type; outliers are drawn as points (n=142, $p<0.05$, r=0.19).

3.1.3 Correlations with total waste per portion

The total waste per portion being the sum of both plate and serving waste per portion was strongly positively correlated to portion size and moderately positively correlated to comparable age. Satellite kitchens had significantly higher waste per portion than production units. (Table 5 and Figure 13, 14 and 16)

Table 5 Significant correlations with total waste per portion; method, number of data points (n), p-value and the strength of the correlation according to the correlation coefficient

Factor	Method	n	p-value	Correlation strength
Comparable age	Kendall	35	<0.001	tau=0.43
Portion size	Spearman	97	<0.0001	rho=0.54
Type of kitchen	Pearson	142	<0.05	r=0.18

Comparable age, portion size and type of kitchen were only weakly influenced by some of the other factors that were examined and can therefore be used to explain total waste per portion (Figure 2).

In addition to these three factors, Kendall's rank correlation indicated a weak negative correlation between total waste per portion and seats per student (n=35, p=0.06, tau=-0.23; Figure 15).

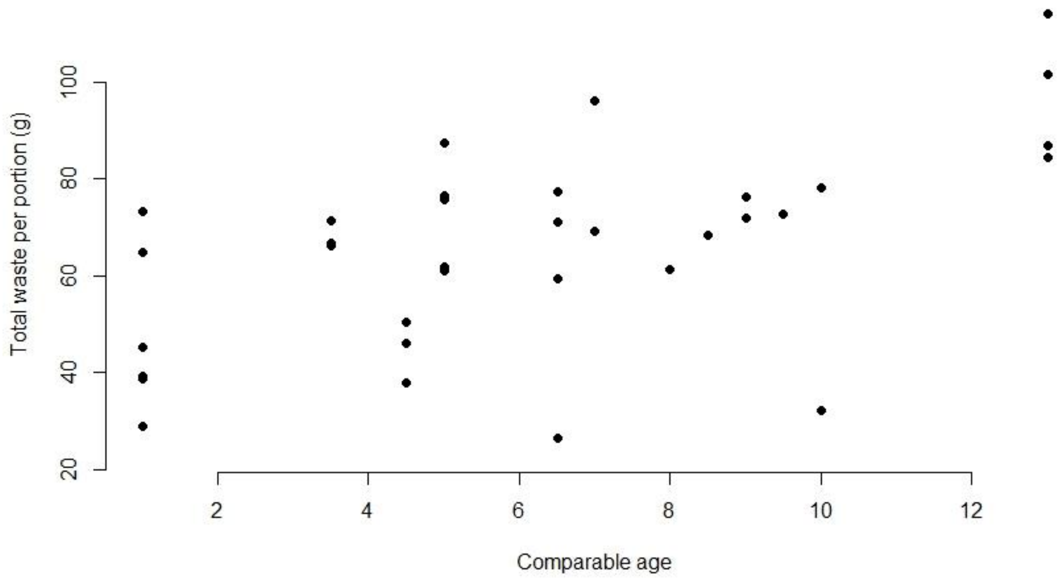

Figure 13 Scatterplot over the relationship between total waste per portion (g) on the vertical axis and comparable age on the horizontal axis; (n=35, p<0.001, tau=0.43).

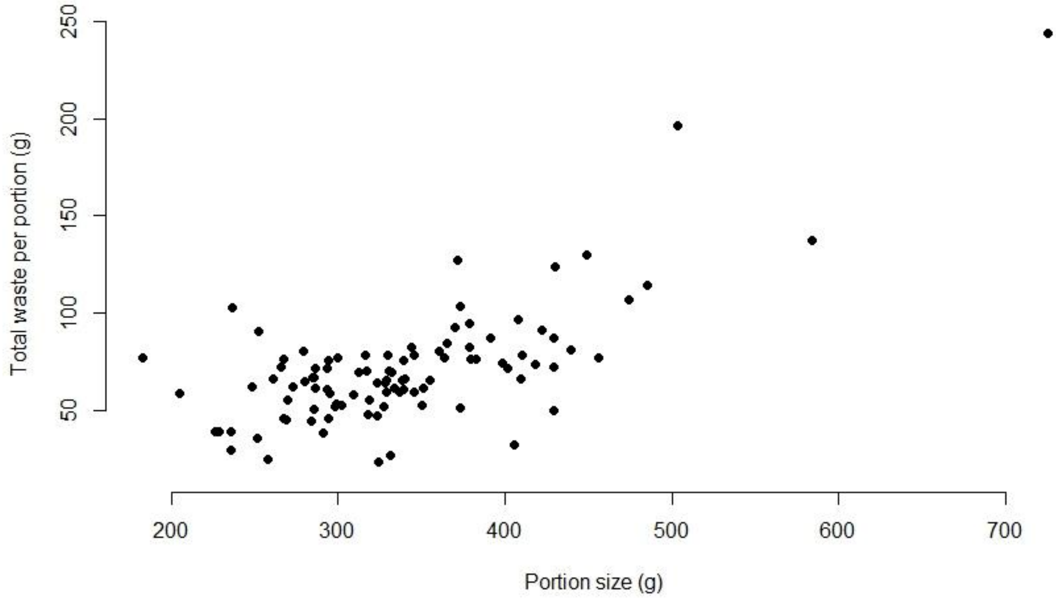

Figure 14 Scatterplot over the relationship between total waste per portion (g) on the vertical axis and average portion size (g) calculated as total amount of served food divided by the number of portions served on the horizontal axis (n=97, p<0.0001, rho=0.54).

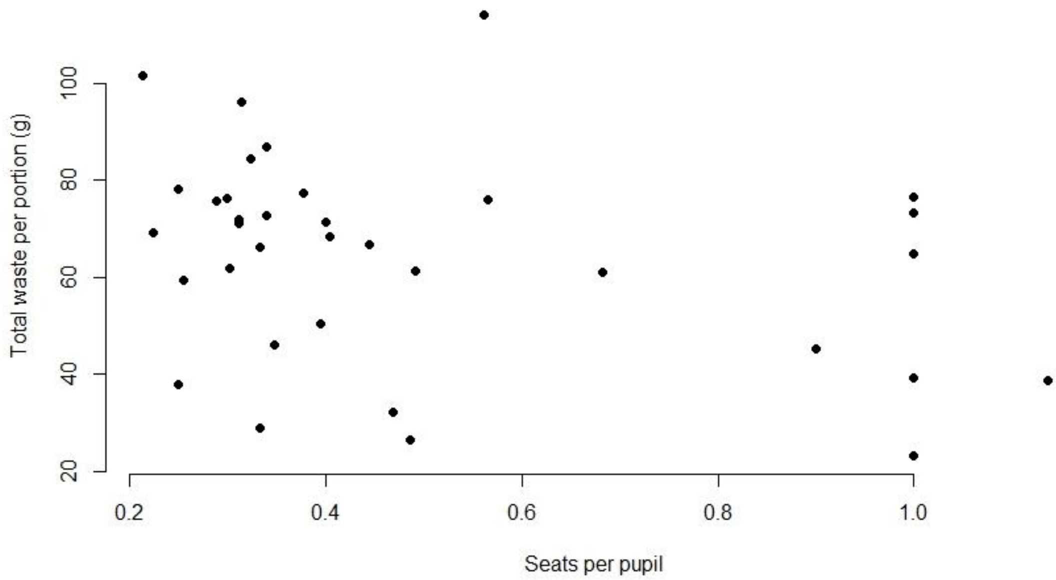

Figure 15 Scatterplot over the relationship between total waste per portion (g) on the vertical axis and seats per student on the horizontal (n=35, p=0.06, tau=-0.23).

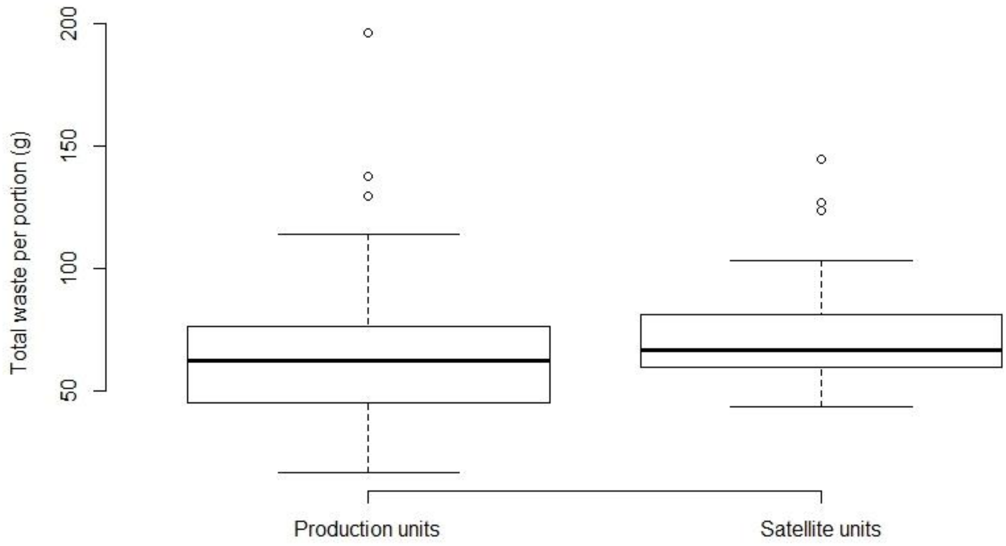

Figure 16 Boxplot comparing total waste per portion in production and satellite units; the vertical axis presents the total waste per portion (g); the bold lines in the boxes represent the mean over the data for each kitchen type; outliers are drawn as points (n=142, p<0.05, r=0.18).

3.2 MULTIPLE LINEAR REGRESSION

3.2.1 Plate waste per portion

Among the models tested, the food waste quantity plate waste per portion was best explained by the multiple linear regression model A including the factors comparable age, number of semesters measured, number of students and the interaction between seats per student and portion size (Eq. 3; Table 6). Together, the factors mentioned explained 72.5 % of the variation in plate waste per portion between the schools used for analysis (n=26, R^2=0.725, p<0.0001). The red line in the residuals plot shows that the residuals for model A are randomly distributed and do not follow a pattern, indicating linearity and homoscedasticity (Figure 17). Moreover, the standardized residuals in the quantile-quantile plot follow the dashed line and fulfill the assumption of linearity (Figure 18).

$$\begin{aligned} Plate\ waste\ per\ portion\ [g] &= 21.58 + 1.53 * Comparable\ age + 3.60 \\ &* Number\ of\ semesters\ measured + 0.03 * Number\ of\ students \\ &+ 0.07 * Seats\ per\ student * Portion\ size \\ &\pm 6.29\ g \qquad (3) \end{aligned}$$

Table 6 Multiple regression model A for plate waste per portion; significant factors and p-values

Model A	Factor	p-value
	Comparable age	<0.01
	Number of semesters measured	<0.01
	Seats per student : Portion size	<0.01
	Intercept	<0.05

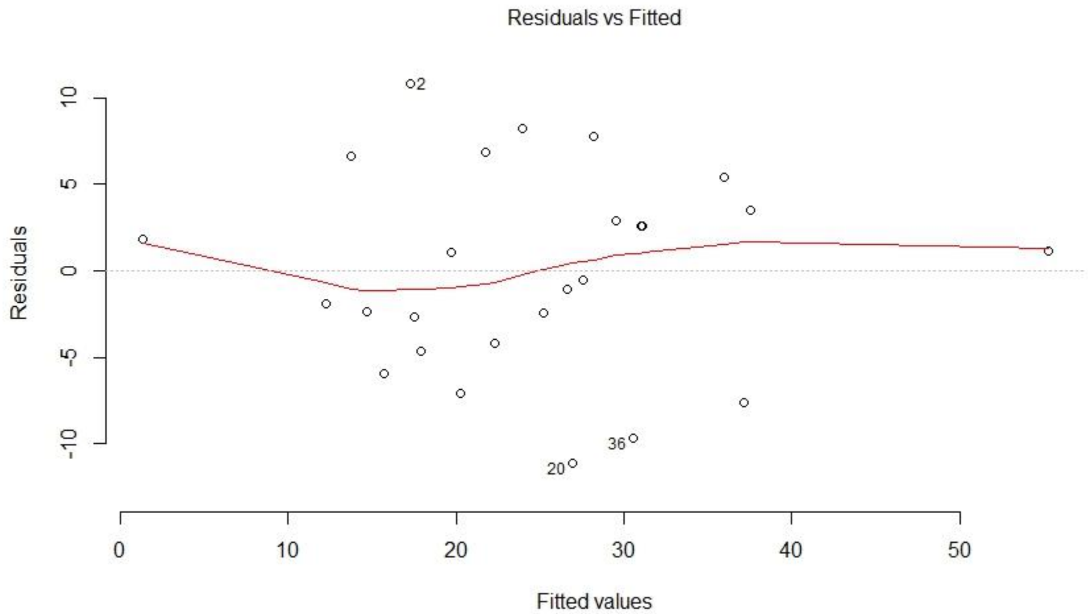

Figure 17 Residuals plot for multiple linear regression model A for plate waste per portion. Observe that the scale on the vertical axis is different from the scale in Figure 19 and 21.

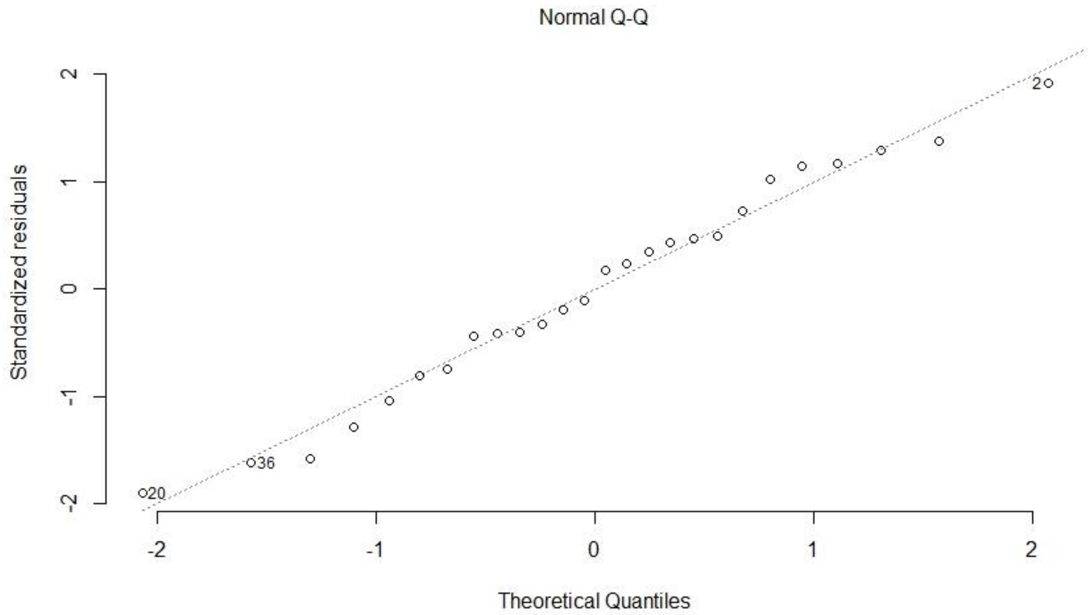

Figure 18 Quantile-quantile plot for the standardized residuals for model A. The horizontal axis shows the theoretical quantiles and the vertical axis shows the standardized residuals.

3.2.2 Serving waste per portion

The food waste quantity serving waste per portion was best explained by the multiple linear regression model B including the interaction between type of kitchen and portion size (Eq. 4; Table 7). The interaction between type of kitchen and portion size explained 11.7 % of the variation in serving waste between the schools used for analysis (n=28, $p<0.05$, $R^2=0.117$). The red line in the residuals plot shows that the residuals for model B are randomly distributed and do not follow a pattern, indicating linearity and homoscedasticity (Figure 19). Moreover, the standardized residuals in the quantile-quantile plot follow the dashed line and fulfill the assumption of linearity (Figure 20).

$$Serving\ waste\ per\ portion\ [g] = 37.76 + 0.04 * Type\ of\ kitchen * Portion\ size \pm 14.68\ g \qquad (4)$$

Table 7 Multiple linear regression model B for serving waste per portion; significant factors and p-values

Model B	Factor	p-value
	Type of kitchen : Portion size	<0.05
	Intercept	<0.0001

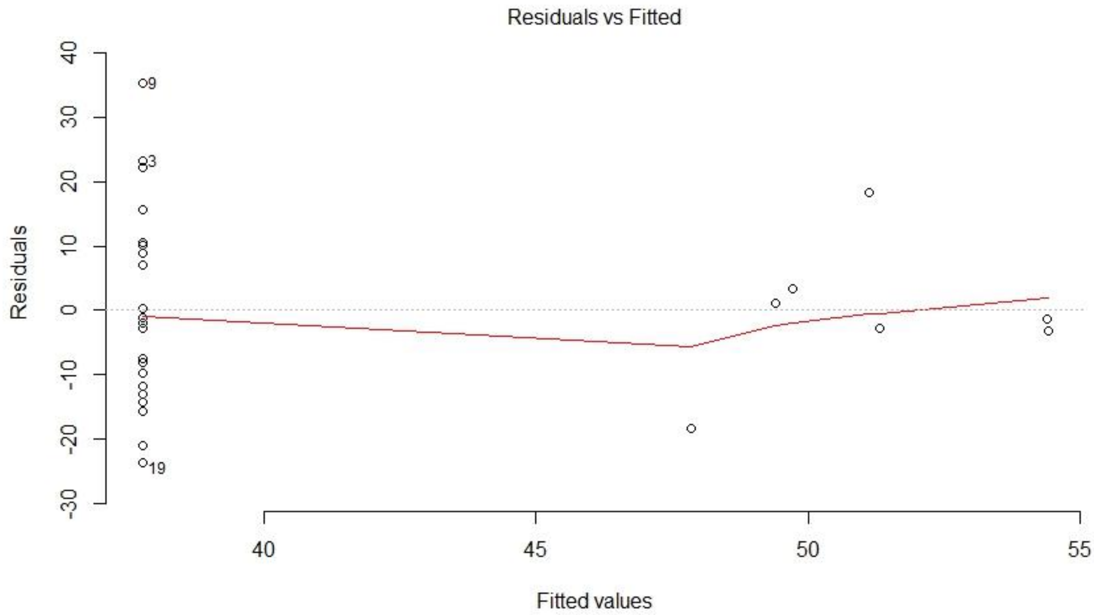

Figure 19 Residuals plot for multiple linear regression model B for serving waste per portion. Observe that the scale on the vertical axis is different from the scale in Figure 17 and 21.

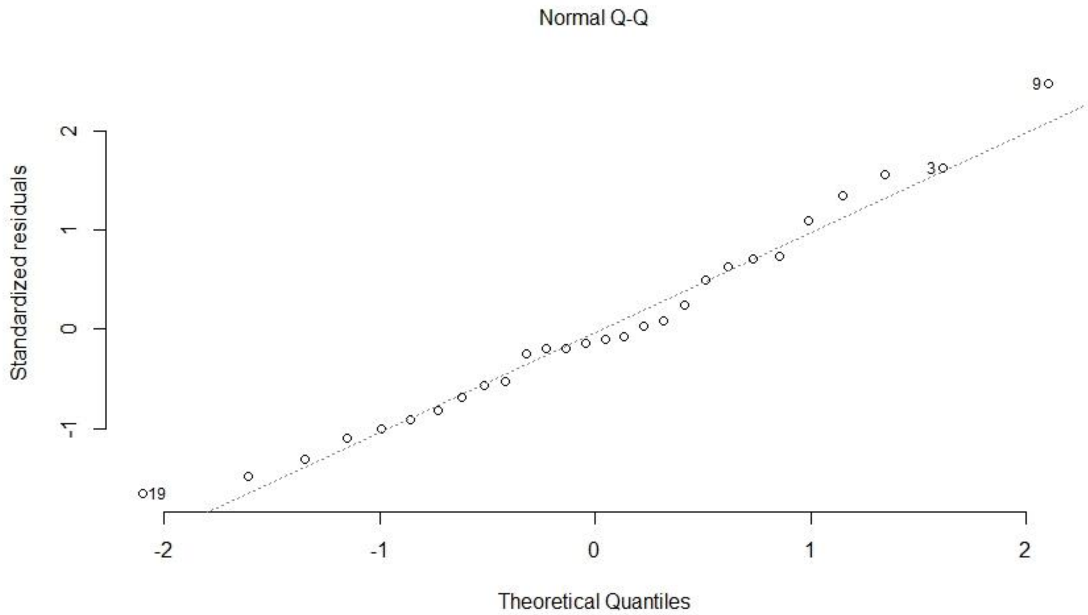

Figure 20 Quantile-quantile plot for the standardized residuals for model B. The horizontal axis shows the theoretical quantiles and the vertical axis shows the standardized residuals.

3.2.3 Total waste per portion

Among the models tested, total waste per portion was best explained by the multiple linear regression model C, including the interaction between comparable age and number of semesters measured and the interaction between seats per student and portion size (Eq. 5; Table 8). Together, these interactions explained 48.3 % of the variation in total waste per portion between the schools used for analysis (n=26, p<0.001, R^2=0.483). The red line indicates that the residuals for model C might not be randomly distributed and the assumptions of linearity and homoscedasticity are not fulfilled (Figure 21). Moreover, the standardized residuals in the quantile-quantile plot deviate from the dashed line, indicating that the assumption about normality is not fulfilled (Figure 22).

$$Total\ waste\ per\ portion\ [g] = 24.58 + 0.79 * Comparable\ age * Number\ of\ semesters\ measured + 0.12 * Seats\ per\ student * Portion\ size \pm 14.08\ g \quad (5)$$

Table 8 Multiple linear regression model C; significant factors and p-values

Model C	Factor	p-value
	Comparable age : Number of semesters measured	<0.0001
	Seats per student : Portion size	<0.01
	Intercept	<0.05

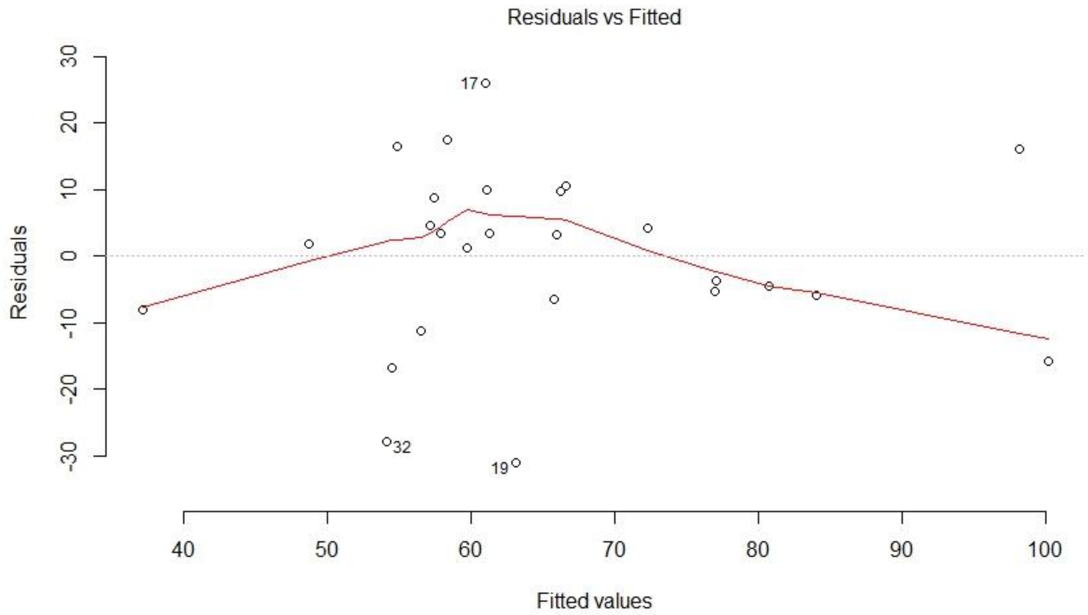

Figure 21 Residuals plot for multiple linear regression model C for total waste per portion. Observe that the scale on the vertical axis is different from the scale in Figure 17 and 19.

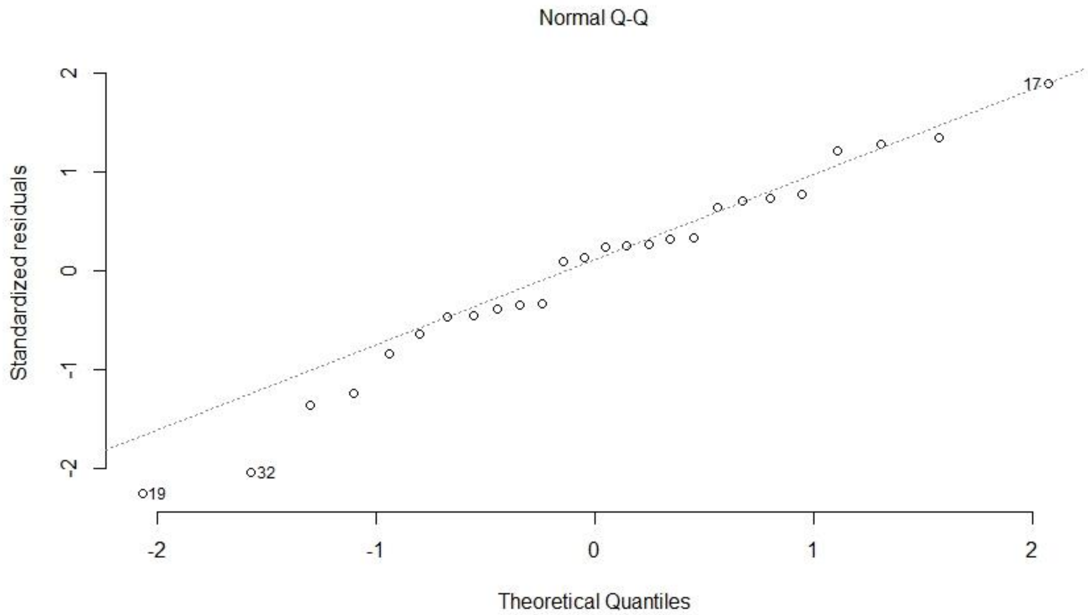

Figure 22 Quantile-quantile plot for the standardized residuals for model C. The horizontal axis shows the theoretical quantiles and the vertical axis shows the standardized residuals.

4 DISCUSSION

4.1 UNCERTAINTIES AND RESTRICTIONS

Facilities located in different municipalities and different types of educational establishments complicate the collection of unified food waste measurements. The food waste measurements used for analysis and model development in this study therefore held uncertainties. However, general trends and associations could be detected with the material used.

Due to the biased opinions caused by public view on educational establishments' dining systems (Persson Osowski, 2012), only quantified factors were used for analysis. The background data was collected through a questionnaire to which 36 schools in four Swedish municipalities responded. The questions about the number of meal options served and distance between dining space and classroom were interpreted and answered to differently by the kitchen head chefs that were approached. Factors examined including the number of meal options served or the distance between dining space and classroom should therefore be examined further with the aid of a more specific survey.

Furthermore, the number of employees could be defined as the number of work hours instead of the number of staff members when examining correlations between number of employees or employees per student and food waste quantities. The remaining factors were considered to contain sufficiently small uncertainties to detect general trends and associations with the given amount of data.

4.2 MULTIPLE LINEAR REGRESSION MODELS FOR THE EXPLANATION OF FOOD WASTE IN SCHOOLS AND KINDERGARTENS

Among the plate waste models tested, model A (section 3.2.1) had the highest coefficient of determination. The factors included in model A could together be used to explain 72.5 % of the plate waste generated in schools and kindergartens. According to this multiple linear regression model, comparable age, number of students, number of semesters measured and the interaction between seats per student and portion size significantly contributed to plate waste. The significant intercept showed that an averaged amount of approximately 22 g of plate waste would remain if the effect from all the mentioned factors would be minimized.

As the residuals were normally distributed and the assumptions of linearity and homoscedasticity held (Figure 17 and 18), model A can be generalized beyond the data range used for developing the model (Field et al., 2012). Thus, the plate waste per portion generated in schools and kindergartens is dependent on children's age, the number of semesters with food waste measurements and the interaction between portion size and seats per student with a residual standard error of about 6 g (Eq. 3).

That plate waste increases with children's age, number of students and number of semesters measured is in line with the results from the correlation analysis. Plate waste was also expected to increase with bigger portion sizes, which was confirmed by model A.

According to model A, the interaction between seats per student and portion size also contributed significantly to the plate waste. The contribution was at its highest when both portion size and seats per student had high values. As portion sizes tended to be big (>300 g), the interaction could increase plate waste by up to 15 g (with a portion size of 400 g and 0.5 seats per student; Eq. 3). A reason for the significance of the interaction in the plate waste model could be that students overestimate their food intake under the conditions of expanded food supply and a spacious dining space.

In order to diminish the effect from the interaction, schools and kindergartens could on one hand reduce the food supply in case of an overproduction. This on the other hand would increase the generation of serving waste. A better option would be to diminish portion sizes in general and more accurately estimate the daily amount of diners.

Among the models tested for serving waste per portion, model B (section 3.2.2) could be generalized beyond the data range used for development, as the assumptions about linearity, homoscedasticity and normality held (Figure 19 and 20). The interaction between portion size and type of kitchen contributed significantly to serving waste per portion and explained 11.7 % of the serving waste generated in schools and kindergartens. The effect by the interaction factor was at its highest if portion sizes were big in satellite units (Eq. 4), due to their difficulties handling and storing food left-overs (Eriksson et al., 2017). As the data for the factor type of kitchen was binary, the significant intercept shows that the average serving waste in production units answered to approximately 38 g of serving waste (compare Figure 12).

Since only 11.7 % of the variation in serving waste per portion could be explained by model B and the residual standard error answered to about 14 g, serving waste is supposedly influenced by factors that were not examined in this study. Other factors that might explain the variation in serving waste per portion could be management factors or stress (Kinasz et al., 2015), as might a different approach for quantifying knowledge about diners. Considering the results from the correlation analysis, flexibility of the menu should also be considered as a contributing factor and be examined with a bigger data set.

Model C (section 3.2.3), including the interaction between comparable age and number of semesters measured and the interaction between seats per student and portion size, explained the variation in the total waste per portion by 48.3 % for the given data set with a residual standard error of approximately 14 g. Then again, model C should not be generalized beyond the data set used for development, as the residuals were not adequately normally distributed and the assumptions about linearity and homoscedasticity could be questioned (Figure 21 and 22).

Although the factors comparable age, number of semesters measured, seats per student and portion size, which sufficiently explained the variation in plate waste per portion, were included in the model, serving waste is estimated to contribute with two thirds to the total waste per portion (Eriksson et al., 2016; Figure 1). Since total waste per portion is the sum of both serving and plate waste per portion, the uncertainties in model C most likely resulted from the lack of factors to sufficiently explain the variation in serving waste per portion.

In order to find a model that can be generalized, more factors explaining the variation in serving waste per portion should be included in the model development. Still, a decrease in plate waste per portion would decrease the total waste per portion, which was implied by the significant factors in model C that according to the correlation analysis significantly increased plate waste.

4.3 CORRELATION ANALYSIS AND SIGNIFICANT INFLUENCES ON FOOD WASTE IN SCHOOLS AND KINDERGARTENS

Graphical analysis showed that comparable age and plate waste per portion follow a monotonic relationship, verifying Kendall's rank correlation tau as an appropriate method for correlation analysis.

Plate waste significantly increased with comparable age, meaning that children in higher grades produce more plate waste than children in lower grades. Children in kindergarten had the lowest plate waste while students in high school generated the highest amount of plate waste. In addition to plate waste, the total waste per portion significantly increased with the children's age. As the correlation's strength (tau=0.43) was similar to the correlation strength of plate waste per portion and comparable age (tau=0.44), it is likely that the food waste quantity serving waste per portion does not depend on the children's age and plate waste induces the correlation between total waste and comparable age.

A reason for the correlation between plate waste and comparable age could be that younger children often eat accompanied by their teachers and have more structured lunch breaks than students in higher grades. As an example, pupils at Flogstaskolan in Uppsala eat with their teachers and have "quiet minutes" during their lunch breaks, which lets them eat without any distractions (Appendix 7.1). Another reason for the correlation between children's age and plate waste could be that students in higher grades have the possibility to purchase food outside the dining hall which according to Marlette et al. (2005) increases plate waste.

Schools with students in higher grades could most likely lower their plate waste by introducing more structured lunch breaks and should examine whether many of their' students purchase competitive food items. If the majority of the students tends to buy their food outside of the dining hall, it is important to find the causes for this phenomenon in order to effectively lower plate waste.

Graphical analysis showed that the number of semesters measured and plate waste per portion follow a monotonic relationship, verifying Kendall's rank correlation tau as an appropriate method for correlation analysis.

Plate waste per portion significantly increased with the number of semesters with food waste measurements. A possible explanation for the correlation is indifference and habit developing towards the food waste issue after the first couple of measurements. Children become used to the measurements and are less alerted by the measurements taking place. This theory also implies that students usually generate higher plate waste during periods without measurements. To diminish the plate waste in schools and kindergartens, students should therefore constantly be informed about and reminded of food waste as an issue even if no measurement is taking place at the time being. According to model A, about 25 g of plate waste per portion and day could be prevented if children's attention is drawn to food waste as an issue as it is during the first measurement period.

Graphical analysis showed that the variety of meal options and portion size follow a monotonic relationship with serving waste per portion, verifying that Kendall's rank correlation tau and Spearman's rank correlation rho are appropriate methods for correlation analysis. Graphical analysis also confirmed the result from Pearson's product-moment correlation r concerning the relationship between serving waste per portion and type of kitchen.

Both plate and serving waste significantly increased with bigger portion sizes, which also is confirmed by the rise in total waste per portion for bigger portion sizes. Since portion size is defined as the total amount of produced food divided by the number of portions that were actually served, portion sizes increase when a facility has few diners compared to the amount of food prepared. The portion size can therefore be seen as an indicator for food overproduction. According to the municipalities, the schools and kindergartens had no booking system to plan the food production. Instead, the food production follows the number of students registered at the school and often neglects knowledge about students that are not able to attend the meal due to illness or excursions (Personal communication: Falun, Malmö, Sala and Uppsala municipality (2017)). Due to the lack of information about the daily number of diners, the risk for food overproduction is high.

Food overproduction might reduce the staff's urge to balance the children's portion sizes and tempt children to take more food than they intend to eat, which could be an explanation for the correlation between plate waste and portion sizes.

Serving waste naturally increases in case of an overproduction. According to model B, serving waste reached its peak when portion sizes were big in a satellite unit. Satellite units in general had significantly higher serving waste than production units, which concurs to the findings of Eriksson et al. (2017). Production units, rather than satellite units, have possibilities to cool and store left-overs and have a more flexible menu where left-overs can be integrated, which explains the correlation between type of kitchen and serving waste. For satellite units, also the total waste per portion was higher compared to the total waste in production units, though the correlation strength ($r=0.18$) was similar to the correlation strength of serving waste per portion and type of kitchen ($r=0.19$), indicating that plate waste per portion is not affected by the type of kitchen.

Flexibility of the menu was also examined as a factor in the correlation analysis and was expected to decrease serving waste, due to the possibility to integrate one day's left-overs in another day's menu.

According to the correlation analysis, the variety of meal options was almost significantly correlated to serving waste per portion, the result being based on few data points (n=33, p=0.07, tau=-0.26). As the p-value tends to decrease with an increased set of data points (Field et al., 2012) and a negative correlation is likely (compare Eriksson et al., 2017), a bigger data set should be used to examine this correlation. Though it is supposable that serving waste decreases with a more flexible menu, a potential data collection should specify whether the stated number of dishes in the questionnaire is used on a daily basis or just sporadically.

Given that both serving and plate waste could be effectively reduced by preventing overproduction, especially in satellite units, schools and kindergartens would benefit from better informational grounds to estimate the daily amount of diners. Proper estimations about the portion sizes and enhanced planning are confirmed as solutions decreasing food waste in schools by Cordingley et al. (2011).

Graphical analysis showed that the percentage of men, seats per student, number of students, number of employees and number of seats in dining space follow a monotonic relationship with all three food waste categories, verifying that Kendall's rank correlation tau and Spearman's rank correlation rho are appropriate methods for correlation analysis.

Although the percentage of men employed in the kitchen significantly increased plate waste, an expanded data set is required to confirm the presence of men as a factor influencing plate waste. The factor was influenced by the number of students (tau=0.49) and comparable age (tau=0.50). Both number of students and comparable age increased the generation of plate waste and could therefore have influenced the correlation between the percentage of employed men and plate waste per portion.

Additionally, plate waste was significantly influenced by the number of students, the number of seats in dining space and the number of employees. As all three factors strongly influenced each other (tau>0.7), it is possible that only one of these three factors directly influences plate waste. The number of employees had a stronger correlation with plate waste per portion (tau=0.45) than the number of seats in dining space (tau=0.36) according to Kendall's rank correlation tau. The number of students was strongly correlated with plate waste per portion (rho=0.52) and is likely to influence the number of employees and the number of seats in dining space, since a school with many students requires a bigger dining hall and a higher number of employees in the school kitchen. Considering that Spearman's rho tends to be higher than Kendall's tau for monotonic relationships (Helsel and Hirsch, 2002) and the number of data points differs between the factors, no direct conclusion about the strength of the correlations compared to each other can be drawn.

The number of seats in dining space is the quantity most likely to affect plate waste as increased noise levels in the dining space and a stressful environment probably increase plate waste (Naturvårdsverket, 2009; Byker et al., 2014; Kinasz et al., 2015; Painter et al., 2016). Then again, the number of students was a significant factor in model A, though the contribution was rather small (0.03 g per student). A bigger data set including number of seats in dining space, number of students and number of employees should be analyzed in order to determine which one of the three factors directly influences plate waste. A different definition for the number of employees should be considered to quantify knowledge of diners and management factors as mentioned in Kinasz et al. (2015). Instead of defining the number of employees as the number of staff members in the dining facility, the accumulated number of work hours per week could be used to quantify the staff resources.

The factor seats per student was almost significantly correlated with the total waste per portion (n=35, p=0.06, tau=-0.23). As a negative correlation is expected considering that queue time increases and lunch breaks shorten with a decreased number of seats per student, both serving and plate waste are expected to decrease if the number of seats per student increases (Getlinger et al., 1996; Byker et al., 2014; Niaki et al., 2017). A bigger data set should therefore be examined regarding the number of seats per student.

Neither plate waste nor serving waste per portion was significantly influenced by the type of dinging space according to correlation analysis. Whether children eat in their classrooms or in a separate dining hall has therefore no impact on the food waste generated in schools and kindergartens.

5 CONCLUSIONS

Children's age, number of students, number of semesters measured and the interaction between seats per student and portion size together explain 72.5 % of the variation in plate waste.

Plate waste in schools and kindergartens increases with children's age and could be reduced by implementing more structured lunch breaks for schools with students in higher grades. Plate waste in schools and kindergartens also increases with the number of semesters with food waste measurements, implying that students become used to the measurements. Students should therefore constantly be reminded of food waste as an issue in order to reduce the plate waste. Both plate waste and serving waste increase with bigger portion sizes. Schools' and kindergartens' food waste in total could therefore effectively be reduced by a more accurate estimation of the daily number of diners. Serving waste is generally higher in satellite units than in production units. Since serving waste is at its highest when portion sizes are big in satellite units, especially satellite units would benefit from information to more accurately estimate the daily number of diners. Whether students eat in their classrooms or in a separate dining hall has no impact on the food waste generated in schools and kindergartens.

5.1 FUTURE RESEARCH

The majority of the variation in plate waste per portion could be explained by the developed multiple regression model A. To explain a bigger part of the variation in serving waste per portion and total waste per portion, future research should focus on quantitative factors influencing serving waste per portion. Such factors could include information about management structures, knowledge about diners, awareness about food waste as an issue and a different definition of the number of employees. Additionally, the variety of meal options should be examined with the aid of a more specific survey.

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6.1 PERSONAL COMMUNICATION

Falun minucipality: Mathilda Strand, (2017). Leg. Dietist, Serviceförvaltningen, Kostavdelningen, Falu kommun. mathilda.strand@falun.se [February 2017]

Malmö municipality: Mimmi Hägg, (2017). Koststrateg och legitimerad dietist, Service förvaltningen Skolrestauranger, Malmö stad. mimmi.hagg@malmo.se [February 2017]

Sala municipality: Lisa Eriksson, (2017). Kostekonom (vik.), Samhällsbyggnadskontoret, Sala kommun. Lisa.eriksson@sala.se [February 2017]

Uppsala municipality: Marielle Lindblom, (2017). Verksamhetssamordnare, Kommunledningskontoret, Uppsala kommun. marielle.lindblom@uppsala.se [February 2017]

7 APPENDIX

7.1 EXAMPLES OF SCHOOLS IN UPPSALA MUNICIPALITY

7.1.1 Flogstaskolan, an elementary school in the south-west of Uppsala

Flogstaskolan is, with 180 pupils from grade 0 to 3, a relatively small school compared to other facilities in Uppsala. The kitchen staff consists of a man and a woman who both seem to have a cordial relationship to the children. All children are known by name and the kitchen staff has knowledge of their food preferences. Although the school kitchen receives most of the lunch components from another school in the neighborhood (Östra Stenhagens skola), pasta, rice, potatoes and salad are prepared within the kitchen and the staff often uses this as an opportunity to add new components to the salad bar. According to the staff, these components are mostly very popular among the children. The most popular main dish is pasta and meatballs; the vegetarian option that is offered is not as liked.

The dining hall is spacious and bright and has a capacity of around 80 seats. As the children eat in groups of 40 to 50, the queues for the food are short and well-organized. The children fill their plates by themselves. In the space of time from 11 o'clock to 12 o'clock, each group has 20 minutes to eat whereof 7 minutes are "quiet minutes" during which no one may speak and the pupils have time to focus on their lunch. Many of the children return to the buffet after some minutes to refill their plates.

7.1.2 Katedralskolan, a high-school in the center of Uppsala

Katedralskolan is one of the bigger schools in Uppsala and most of the students are between 16 and 19 years old. For the moment being (January and February 2017), the school's 1000 students commute between their classrooms located in Katedralskolan's building and the dining hall, currently located in Linnéskolan's building and a 10 to 20 minutes' walk away from the classrooms. A normal lunchbreak equates to 60 minutes in most of the students cases. As the dining hall is relatively small compared to the amount of students eating there, the time for lunch can vary over a time span of four hours, starting at 10 o'clock and ending at 14 o'clock. Usually, the school kitchen is a preparing kitchen but due to the commuting situation, the kitchen receives food from Rosendalsgymnasiet at present.

The dining hall itself is crowded and messy. Tables are not being cleaned until all students have eaten and the noise level is high.
The food selection consists of two meals, including one vegetarian meal, salad, soup and bread. Both milk and water are offered as beverages. As the queues to the food selection are long, students rarely return to refill their plates.

Students opinions about the food quality differ and some students mention Domarringens skola as an example for a school kitchen that prepares extraordinarily tasty food.

7.2 FURTHER INFORMATION ABOUT THE BACKGROUND DATA COLLECTION

A questionnaire containing eleven questions was sent out to the persons responsible for public kitchen organization of Sala, Uppsala, Malmö and Falun. The municipality of Sala responded and offered to collect the answers from each kitchen unit in their municipality themselves while Uppsala, Falun and Malmö returned a list containing e-mail-addresses to each kitchen. As all municipalities confirmed that the serving system was trayless in each kitchen, the question regarding trays was removed from the questionnaire until it was sent out to the given e-mail-addresses. (Personal communication: Falun, Malmö, Sala and Uppsala municipality (2017))

The questionnaire was sent out in Swedish and looked as follows including an example for the draft of an answer:

“[...] Det bästa för mig vore att få svar per skola (exempelvis: Skola X; 4 köksanställda, varav två män; ingen utbildning om matsvinn; 200 elever; grundskola åk 1-6; osv). Även om ni bara har svar på några av frågorna är detta till stor hjälp för mig.

1. Hur mycket personal jobbar i skolköket?

2. Hur ser könsfördelningen bland personalen ut (hur många kvinnor, hur många män jobbar i vilken skolas matsal)?

3. Hur stort är avståndet från matsal till elevernas klassrum? (om möjligt)

4. Har personalen fått utbildning om matsvinn?

5. Har eleverna fått information om matsvinn? (om möjligt)

6. Finns det ett bokningssystem, dvs vet man i förväg hur många elever som kommer äta i skolmatsalen varje dag?

7. Hur många olika menyer kan eleverna välja emellan?

8. Hur många elever går på varje skola (antal ätande)?

9. Hur många platser finns det i matsalen (sittplatser)? (om möjligt)

10. Hur gamla är eleverna (åldersspann eller årskurser) och typ av skola (gymnasie, förskola, lågstadie, blandat etc)? [...]

7.3 OVERVIEW OVER SCHOOL AND KINDERGARTENS FOR WHICH FOOD WASTE MEASUREMENTS WERE AVAILABLE VIA MATOMATIC AB AT THE TIME OF THE STUDY

Table 9 Data over food waste measurements was available for the following schools and kindergartens in Falun, Malmö, Sala and Uppsala municipality; kitchens that responded to the questionnaire are marked in cursive

Sala	Uppsala	Falun	Malmö
Bellanderska	Almtunaskolan	*Bjursås*	Agnesfrid
C-huset	Almungeskolan	Främby	Anneberg
Dalhem	Bellmanskolan	*Hälsingbergs*	Apelgård
Ekeby	Bergaskolan	*Hälsinggårds*	Augustenborg
Ekorren	Björklinge skola	*Kristinegymnasiet*	Bellevue
Emmylund	Björkvallsskolan	Lugnet gymnasiet	Berga
Gärdesta	*Bolandsgymnasiet*	*Tegel/Montessori*	Blankebäck
Heden	Bälinge skola	*Västra*	Broskolan
Kila	Börje skola		Bulltofta
Kilbo	Celsiusskolan		Bäckagård
Klockarbo	Danmarksskolan		Bäckagård fsk paviljon
Kungsängen	Domarringens skola		Bäckagård paviljon
Lärkbacken	Eriksbergsskolan		Dammfri
Möklinta	Eriksskolan		*Djupadal*
Ransta	*Flogstaskolan*		Fosiedals fsk
Ransta fsk	Funbo skola		Fridhem
Salbo	Gamla Uppsala skola		Geijer
Sätrabrunn	Gottsundaskolan		Gullkragen fsk
Turbo	Gränbyskolan		Gullvik
Valla	*Gåvsta*		Hedmätaren
Varmsätra	Hågadalsskolan		Heleneholm
Västerfärnebo	Johannesbäck		Hermodsdahl
Åby	Jumkil		Holma
Åby fsk	Järlåsa		Husie
Åkra	Katedralskolan		Hyllie
Ängshagen	Knutby skola		Högaholm
Ösby	Kvangärdesskolan		Höja
	Lilla Valsätra köket		Idrottsgymnasiet
	Lundellska skolan		Internationella skolan
	Malmaskolan		Johannes
	Nannaskolan		Junibacken fsk
	Pluggparadisets restaurang		Jägersro
	Ramsta skola		Karl-Johan
	Rosendalsgymnasiet		*Karlshög*
	Skyttorp skola		Kirseberg
	Stavby skola		Klagshamn
	Stordammen		Kroksbäck
	Storvretaskolan		Kryddgård
	Sunnerstaskolan		Kulladal

Sverkerskolan	Kungshög
Treklangen	Kvisttofta fsk
Tuna skola	Lindeborg
Tunabergsskolan	Lindängen
Vaksalaskolan	Linne
Valsätraskolan	Lorensborg
Vattholmaskolan	*Malmö Borgar*
von Bahr skolan	Malmö Latin
Vängeskolan	Medie
Växthuset 3	Mellanbäcken fsk
Åkerlänna	Mellanheden/Slottstaden
Ångelsta	*Monbijou*
Årstaskolan	Mosaik
Ärentuna	Munkhätte
	Mölletofta
	Möllevången
	Norra sorgenfri
	Nydala
	Oxievång
	Pauli
	Pilbäck
	Ribersborg
	Riseberga
	Rosengård
	Rosenholm
	Roskilde fsk
	Rönnen
	Rönnen gymnasium
	Rörsjö
	Rörsjö Zenith
	Segevång
	Sofielund
	Sorgenfri
	Petri
	Stenkula
	Stockrosen fsk
	Strand
	Sundsbro
	Söderkulla
	Tingdamm
	Tornfalken fsk
	Tygelsjö
	Universitetsholmen
	Valdemarsro
	Verner ryden
	Videdal
	Västra
	Västra hamnen
	Ängslätt
	Ön

	Örtagård *Österport*

7.4 R-SCRIPT FOR THE CORRELATION ANALYSIS IN FORM OF AN IMPLEMENTED FUNCTION “CORRANALYZE”

```
corranalyze<-function(dataframe,a,b,i,j)
{
  shapa<-shapiro.test(a)
  shapb<-shapiro.test(b)
  if (shapb$p.value>0.05&shapa$p.value>0.05)
           {cat(names(dataframe[i]),"  and ",names(dataframe[j]),"\n
           Data normally distributed according to Shapiro-Wilk test.")
           cat(length(b)," samples used for
           analysis.",sum(is.na(b)),"missing values.")
           zpears<-cor.test(a,b,na.rm=TRUE)
           return(zpears)}
 else
           {cat(names(dataframe[i]),"  and ",names(dataframe[j]),"\n
           Data non-normally distributed according to Shapiro-Wilk
           test. ")
           cat(length(b)," samples used for
           analysis.",sum(is.na(b)),"missing values.")
           zspear<-cor.test(a,b,method="spearman",na.rm=TRUE)
           zkend<-cor.test(a,b,method="kendall",na.rm=TRUE)
           return(list(zkend,zspear))}
    }
```