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Comparison of two measures for assessing the volume of food waste in Swiss households

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ABSTRACT

The huge amount of food wasted at the consumer or household level has severe environmental and economic consequences. In the present work, we compared two self-report measures for the assessment of food waste quantities at the household level in Switzerland. Participants ($N = 223$) were asked to complete an online food waste questionnaire (FWQ), in which they were instructed to report the average amount of food waste produced in their households. In the second step, participants were asked to maintain a food waste diary (FWD) for 21 days. They were instructed to write down all food waste items, including their relative amounts, as well as the reason and method for their disposal. Using correlation and regression analyses, we found that the amount of food waste reported on the FWQ and in the FWD were highly correlated, revealing similar patterns in terms of their psychological predictors. In the context of the range of different methods available for the assessment of household food waste, our study has provided valuable insights into two of the most used self-report measures. Similarities between and limitations of the methods have also been discussed. This knowledge can be used to contextualise the available results, to design future studies, and ultimately, to help develop intervention strategies to reduce household food waste.

1. Introduction

Globally, approximately one-third of the food we produce for human consumption is lost or wasted somewhere along the food chain (Gustavsson et al., 2011). In industrialised countries, more than 40% of food is wasted at the retail and consumer stage, even though this area provides actionable opportunities for individuals to reduce food waste (Cicatiello, 2018; Gustavsson et al., 2011). The production of food and its manufacturing, transportation, storage, retailing, and preparation requires significant amounts of resources; therefore, food waste is not only a huge waste of precious resources but also comes with economic, environmental, and moral implications (Abeliotis et al., 2014). A better understanding of the food waste produced at the household level is needed to address this issue through the design of effective policy measures or information campaigns. However, to understand the drivers of food waste behaviour, we must first be able to quantify household food waste reliably. Several measures for the assessment of food waste quantities exist, each of which has its own set of limitations (Cicatiello, 2018).

1.1. State of the art of food waste assessment at the household level

The available data on household food waste are heterogeneous, differing not only in terms of the definitions involved but also in terms of the methodology applied (Roodhuyzen et al., 2017; Spang et al., 2019). In Switzerland, food waste has mainly been assessed using postal surveys (Delley and Brunner, 2017; V.H. Visschers, Wickli, and Siegrist, 2016). A comparison between the postal survey method and extrapolations from national waste composition analysis reports revealed a tenfold discrepancy (Delley and Brunner, 2018). Despite the challenges posed by self-report measures (for example, cognitive bias), food waste must be assessed at the household level to understand the psychological variables that influence food waste behaviours amongst individuals more fully.

Household food waste may be quantified by either participants or third parties (Langley et al., 2010). Self-report measures of food waste, in which participants assess the amount of food they waste, tend to be more time-saving and cost-efficient but less objective than measures in which third parties assess the amount of food wasted. In this work, we focused on two of the most popular self-report measures, which were

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diaries and questionnaires. In the food waste questionnaire (FWQ), participants were asked to report details of their food waste habits. With the FWQ, the type of food waste and its amount and frequency can be determined. The FWQ relies on the assumption that participants accurately remember and recall how much food they and other members of their household have wasted, as well as how frequently (Elimelech et al., 2019). This method probably ranges amongst the least cost- and time-consuming for both participants and researchers. Nevertheless, it is limited by a degree of uncertainty about the accuracy of reports made by one person about the food waste behaviours of themselves and other household members.

Using a food waste diary (FWD) helps researchers gather detailed information about the composition of food waste, the reasons for its disposal, and the means by which it is disposed (Koivupuro et al., 2012). In the FWD, participants measure the food waste they produce during a certain time period. They weigh all their food waste, report the reasons for its disposal, and describe the disposal methods they used. This method is demanding and time-consuming for participants and requires a high level of involvement. Participants may develop more conscientious behaviour as a result of reporting their food waste habits precisely, which may lead to a reduction in the amount of food wasted during the research period (Koivupuro et al., 2012).

Common practices for measuring food waste data vary widely; therefore, it is difficult to compare studies (Cicatiello, 2018; Elimelech et al., 2019). One of the few studies that has directly compared data reported in diaries and questionnaires was conducted by Giordano et al. (2019), who found that reported quantities were heavily biased, with significantly higher reported quantities in FWDs than in FWQs. However, they did not report correlations between the two measures. In their study, participants were required to select one of several pre-assigned options, which may have introduced bias into the data. We have assumed that when provided with answer options, participants provide responses that vary from those given when they are asked to estimate the amount of wastage without any point of reference provided. Van Herpen and colleagues (E. 2016) also reported higher values for diaries than for questionnaires; however, the survey measure in which participants reported their food waste in the past week was highly correlated with the food waste diary ($r = 0.71$). Still, validating food waste questionnaires by investigating their relationship with drivers of food waste is an important endeavour that requires further research.

1.2. Predictors of household food waste

Multiple factors may contribute to the production of food waste (Hebrok and Boks, 2017; Principato, 2018; Quested et al., 2013; Schanes et al., 2018; Thyberg and Tonjes, 2016). Successful food waste interventions require not only valid tools to measure the amount of food waste produced but also a fundamental understanding of the factors that influence it. In the following, we have described some of the most important factors and how they impact food waste behaviour.

1.2.1. Sociodemographic factors

In terms of socio-economic factors, various studies have reported that younger people waste more food than older people (Aschemann-Witzel et al., 2020; Principato, 2018; Thyberg and Tonjes, 2016). However, the literature is in disagreement on how sex impacts food waste behaviour. Some studies identified females as more likely to reduce food waste than males (Barr, 2007; Secondi et al., 2015; V.H. Visschers et al., 2016), whereas other studies reported the opposite (Katajajuuri et al., 2014). In terms of household composition, it has been reported that larger households tend to waste less food per capita than smaller households (Stancu et al., 2016) and that there is a tendency for households with children to waste more food than households with no children (Parizeau et al., 2015).

1.2.2. Behavioural intention and perceived behavioural control

The theory of planned behaviour (Ajzen, 1991) suggests that intention – that is, the motivation and willingness to act – determines an individual's behaviour (Ajzen, 1991). Intention is further predicted by attitudes (the favourability of a particular behaviour), subjective norms (beliefs about whether most people approve or disapprove of the particular behaviour), and perceived behavioural control (the extent to which an individual believes they are able to perform the behaviour; Graham-Rowe et al., 2015; V.H. Visschers et al., 2016). In addition to the intention to avoid food waste, perceived behavioural control was also shown to influence food waste behaviour directly, as a person may intend to perform a behaviour but may only go through with it if they are in control of their actions (Stefan et al., 2013; V.H. Visschers et al., 2016).

Previous studies have found that the theory of planned behaviour can be used to explain the amount of household food waste (Stefan et al., 2013) or to predict the likelihood that participants will reduce their household food waste after an intervention (Graham-Rowe et al., 2015). However, another study that included additional factors (that is, shopping routine and planning) in the model found that there was no significant effect of the intention to avoid wasting food on reported food waste (Stefan et al., 2013). It appears that attitudes and intention do not always translate into action, and this is called the "attitude-behaviour" gap (Schanes et al., 2018). Consequently, the theory of planned behaviour has been criticised for relying largely on rational, cognitive drivers of behaviour, underrepresenting the contribution of less cognitive drivers like habits and emotions (Bamberg, 2003).

1.2.3. Individual capabilities, skills, and routines

Basic routines, including the act of grocery shopping, can have a significant effect on food waste. Those who regularly buy too much food out of habit or who tend to buy discounted products tend to waste more food (Graham-Rowe et al., 2014; Mondéjar-Jiménez et al., 2016; Stancu et al., 2016). Therefore, an individual's capacity to measure their actual shopping needs – that is, how well they approximate what food they actually need and the extent to which they can resist impulse purchases while grocery shopping – can be an important driver of their food waste behaviour. A habit of careful meal planning can also contribute to the reduction of food waste (WRAP, 2013), as this helps people determine the right amount of food to buy as well as the likelihood of cooking too much. Finally, it has been argued that an individual's cooking skills can help them improvise in the kitchen (Evans, 2012) and, thereby, reduce the amount of food waste produced (Schanes et al., 2018).

1.2.4. Disgust and health risk

Disgust, another motivator for wasting food, has gained increasing research interest in recent years (Egolf et al., 2018). Disgust is a basic human emotion and seemingly evolved to protect organisms from contact with toxins and pathogens (Curtis et al., 2011; Rozin et al., 2008; Tybur et al., 2013). Disgust sensitivity describes a person's tendency to respond with disgust to agents that pose a high risk of contamination (for example, faeces, rotten food) and to cues indicating potential contamination (for example, items that smell bad or have a slimy texture). Measurements of domain-specific food disgust sensitivity (that is, an individual's tendency to respond with disgust to food-related disgust cues) showed a positive association with food waste behaviour (Egolf et al., 2018). In line with this, it has been shown that people who reported high levels of disgust were less willing to consume expired food items (Ammann et al., 2019). Perceived health risk is a construct that is closely related to disgust. In the food domain, perceived health risk is a measure of the degree to which individuals associate certain food items with health risks. Previous research has reported associations between risk perception and a willingness to consume expired food products (Thompson et al., 2018) as well as correlations between perceived health risk and food waste amounts (V.H. Visschers et al., 2016). On a more sensory level of perception, visual sub-optimalities of a product

might signal potential danger and can seemingly influence the perceived attractiveness and safety of a product (de Hooge et al., 2017).

1.3. Aim of the study

Given the availability of various methods for the assessment of household food waste, in the present study, we aimed to compare two such measures. We chose an online FWQ in which participants could estimate the average amount of food they wasted and an FWD in which participants were asked to weigh and record all instances of food waste for 3 weeks, which contrasted most previous studies that used a 1-week assessment period. Previous studies have shown that these measures differ in terms of the quantities of food waste they record (Giordano et al., 2019). In our study, we aimed to assess whether the two measures were correlated as well as to investigate whether the psychological predictors for both measures were the same. It is important to understand such methodological differences to be able to choose the most appropriate method for a specific research purpose. Similarly, measuring and understanding the amount of food waste produced is of crucial importance when designing effective interventions to reduce the food waste.

2. Materials and methods

2.1. Participants and procedure

We recruited a convenience sample from a panel of people who previously agreed to be contacted with invitations to complete an online survey about food waste behaviour. In the instructions, we informed participants that the person who is primarily responsible for grocery shopping and meal preparation in the household should complete the survey. In total, 308 participants completed the online survey, which included the FWQ and various scales as potential predictors for food waste (see Section 2.2). Upon completion of the online survey, participants were asked whether they wanted to continue with the study by keeping an FWD. Participants who completed both parts received a reimbursement. Most participants (81%) agreed to complete the FWD. These 250 households received a printed version of the FWD with an instruction flyer, an explanation letter, the promised reimbursement of 20 CHF (approximately 20 USD) and a reply envelope to return completed surveys. We instructed participants to start the diary as soon as possible and to record entries continually during a period of 21 days. A total of 233 diaries (93%) were returned by the deadline. We excluded two diaries, because they lacked comprehensible indications of waste quantity. Using participants' age, sex, and identification number, we matched questionnaire data with the diaries and obtained 223 successful matches. Our sample ($N = 223$) consisted of single households (32%), two-person households (40%), and households with three or more people (38%). Of all households tested, 84% contained no children younger than 18 years. Other households contained between one and four children. Participants' mean age was 41 years, and most (80%) were female. Household monthly income was categorised as low (less than 5′000 CHF), medium (5′000–9′000 CHF), or high (more than 9′000 CHF). A total of 11% of participants chose not to disclose their household income. Of the remaining participants, 42% reported a low income, 32% reported a medium income, and 26% reported a high monthly income. In terms of employment, 29% of participants indicated that they worked full time, 48% worked part time, and 61% did not work (those that did not work were, for example, students, housewives, and those who were retired).

2.2. Questionnaire and measures

We used Qualtrics (Qualtrics International Inc., United States, 2018) software to design and administer the online survey. In addition to the FWQ, it measured the following constructs: sociodemographic

Table 1
Scales and items used as predictors for the amount of food waste produced.

Scales and items		Source
Intention to avoid food waste (α = 0.90, *M* = 6.38, *SD* = 0.88)		
1	I try to waste no food at all.	(V.H. Visschers et al., 2016)
2	I always try to eat all purchased foods.	(V.H. Visschers et al., 2016)
3	I try to produce only very little food waste.	(V.H. Visschers et al., 2016)
4	I aim to use all leftovers.	(V.H. Visschers et al., 2016)
Perceived behavioural control (α = 0.77, *M* = 5.71, *SD* = 1.19)		
1	I find it difficult to prepare a new meal from leftovers. (R)	(V.H. Visschers et al., 2016)
2	I find it difficult to make sure less food is wasted in my household. (R)	*(V.H. Visschers et al., 2016)
3	I find it difficult to plan my food shopping in such a way that all the food I purchase is eaten. (R)	(V.H. Visschers et al., 2016)
4	I have the feeling that I cannot do anything about the food wasted in my household. (R)	(V.H. Visschers et al., 2016)
Cooking skills (α = 0.86, *M* = 5.79, *SD* = 1.20)		
1	I can cook complicated multicourse meals.	(Hartmann et al., 2013; van der Horst, Brunner, and Siegrist, 2011)
2	I can prepare a lot of meals even without a recipe.	(Hartmann et al., 2013; van der Horst et al., 2011)
3	I can prepare gratin potatoes.	(Hartmann et al., 2013; van der Horst et al., 2011)
4	I can prepare soup.	(Hartmann et al., 2013; van der Horst et al., 2011)
5	I can prepare a sauce.	(Hartmann et al., 2013; van der Horst et al., 2011)
6	I can bake a cake.	(Hartmann et al., 2013; van der Horst et al., 2011)
7	I can bake bread.	(Hartmann et al., 2013; van der Horst et al., 2011)
Meal planning (α = 0.69, *M* = 4.84, *SD* = 1.11)		
1	I adapt my meal plan to first use the most perishable food.	(Delley and Brunner, 2017)
2	Before I prepare food, I always consider precisely how much I need to prepare.	*(V.H. Visschers et al., 2016)
3	Before I prepare food, I always consider precisely what I will do with the leftovers.	*(V.H. Visschers et al., 2016)
4	I always plan the meals in my household ahead and I keep to this plan.	*(V.H. Visschers et al., 2016)
5	I/we often decide spontaneously to eat out. (R)	*(Grunert et al., 1993)
Shopping control (α = 0.79, *M* = 5.79, *SD* = 1.20)		
1	We often buy food in packages that are too big for our household's needs. (R)	(Stancu et al., 2016)
2	I frequently buy too much food. (R)	*(Stefan et al., 2013)
3	I frequently end up buying food that I did not intend to buy. (R)	(Stefan et al., 2013)
4	The layout of the products in supermarkets make me purchase unnecessary items. (R)	(Mondéjar-Jiménez et al., 2016)
5	Special offers in supermarkets make me buy more food than necessary. (R)	(Mondéjar-Jiménez et al., 2016)
Willingness to consume expired food (α = 0.72, *M* = 4.87, *SD* = 1.27)		
1	I eat food that has passed its expiry date by a few days.	*(Thompson et al., 2018)
2	I cook with products that have passed their expiry date by a few days.	New
3	When cooking, I check that the used ingredients have not passed their expiry dates. (R)	New
Perceived health risk (α = 0.83, *M* = 2.58, *SD* = 1.37)		
1		(V.H. Visschers et al., 2016)

(*continued on next page*)

Table 1 (*continued*)

Scales and items	Source	
	I believe that the risk of becoming ill as a result of eating food past its use-by date is high.	
2	I am not worried that eating leftovers results in health damage. (R)	(V.H. Visschers et al., 2016)
3	I think that consuming leftovers is harmless. (R)	(V.H. Visschers et al., 2016)
4	I think that one can perfectly and safely eat food products whose use-by dates expired a few days ago. (R)	(V.H. Visschers et al., 2016)
Food disgust sensitivity ($\alpha = 0.70$, $M = 3.31$, $SD = 0.88$)		
1	To put animal gristle into my mouth	(Hartmann and Siegrist, 2018)
2	To eat with dirty silverware in a restaurant	(Hartmann and Siegrist, 2018)
3	Food donated from a neighbour whom I barely know	(Hartmann and Siegrist, 2018)
4	To eat hard cheese from which mould was cut off	(Hartmann and Siegrist, 2018)
5	To eat apple slices that turned brown when exposed to air	(Hartmann and Siegrist, 2018)
6	The texture of some kinds of fish in the mouth	(Hartmann and Siegrist, 2018)
7	To eat brown-coloured avocado pulp	(Hartmann and Siegrist, 2018)
8	There is a little snail in the salad that I wanted to eat.	(Hartmann and Siegrist, 2018)

Note. All items have been translated into German. *= items have been rephrased and differ from the original, (R) = reversed items.

measures, food disgust sensitivity, willingness to consume expired food, perceived health risk, intention to avoid food waste, perceived behavioural control, cooking skills, shopping control, and meal planning.

2.2.1. Sociodemographic measures

Sociodemographic measures included participants' age and sex, the size of the household in which they lived, the number of children living in their household, and their income.

2.2.2. Behavioural intentions and perceived behavioural control

To include the theory of planned behaviour in the prediction of food waste behaviour, we used behavioural intentions and perceived behavioural control, as these factors have been shown to have a direct influence on food waste behaviour (for example, V.H. Visschers et al., 2016). To measure participants' intention to reduce their food waste behaviour, we included four items based on previous research by Visschers and colleagues (V.H. 2016). Participants rated their agreement with various statements (see Table 1) on a 7-point Likert scale, with higher values corresponding to stronger agreement. The degree of difficulty participants expected to encounter in reducing their food waste behaviour (perceived behavioural control) was assessed through four items based on previous research (V.H. Visschers et al., 2016) and rated on a 7-point Likert scale with increasing values indicating stronger agreement with the statements (see Table 1).

2.2.3. Personal capabilities, habits, and routine

Participants' cooking skills were measured with seven items (see Table 1). For each statement, participants indicated how much it applied to them on a 7-point Likert scale ranging from 1 (*do not agree at all*) to 7 (*agree very much*). To assess participants' shopping control, we used five items based on previous research (Mondéjar-Jiménez et al., 2016; Stancu et al., 2016; Stefan et al., 2013). These items, as listed in Table 1, were rated on a 7-point Likert scale assessing participants' level of agreement with the various statements. Based on previous research (Delley and Brunner, 2017; Grunert et al., 1993; V.H. Visschers et al., 2016), we put together five items to assess participants' meal planning habits (see Table 1). Items were rated on a 7-point Likert scale assessing participants' level of agreement with the various statements.

2.2.4. Disgust and health risk

We measured disgust and health risk. To assess participants' food disgust sensitivity, we used the 8-item version of the Food Disgust Scale (FDS short; Hartmann and Siegrist, 2018). The scale consists of eight products or situations that participants rate on a scale from 1 (*not disgusting at all*) to 6 (*extremely disgusting*). The scale had good reliability (see Table 1), with values comparable to those reported in previous studies conducted in Switzerland (Ammann et al., 2019). To assess participants' willingness to consume expired food, three items were used (see Table 1). Participants rated their level of agreement with various statements on a 7-point Likert scale. Perceived health risk was measured with five items from V.H. Visschers et al. (2016). These items assessed whether participants perceived certain food items as potentially dangerous or harmful (see Table 1). Participants rated each item on a 7-point Likert scale showing their level of agreement with various statements.

In addition to established questionnaires, we added an intuitive measure of participants' tolerance for food imperfection, which was a measurement instrument based on six pictures of apples (see Fig. 1) shown in a random order. Participants were asked to rate their

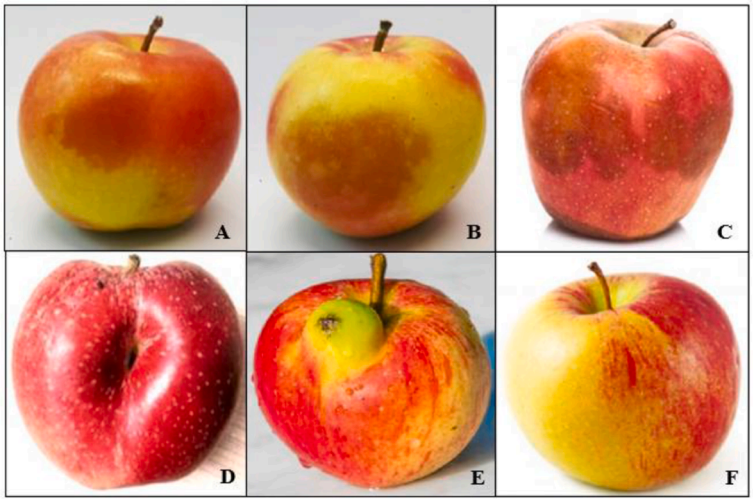

Fig. 1. Images of apples used to assess participants' tolerance for imperfection.

Table 2
Food categories and products used for self-reported food waste amounts in the food waste questionnaire.

Food category	Products
Fruits and vegetables	Fruits (fresh, frozen, from a jar or can, processed)
	Vegetables (fresh, frozen, from a jar or can, processed)
Starches and sugar	Potatoes or potato products (for example, French fries, gratin)
	Pasta and noodles
	Cereals (for example, rice, quinoa, corn, oatmeal)
	Bread/bread rolls
	Salty baked goods and snacks (for example, pretzel sticks, crisps)
	Sweet baked goods and confectionery
Plant-based protein and fat	Legumes (for example, lentils, chickpeas)
	Meat substitutes (for example, tofu, Quorn)
	Nuts/kernels/seeds
Animal-based protein and fat	Meat (for example, poultry, pork strips, beef)
	Meat products (for example, cold cuts, sausages)
	Fish and fish products
	Liquid milk/milk products (for example, cream, buttermilk)
	Solid milk products (for example, yoghurt, ice cream, butter, curd)
	Eggs
Other	Leftovers of homemade meals
	Ready-to-eat meals
	Sauces, oil, vinegar
	Non-alcoholic beverages
	Alcoholic beverages
Peels	Edible peel (for example, apple peel, broccoli stems)

willingness to consume each of the apples on a scale from 0 (*certainly not*) to 100 (*absolutely*). Pictures differed in the degree of visual perfection of the apples shown. Three of the six apples had bumps (A, B, and C), two had malformations (D and E), and one included as a control looked perfectly fine (F). Pictures A and B were taken by the authors; pictures C, E, and F were obtained from a commercial provider (*iStock.com)*; and picture D was kindly provided by Anne Norman and her research group from the SP Technical Research Institute of Sweden. The scale had good reliability ($\alpha = 0.86$, $M = 78.55$, $SD = 21.42$). Participants rated the apples only according to their visual appearance and in the absence of other sensory information, such as smell or touch, which was an important limitation.

2.2.5. Food waste questionnaire (FWQ)

In the FWQ, we asked participants to estimate the frequencies and quantities of food waste they produced on average using 23 different food products from six food categories (see Table 2). Participants reported the frequency of disposal and the average amount of waste produced for each category (see Fig. 2). The categorisation of food products was inspired by previous research (Beretta et al., 2013; V.H. Visschers et al., 2016) as well as by studies conducted by the Waste and Resources Action Program (WRAP, for instance, Quested and Johnson, 2009; Quested et al., 2011). We adapted and optimised the categories to allow for a distinction between plant- and animal-based products to account for the higher environmental impact of animal-based products compared to plant-based products (Weber and Matthews, 2008). The category *peels* described edible peels and raw organic remains. This category could also be described as possibly avoidable food waste.

2.2.6. Food waste diary (FWD)

We used an FWD as a second measure of the amount of food waste participants produced. Participants recorded the kind of food items they disposed of, the amounts they disposed of, the primary reason for their disposal, and the disposal method (see Fig. 3). For the disposal reason and disposal method, we provided participants with categories from which to choose (see Appendix). They kept the diary for a 3-week period, and they were instructed to consider only their household. Food that was discarded away from home (for example, at the workplace or at a restaurant) was considered irrelevant for the present study.

2.3. Data processing and statistical analysis

Food waste data for the FWQ and FWD were recorded in portions, pieces, or metric units. To transform the data from portions to grams, we defined a volume for one portion (= *a* handful) and multiplied it by a category-specific density. The category-specific density was defined by calculating the mean of five representative food densities of that category. To define what metric values should be attributed to a "handful," we collected estimations from 10 adults (mean age of 36 years, 50% female). This resulted in half an American cup representing a volume equivalent to a portion equalling 118 millilitres.

For the food densities of food products representative of each category, we collected information from three databases.[1] Using this method, we found five representative food products for each category and calculated their mean density to finish the weight transformation from portions to grams. Other commonly used metrics in cooking were transformed to metric units (grams) using a cookbook (Affolter et al., 2008). Food products with the weight unit *piece* and other weight units, such as bottles, packages, cans, and slices, were searched for these specific food products (Lebensmittelwerke, 1997). If they could not be found, then the Fruits and Vegetables Measurement Programme of a governmental website, Food Standards Australia New Zealand, was consulted (FSANZ, 2013). If these sources did not include the food under scrutiny, the website of the grocery store, Migros (produkte.migros.ch, assessed in March 2019), which contained product information, such as weight per piece, was used.[2] Still, there were 25 food products for which we could not find weight information. In certain cases, the weight was negligible (for example, one berry), while in other cases, the weight was assessed as a portion. If this was still not possible, we weighed a middle-sized version of the respective food product.

In the next step, categories were aggregated into the same six categories as those used in the FWQ. Products that could not be categorised were included in the category *other*. Certain diaries were kept for longer than 21 days. In these cases, only entries for the first 21 days were considered. Three diaries were kept for only 20 days. They were, nonetheless, included in the data evaluation.

Kolmogorov-Smirnov and Shapiro-Wilk tests were both significant, so the assumptions for parametric testing were not fulfilled. Therefore, Spearman's rank correlations were used to estimate associations between variables (Murray, 2013). For regression analysis, food waste data were logarithmically transformed to obtain a normal distribution of the residual values of the regression analysis. Due to many reported values being zero, however, the data still showed a non-normal distribution. Therefore, in addition to a linear regression analysis, we tested a non-parametric regression analysis method, additive nonparametric regression. These calculations were performed with R software (RStudio, 2018). As the findings of non-parametric testing were similar to the results from the linear model, only the data from the linear model have been presented in the results.

[1] Food densities were accessed from foodinfo.us, which included data from the USDA National Nutrient Database (USDA, 2015). When no satisfactory data could be found, the INFOODS database of the Food and Agricultural Organization was consulted (FAO, 2014). Alternatively, the website, Aqua-Calc, was used (AVCalcLLC, 2019).

[2] Migros is one of the main retail merchants in Switzerland that specialises in food products (Hügli, 2005).

Bitte geben Sie zu jeder Lebensmittelkategorie an, wie häufig (linke Spalte) Sie diese Art von Lebensmittel durchschnittlich wegwerfen.

Und geben Sie ebenfalls an, wie viele Portionen (rechte Spalte) Sie durchschnittlich wegwerfen.

Dabei gilt: 1 Portion = 1 Handvoll (z.B. 1 Handvoll Früchte/Gemüse, 1 Handvoll Essensreste, 1 Handvoll Fleisch, 1 Handvoll Rüstabfälle); = 2 dL Getränke/Flüssigkeiten

Falls Sie diese Art von Lebensmittel nie zuhause haben, wählen Sie in der linken Spalte "kaufe ich/wir nie" und in der rechten Spalte "nichts".

	Häufigkeit								Menge				
	6-7 Mal pro Woche	3-5 Mal pro Woche	1-2 Mal pro Woche	2-3 Mal pro Monat	etwa 1 Mal pro Monat	6-10 Mal pro Jahr	selten oder nie	kaufe ich/wir nie	mehr als 3 Portionen	2 bis 3 Portionen	1 Portion	halbe Portion	nichts
Früchte (frisch, tiefgekühlt, aus Glas oder Büchse, verarbeitet)	○	○	○	○	○	○	○	○	○	○	○	○	○
Gemüse (frisch, tiefgekühlt, aus Glas oder Büchse, verarbeitet)	○	○	○	○	○	○	○	○	○	○	○	○	○
Kartoffeln oder Kartoffel-Produkte (z.B. Pommes Frites, Gratin, Rösti, Kartoffelstock)	○	○	○	○	○	○	○	○	○	○	○	○	○
Pasta und Nudeln	○	○	○	○	○	○	○	○	○	○	○	○	○
Getreide (z.B. Reis, Quinoa, Mais, Haferflocken)	○	○	○	○	○	○	○	○	○	○	○	○	○
Brot/ Brötchen	○	○	○	○	○	○	○	○	○	○	○	○	○
Salzige Backwaren und Snacks (z.B. Salzstängeli, Chips)	○	○	○	○	○	○	○	○	○	○	○	○	○

Fig. 2. Excerpt from the food waste questionnaire listing the food categories (first column), reported frequency of disposal (middle columns), and the amount of food disposed of (columns on the right).

Tagebucheinträge

Lebensmittel	Menge	Einheit (g/dL/Port./Stk.)	Entsor-gungsart	Entsor-gungsgrund	Datum	Bemerkung
Beispiele:						
Brot	170	g	5	F	16.01.	
Käse	30	g	1	A	16.01.	geschätzt
Tomatensuppe	4	dL	2	C	16.01.	
Pastasalat	3	Port.	1	G	16.01.	
Eier	2	Stk.	2	D	16.01.	
Rüstabfälle Gurke	30	Port.	2	F	16.01.	
Wein	7	dL	3	F	17.01.	
Kuchen	60	g	1	C	17.01.	
Rindfleisch	2	Port.	4	A	17.01.	

Fig. 3. Excerpt from the food waste diary showing a list of possible entries, including the food item (first column), the amount wasted (second column), the unit used to report the amount of food waste (third column), the method for disposal (fourth column, number code relating to different methods), the reason for disposal (fifth column, letter code relating to different reasons), the date of disposal (sixth column), and additional remarks (last column).

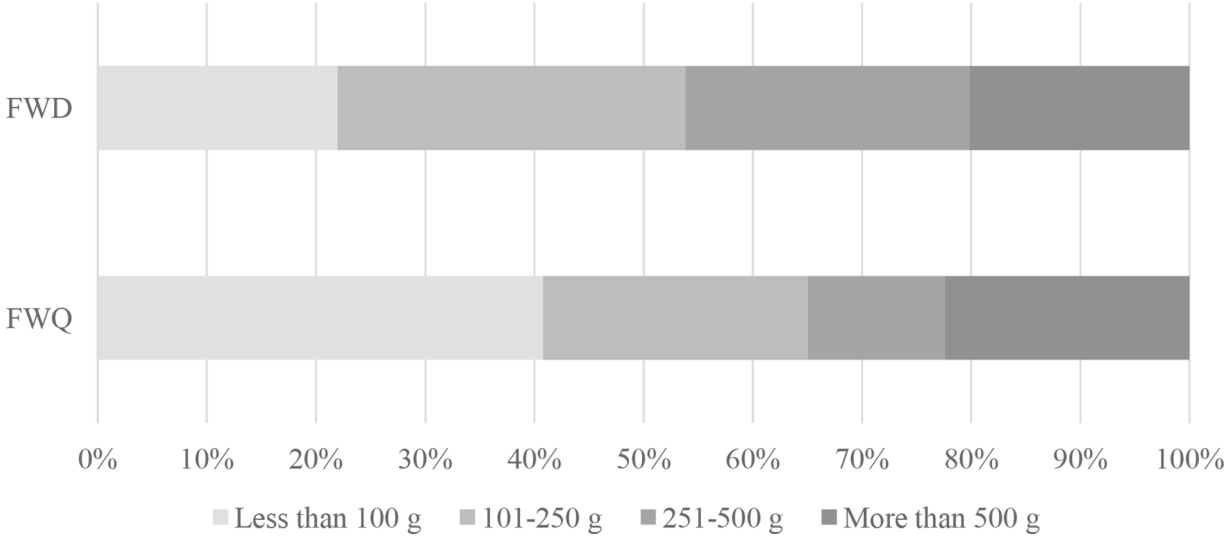

Fig. 4. Total amount of food wasted in grams per person per week for the food waste questionnaire (FWQ) and food waste diary (FWD) methods ($N = 223$).

3. Results

3.1. Descriptive statistics

On average, participants reported wasting 348 g ($SD = 397$, $Mdn = 233$) of food per person per week in the FWD and 383 g ($SD = 687$, $Mdn = 143$) of food per person per week in the FWQ. Categorising the weekly amounts of food waste per person revealed that the biggest difference between the FWD and FWQ was in the proportion of individuals reporting a very small amount of weekly food waste, that is, lower than 100 g (see Fig. 4). This proportion was clearly smaller for the FWD (22%) than the FWQ (41%).

Reported amounts of food waste per food category resulted in similar patterns for the FWQ and FWD (see Fig. 5. The largest amounts of food waste were assigned to the *fruits and vegetables* and *peels* categories in both the FWQ and the FWD. For both measures, the smallest amounts were attributed to the *plant-based protein and fat* category.

3.2. Correlation analyses

The weekly amounts of food waste reported per person in the FWQ and FWD were positively correlated ($r_{s=0}.51, p < .001$). The relationship between the two measures can also be seen in the scatterplot after logarithmically transforming the data (see Fig. 6).

Correlational patterns between socio-demographic variables and the weekly amount of food waste per person were similar between the FWD and FWQ (Table 3). The amount of food waste per person was significantly negatively correlated with household size, indicating that participants tended to waste less food with increasing household size. Similarly, the amount of food waste tended to decrease with a higher number of children living in the household and with increasing household income. Similarly, we found that the presence of children in a household was significantly negatively correlated with the amount of food waste per person both in the FWD and FWQ ($r = -0.16, p < .05$ and $r = -0.13, p < 0.05$).

Looking at the correlational patterns between habits and routines, socio-psychological variables, and the weekly amounts of food waste,

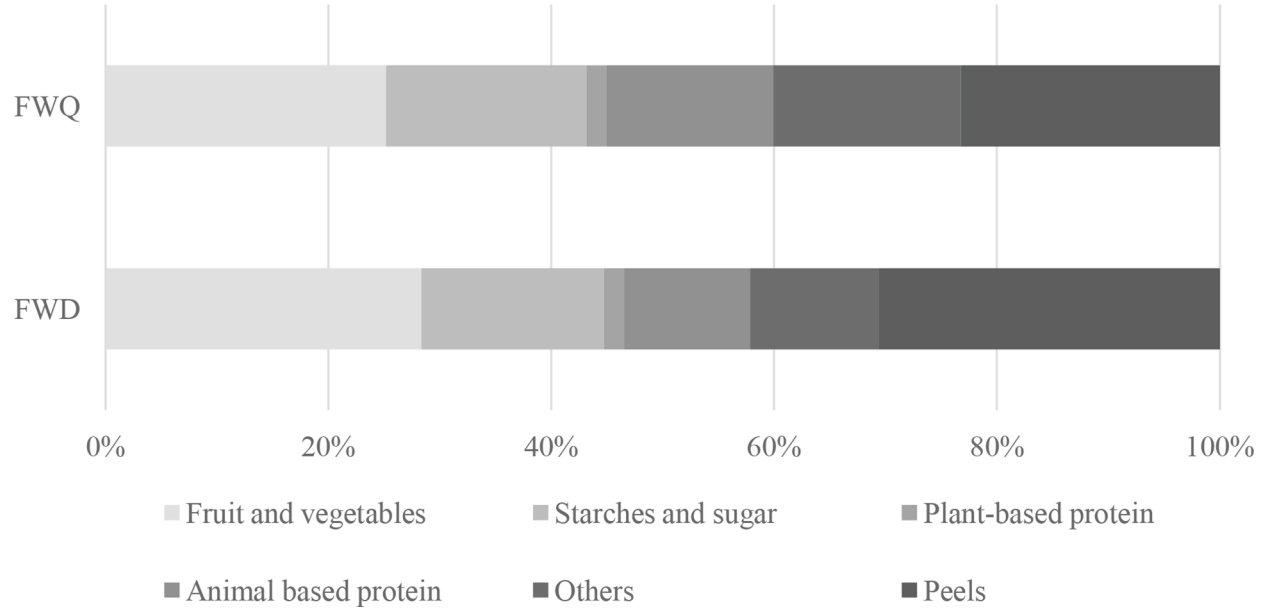

Fig. 5. Total amount of food wasted per person per week given as percentages per food category for the food waste questionnaire (FWQ) and food waste diary (FWD) methods.

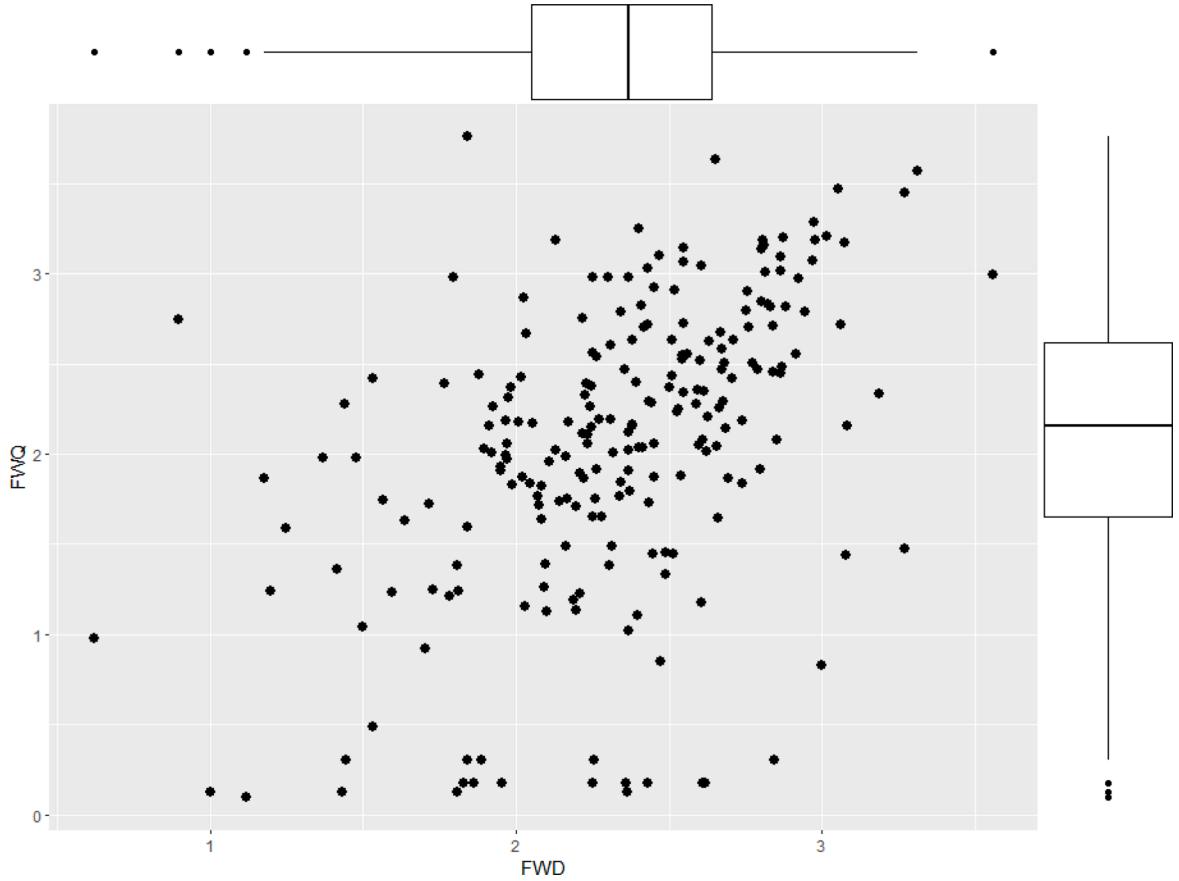

Fig. 6. Enhanced scatterplot with marginal boxplots for the log-transformed amounts of food waste in grams per person per week reported in the food waste questionnaire (FWQ) and food waste diary (FWD). The bold line dividing the box represents the median (midpoint of the data).

similar patterns were found for the FWQ and FWD (see Table 4). With increasing food disgust sensitivity or perceived health risk, participants reported higher amounts of food wasted per week. With increasing willingness to consume expired food and with increasing tolerance for imperfection, participants tended to report lower amounts of food wasted. Increasing levels of meal planning, shopping control, and cooking skills also led to lower levels of reported amounts of food waste. Finally, for the attitudinal and contextual variables – intention to avoid

Table 3
Spearman's rank correlations for the amounts of food waste reported (FWQ and FWD) and socio-demographic variables ($N = 223$).

		1	2	3	4	5	6	7
1	FWD	1.00						
2	FWQ	.51***	1.00					
3	Age	.15*	−0.10	1.00				
4	Gender	−0.05	−0.11	−0.09	1.00			
5	Household size	−0.31***	−0.28***	<0.01	.06	1.00		
6	Children	−0.15*	−0.14*	.16*	.06	.49***	1.00	
7	Income	−0.16*	−0.17*	.03	.05	.51***	.21**	1.00

Note. FWQ = amount of food waste in grams per person per week reported in the food waste questionnaire; FWD = amount of food waste in grams per person per week reported in the food waste diary.
*$p < .05$, ** $p < .01$, *** $p < .001$.

Table 4
Spearman's rank correlations of food waste amounts of the FWQ and FWD and their predictors ($N = 223$).

		1	2	3	4	5	6	7	8	9	10	11
1	FWQ	1.00										
2	FWD	.51***	1.00									
3	FDS short	.23**	.31***	1.00								
4	Tolerance for imperfection	−0.30**	−0.40**	−0.36**	1.00							
5	WTC expired food	−0.15*	−0.21**	−0.31**	.44**	1.00						
6	Perceived health risk	.23**	.37**	.38**	−0.47**	−0.54**	1.00					
7	Intention to avoid food waste	−0.22**	−0.27**	−0.33**	.43**	.34**	−0.47**	1.00				
8	Perceived behavioural control	−0.26**	−0.35**	−0.24**	.35**	.21**	−0.40**	.59**	1.00			
9	Cooking skills	−0.13*	−0.21**	−0.31**	.33**	.25**	−0.42**	.44**	.42**	1.00		
10	Shopping control	−0.16*	−0.25***	−0.17**	.17*	−0.05	−0.18**	.19**	.40***	.15*	1.00	
11	Meal planning	−0.12	−0.19**	−0.20**	.21**	.08	−0.22**	.44***	.42***	.29***	.33***	1.00

Note. FWQ = food waste questionnaire; FWD = food waste diary; FDS short = 8-item Food Disgust Scale; WTC = willingness to consume.
*$p < .05$, ** $p < .01$, *** $p < .001$.

Table 5
Hierarchical linear regression model (including B-values, standard errors, and t-values) predicting the logarithmically transformed amounts of food waste (FWQ and FWD) from various individual variables ($N = 223$).

	FWQ_{log}				FWD_{log}			
	B	SE	β	t	B	SE	β	t
(Constant)	2.96	.65		4.58***	2.94	.37		7.86***
Household size	−0.06	.05	−0.09	−1.15	−0.10	.03	−0.27	−3.30**
Age	−0.01	.04	−0.10	−1.57	.01	<.01	.21	3.31**
Number of children	−0.04	.09	−0.03	−0.41	.01	.05	.01	.10
Income	−0.03	.03	−0.08	−1.21	−0.02	.02	−0.09	−1.31
FDS short	.13	.06	.14	2.12*	.01	.04	.01	.16
Tolerance for imperfection	−0.01	<0.01	−0.23	−3.11**	−0.01	<.01	−0.24	−3.16**
WTC expired food	<−0.01	.05	.01	−0.08	<.01	.03	−0.01	−0.12
Perceived health risk	.10	.05	.17	2.16*	.03	.03	.10	1.23
Intention to avoid food waste	.02	.07	.02	.23	−0.01	.04	−0.03	−0.34
Perceived behavioural control	−0.14	.05	−0.20	−2.70**	−0.07	.03	−0.17	−2.29*
Cooking skills	.11	.05	.16	2.24*	.07	.03	.19	2.64**
Shopping control	−0.05	.04	−0.08	−1.14	−0.02	.03	−0.07	−0.99
Meal planning	−0.03	.05	−0.04	−0.53	−0.03	.03	−0.06	−0.88
Model statistics		*$R^2 = 0.31$*				*$R^2 = 0.29$*		
		*$F(13, 222) = 7.32$****				*$F(13, 222) = 6.45$****		

Note. FWQ_{log} = log-transformed weekly amount of food waste in grams per person per week reported in the questionnaire; FWD_{log} = log-transformed weekly amount of food waste in grams per person per week reported in the diary; FDS short = 8-item Food Disgust Scale; WTC = willingness to consume.
*** $p < .001$, ** $p < .01$, *$p < .05$.

food waste and perceived behavioural control – we found significant negative correlations, indicating that with increasing levels of these variables, the amount of food waste tended to decrease.

3.3. Regression analysis

We transformed the food waste data logarithmically before running the regression analysis. Next, we ran an additive non-parametric regression analysis using R software (RStudio, 2018). As the findings of the non-parametric testing were similar to the findings of the linear model, only the data of the linear model have been presented here. Tolerance for imperfection, cooking skills, and perceived behavioural control were significant predictors in both regression models, predicting the FWQ as well as the FWD (see Table 5). Age was a significant predictor for the FWD only, whereas perceived health risk reached statistical significance as a predictor only for the FWQ. The models explained 29% (FWD) and 31% (FWQ) of the variance.

4. Discussion

In this study, we compared two self-report measures of household food waste. We compared them quantitatively, assessing whether the two measures resulted in similar amounts of food waste and qualitatively, in terms of their predictors. Overall, the two measures were

significantly correlated and shared similar patterns in their predictors in correlational and regression analysis. In the following, we have discussed our findings and their implications for food waste research in more detail.

4.1. The assessment of food waste

The quantity of food waste reported was highly correlated for the FWD and FWQ. This was in line with the findings of E. van Herpen et al. (2016). Given that the quantities of food waste reported by the two methods also shared the same correlation patterns and predictors in the regression analyses, we concluded that both methods can be used when investigating the predictors of food waste behaviour.

Participants reported slightly smaller food waste quantities when using the FWQ than when using the FWD. Similar findings have been reported by previous research (Giordano et al., 2019; E. van Herpen et al., 2016). Further, we found that the differences were pronounced in the group of participants who reported wasting very little food. For the FWQ, this group of people who reported to waste very little food was clearly larger than for the FWD, which indicated that participants tended to underreport food waste amounts in the FWQ. A risk of underestimation of 20% in questionnaires has been reported (Giordano et al., 2019, 2018). This can be due to several factors. For instance, most consumers are not consciously aware of the fact that they are wasting food or how much they are wasting (Hebrok and Boks, 2017; Lyndhurst, 2007). Food waste might be regarded as unavoidable and, therefore, not considered a major concern.

Another obstacle in the comparison of food waste amounts between consumers is the great variation between households, which has been reported to range from 5 to over 100 kg per person per year (Cicatiello, 2018). This was in line with the huge standard deviations we found in our study. Similarly, substantial discrepancies were identified between the values reported in various studies. The amounts of food waste reported in our study were clearly lower than the values reported for Italian (Giordano et al., 2019, 2019) and Finnish samples (Koivupuro et al., 2012). At the same time, a diary study conducted in Finland reported amounts similar to those we found using the FWD (Silvennoinen et al., 2014). Some of the variance may be attributable to territorial differences (Secondi et al., 2015), whereas methodological differences in the assessment or definition of food waste may also be a source of variance. For instance, some studies did not include potentially avoidable food waste in their assessment of household food waste (V.H. Visschers et al., 2016).

The biggest portion of food waste reported by participants was attributed to the *fruits and vegetables* and *peels* categories. Given that produce is highly perishable and considering the similar results reported in previous research, this finding was unsurprising (Katajajuuri et al., 2014; Langley et al., 2010; WRAP, 2013). At home, such food may be stored incorrectly, and it may also be kept with the hope that it will be consumed at some point. When it spoils, it is obviously discarded. Thus, as advocated by Hebrok and Boks (2017), decisions made and actions taken long before the food is ultimately wasted may irrevocably lay the pathway straight to the bin.

4.2. Food waste predictors

Unsurprisingly, we found that food waste amount decreased with increasing household size. Most studies found the same relationship and reported that smaller households wasted more than bigger households (Parizeau et al., 2015; Williams et al., 2012; WRAP, 2013). In contrast to previous research showing that households with children wasted more than households without children (Parizeau et al., 2015; Thyberg and Tonjes, 2016), our data revealed that households with children tended to produce more food waste per capita than households in which no children were present. In our sample, 84% of the households contained no children, which may have influenced the relationship between household size and amount of food waste produced.

In terms of the potential drivers of food waste, we found that perceived behavioural control was an important predictor for both the FWQ and the FWD. This finding was in line with previous research (Stancu et al., 2016; V.H. Visschers et al., 2016), whereas participants' intention to avoid food waste was insignificant, which accorded with studies indicating the small role of this factor in food waste behaviour (for example, Graham-Rowe et al., 2015; Stefan et al., 2013) . Participants may have the intention to waste less food, but they must also carry out their intentions with actions. Perceived behavioural control can be conceptualised as a proxy for actual control and a reflection of skills and abilities (Ajzen, 1991; Manstead and van Eekelen, 1998). Thus, it seems reasonable that our data identified people's cooking skills as a relevant predictor for their food waste amount reported in the FWQ as well as the FWD. Cooking skills are essential for forming routines and habits at different levels of food handling and preparation, such as shopping routines and meal planning. Moreover, our finding provided important implications for future interventions and highlighted the importance of cooking classes during school education. Implementing cooking skills training early will likely impact a person's food-related routines and habits not only at the time of study but also later in life. Additionally, cooking classes should not only teach people how to cook certain meals but also how to deal and cook with leftovers. In this way, increasing food handling skills in the population will affect food waste behaviour directly, though it will also have an indirect effect by increasing people's perceived behavioural control (V.H. Visschers et al., 2016).

Finally, tolerance for imperfection was a significant predictor in regression models for the FWQ and FWD. Participants with higher levels of tolerance reported smaller amounts of food waste. Parizeau and colleagues (Parizeau et al., 2015) found that spoilage and dislike were amongst the most frequently mentioned reasons for the disposal of food. These findings highlighted the importance of consumers' assessment of food. Given this and our finding that people's intention to avoid food waste was an insignificant factor in determining food waste amount, interventions to reduce food waste should focus on techniques to slow down the ageing of food and minimise signs of decay rather than increasing people's intention to avoid food waste. This might be achieved by prolonging the shelf life of food along the food chain (for example, through packaging and preservation) or using campaigns to teach consumers how to store food in a way that maximises its shelf life. Such interventions may be particularly useful for decreasing food waste in the *fruits and vegetables* category, as this type of food is highly perishable, and the impact of such interventions would be great, as this was the category of food most wasted in our study.

Summing up, our data indicated that affective drivers seemed to play a more important role than cognitive drivers in predicting food waste behaviour. These affective drivers spanned from a sensory level of food assessment measured as an intolerance for imperfections to cooking skills and the perceived behavioural control of food waste. Sociodemographic variables, such as household size, were also identified as significant predictors.

4.3. Limitations and outlook

There were a few notable limitations to our studies that should be addressed. First, self-report measures are subject to bias. Elimelech et al. (2019) found that self-reported amounts of food waste were not correlated with objective measurements of food waste. The data we used, which were derived from two different methods, were, however, correlated, and we made sure to give participants no incentive to underreport their food waste amounts. We made it clear that all data would be anonymous and treated confidentially. Still, both measures we used are likely to have been affected by social desirability. Future research aiming to measure the exact amounts of food waste should also include a measure of food waste in which the amount is determined by a third party, instead of participants themselves.

Table 6
Reasons for disposal presented to participants in the FWD.

Code used	Reason for disposal
A	Expired shelf life
B	Food is spoilt
C	Cooked too much, package too large
D	Bought too much
E	Bought the wrong product
F	Appearance/taste/consistency does not please
G	Wrong storage (for example, forgot to put it in the refrigerator)
H	Mistake during preparation (for example, burnt, too much salt, or fell on the ground)
I	Other

Note. Participants were instructed to select the most fitting reason for each diary entry. Answer options were collected from different studies (Lanfranchi et al., 2016; Parizeau et al., 2015; Silvennoinen et al., 2014; Willersinn et al., 2015; Williams et al., 2012).

In a similar manner, some questionnaire items were subject to social desirability. Food waste comes with economic, environmental, and moral implications, and, therefore, participants are inclined to state that they do what they can to reduce their food waste. There clearly is a strong inclination towards an agreement with statements, such as "I try to use all leftovers." However, previous research has reported a significant negative correlation between the intention to reduce food waste and the amount of food waste produced (V.H. Visschers et al., 2016) and through the inclusion of more objective measures (for example, the FWD), we can, to a certain degree, put these effects into perspective.

When recording data in the FWQ, participants may not have remembered exactly how much food waste they produced or may have had difficulties in estimating these amounts. Furthermore, participants may have underreported their food waste due to the prevalence of a strong moral judgement against it (V.H. Visschers et al., 2016). An important limitation of the FWD method is that it is relatively demanding in terms of both time and effort for participants. This may create bias during recruitment. Additionally, participants' conscious assessment and awareness of the research may have led to a decrease in the amount of food waste produced (Koivupuro et al., 2012). Similarly, sorting kitchen waste was associated with smaller quantities of food waste (Secondi et al., 2015). Overall, an underestimation of around 40% has been reported for diary studies (Quested et al., 2011; Spang et al., 2019).

5. Conclusion

The results of our study showed that the FWQ and FWD, two self-report measures of household food waste, were highly correlated and shared the same psychological predictors. This served as an indication of the validity of the results. Furthermore, the findings indicated that the choice of method for the assessment of food waste plays a minor role when the primary interest is in the network of psychological factors that contribute to the production of food waste. Concerning the examined drivers of food waste production, our data indicated that affective drivers such as visual appearance of food measured as tolerance for imperfections, cooking skills, and perceived behaviour control were important drivers. The knowledge gained in this study is crucial for future studies that aim to examine how networks of factors are related and where intervention campaigns may be most effective.

CRediT authorship contribution statement

Jeanine Ammann: Formal analysis, Writing - original draft, Writing - review & editing. **Olivia Osterwalder:** Conceptualization, Investigation, Formal analysis, Data curation, Writing - review & editing. **Michael Siegrist:** Conceptualization, Resources, Supervision, Writing - review & editing. **Christina Hartmann:** Conceptualization, Funding acquisition, Writing - review & editing. **Aisha Egolf:** Conceptualization, Data curation, Project administration, Writing - review & editing.

Table 7
Methods of disposal presented to participants in the FWD.

Code used	Method of disposal
1	Garbage can
2	Compost
3	Sink, toilet
4	Animal feed
5	Others

Note. Methods of disposal were taken from V.H. Visschers et al. (2016), the option "through the toilet" was added.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix

(Tables 6 and 7).

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