Waste Management 35 (2015) 218–226

Contents lists available at ScienceDirect

Waste Management

journal homepage: www.elsevier.com/locate/wasman

Food waste in the Swiss food service industry – Magnitude and potential for reduction

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ARTICLE INFO

Article history:
Received 22 May 2014
Accepted 17 September 2014
Available online 8 October 2014

Keywords:
Food waste
Food losses
Food service industry
Material flow analysis (MFA)

ABSTRACT

Food losses occur across the whole food supply chain. They have negative effects on the economy and the environment, and they are not justifiable from an ethical point of view. The food service industry was identified by Beretta et al. (2013) as the third largest source of food waste based on food input at each stage of the value added chain. The total losses are estimated 18% of the food input, the avoidable losses 13.5%. However, these estimations are related with considerable uncertainty.

To get more reliable and detailed data of food losses in this sector, the waste from two companies (in the education and business sectors) was classified into four categories (storage losses, preparation losses, serving losses, and plate waste) and seven food classes and measured for a period of five days. A questionnaire evaluated customer reaction, and a material flow analysis was used to describe the mass and monetary losses within the process chain. The study found that in company A (education sector) 10.73% and in company B (business sector) 7.69% of the mass of all food delivered was wasted during the process chain. From this, 91.98% of the waste in company A and 78.14% in company B were classified as avoidable. The highest proportion of waste occurred from serving losses with starch accompaniments and vegetables being the most frequently wasted items. The quantities of waste per meal were 91.23 g (value CHF 0.74) and 85.86 g (value CHF 0.44) for company A and company B, respectively. The annual loss averaged 10.47 tonnes (value CHF 85,047) in company A and 16.55 tonnes (value CHF 85,169) in company B. The customer survey showed that 15.79% ($n = 356$) of the respondents in company A and 18.32% ($n = 382$) in company B produced plate waste. The main causes of plate waste cited were 'portion served by staff too large' and 'lack of hunger'.

Sustainable measures need to be implemented in the food service industry to reduce food waste and to improve efficiency.

1. Introduction

The wastage of food contravenes sustainable behaviour and is gaining in importance. The economic, environmental, and social consequences of food wastage are significant. For example, the average British household wastes food and drink worth £ 470 each year, including none but costs of avoidable waste (Quested et al., 2013), and retailers and consumers in the USA waste food to a value of US $ 165.6 billion annually (Buzby and Hyman, 2012). With over 840 million people currently suffering from malnutrition (FAO, 2013), food loss is unacceptable from an ethical point of view. Moreover, food loss exerts the third largest impact on the environment globally (Tukker et al., 2005) and affects valuable resources such as land, water and energy.

1.1. Previous studies

According to a study commissioned by the Food and Agriculture Organization of the United Nations (FAO), about one third of food produced worldwide is wasted, in total 1.3 billion tonnes. Food in low-income countries is mainly wasted at the beginning of the food value added chain whereas high-income countries experience major losses at the end. In Europe 280–300 kg of food per capita is wasted per year (Gustavsson et al., 2011), the losses being spread over the whole value added chain. Kranert et al. (2012) evaluated the amount of food loss in Germany along the value added chain (excluding the agricultural sector) and identified that the losses

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http://dx.doi.org/10.1016/j.wasman.2014.09.015
0956-053X/

in the food service industry are the second highest source of food wastage and comprise about 17% of the total losses. A Swiss survey showed that the food service industry was the third largest source of food wastage (18%) after households and the food industry in terms of food input at each stage of the value added chain (Beretta et al., 2013). In addition, Beretta et al. (2013) claimed that out of these 18%, more than two thirds (13.5% of the food input) was avoidable. Wong (2011) investigated a German university canteen and found that the total loss in the value added chain came to 9.65%. Furthermore, Baier and Reinhard (2007) calculated an average of 7.41 tonnes of food loss per year per food service company (in the education and business sectors) in the Swiss canton of Aargau.

Other studies have calculated food waste per meal, which constitutes a useful unit for comparison: Andrini and Bauen's (2005) figure was 50 g food waste per meal, whereas Baier and Reinhard (2007) estimated 124 g per meal. In two Swedish canteens food waste was found to vary from 46 g to 115 g per meal (Engström and Carlsson-Kanyama, 2004), and in an investigation into Jordanian students' food wastage an amount of 70 g per meal was observed (Al-Domi et al., 2011). Moreover, in a study which took place in secondary schools in the UK over a period of three weeks, pupils produced 159–191 g per meal per day of waste (Cordingley et al., 2011). The results per portion vary considerably, which may be accounted for by the different assessment methods used (see Section 3.4).

Even though a few studies have been carried out in the food service industry, there is a lack of data. The customers' perspective and economic considerations are often not considered. Furthermore, different approaches to the weighing process or material flow analysis (MFA) complicate the comparison of data from various studies.

1.2. Aim of the study

The aim of this study was to provide general information about food loss in the food service industry and to assess the level of waste, the reasons for its accumulation, its composition (by food type), and its point of origin in two food service companies in Switzerland. Reasons behind food waste were deduced, and strategies for its reduction were developed.

2. Methods

2.1. Definitions and system boundary

The eating out-of-home market can be divided into three areas of activity: commercial, non-commercial and other food service. This paper is concerned with the non-commercial food service industry, which can be split into four sectors: health, education, care and business (BTG, 2013).

To obtain detailed results, the study was limited to the part of the value added chain affected by the food service industry, namely from the delivery of goods to consumption in a canteen. The investigations took place in two companies in Switzerland, both served by the same major catering enterprise. Company A is located in the education sector (producing about 450 meals per day) and company B in the business sector (catering for employees, over 750 meals per day).

To date, there are no consistent standard definitions of *food loss* and *food waste*. Gustavsson et al. (2011) and Parfitt et al. (2010) use the term *food loss* for losses at the beginning of the value added chain and *food waste* for those appearing at the end. However, in this study the terms *food loss* and *food waste* are regarded as synonyms with both terms being used to include all the losses along the whole value added chain, from the farmer to the consumer. In contrast to Gustavsson et al. (2011), who only consider avoidable losses, food waste in this study is categorised into two groups:

(a) *unavoidable losses*, which applies to parts of food never intended for consumption such as bones, shells or banana skins, and
(b) *avoidable losses*, which applies to food that is normally meant for consumption but can no longer be consumed because of shelf-life regulations, quality requirements, hygiene rules, technical methods or consumption habits (e.g. mouldy or misshapen vegetables). A characteristic of *avoidable waste* is that food in this category was edible at a specific time in the past (e.g. products before showing signs of mould growth or half-eaten sandwiches).

During the cooking process the weight of foodstuff changes. To ensure a consistent unit, which is necessary for MFA, a distinction is made between *gross* and *net food* weight. *Gross food* is unprepared and weighs the same as when delivered, whereas *net food* has been prepared and undergone a weight change (e.g. noodles absorb water and weigh more after cooking, while a piece of meat becomes smaller and lighter after frying). For further details, see Section 2.4. Beverages and cooking oils were not included in the study. Monetary values were calculated in Swiss francs (CHF) with value added tax included, and thus represented cost, and not retail, price.

2.2. Analyses of food waste

The collection of data pertaining to food waste took place over five consecutive representative days (apart from storage losses, which were collected over a period of four weeks). Losses were divided into four categories in accordance with Engström and Carlsson-Kanyama (2004) to encourage harmonisation of data acquisition methods:

(1) storage losses (STOR) – losses through incorrect storage (also prepared food for serving at the buffet which was stored for one more day after preparation, e.g. salads);, collected when they occurred;
(2) preparation losses (PREP) – losses occurring during food preparation and cooking (mostly fruit and vegetable peel, spoiled food, or food which was dropped), collected in the morning during cooking processes;
(3) serving losses (SERV) – food remaining from the buffet and serving bowls at the counter, collected during and after lunch; and
(4) plate waste (PLATE) – residue left on consumers' plates, collected after lunch.

PREP related to unprepared gross food, SERV and PLATE to prepared net food, and STOR mainly to unprepared gross food (e.g. fruit and vegetables, and also to tins).

This classification served to illustrate at which stage losses occurred with various reasons behind each stage. The fifth category used by Engström and Carlsson-Kanyama (2004), that is, 'leftovers', was not necessary for this study as all prepared food was served and not merely left in the kitchen. (It should be noted that 'leftovers' are more common in restaurants than in canteens: in the latter, food which is not served and has not left the kitchen is stored in the fridge, freezer or storeroom and not usually discarded).

In addition to determining the place where waste occurred, it was important to ascertain what kind of waste was produced. Therefore, each category was further divided into seven food classes:

(1) meat/fish (including sausage products),
(2) starch accompaniments (e.g. noodles, potatoes, rice, bread),
(3) vegetables,
(4) fruit,
(5) desserts (e.g. sweet pastries, yoghurt, sweet dishes),
(6) others (e.g. sauce, soup, ketchup, cheese), and
(7) unavoidable losses (e.g. apple cores, banana skins, coffee dregs, egg shells, bones, lemon and orange peel).

Groups (1) to (6) belonged to the avoidable section. However, some food (e.g. paella) was difficult to classify into one of the designated food classes. Further details of how such foods or food components were allotted into the seven food classes is provided in Table 1.

The approach to gather food waste data was developed in consultation with researchers from the Institute of Sustainable Nutrition and Food Production of the University of Applied Sciences Münster where the project "Reduction of food losses and food waste in public catering – an input to improve resource efficiency" is gaining data about food waste in five different German food service companies between 2013 and 2014. This cooperation was made to proof the developed method in diverse case studies and to receive comparable data.

2.3. Analysis of customer survey

A standardized questionnaire with mostly closed ended questions was used to collect data on customers' opinions. The questionnaire was divided into three sections: the first section collected information in respect of the canteen (satisfaction, reason for visit, meal ordered, plate waste and reasons for this), the second section pertained to food waste in general (relevance for the consumer, point of view, and effects), and in the third section sociodemographic data was obtained. The survey was anonymous. In company A the survey took place over two days during lunchtime; in company B on one day. Care was taken that consumers only completed the questionnaire once. SPSS 21 was used for statistical evaluation, the significance level being set at 5%.

2.4. Material flow analysis (MFA)

The MFA demonstrated the quantitative (in kg) and monetary (cost price in CHF) losses for each process stage during the value added chain. Five categories were used to describe losses: delivered goods/stock, goods in kitchen, goods at buffet or serving counter, goods for consumption, and goods consumed. The MFA took into account all food delivered and all food used from stock during the analysis. To consider all the data using the same unit, only net food was used. For this purpose a modification of gross to net food was carried out in accordance with Bognár (2002) and recipes from each company's internal databases (see Table 2). All data in the MFA (except the first gross value) showed the net food weight.

As SERV and PLATE were already net weights, these masses were directly usable. To transform STOR and PREP into net weights, a weighted arithmetic average for each class (meat/fish, starch accompaniments, vegetables, etc.) was calculated (Eq. (1)). To calculate the value (in CHF) of the four food loss categories in the same way, a weighted arithmetic average was used for each class (Eq. (2)). Gross weight was used to calculate prices, because orders are delivered on the basis of gross weight. The average price was arrived at by multiplying the price of product i per kg [CHF/kg] by the mass of product i [kg], and then dividing by the sum of masses (based on orders delivered) of the products i [kg]. Class (7), unavoidable losses, was an exception because no food was specifically delivered for this category. After optical estimation during the weighing process, the assumption was made that company A had unavoidable losses at a ratio of 3:1 (vegetables to fruit) and company B at a ratio of 1:1. The average price and factor of unavoidable losses was calculated from the ratios above as well as from the average prices and factors of vegetables and fruit (see Table 2).

Weighted arithmetic average for factor.

$$\bar{f} = \frac{\sum_{i=1}^{n} f_i * m_i}{\sum_{i=1}^{n} m_i} \quad (1)$$

f_i = factor of product i; m_i = mass of product i [kg].

Weighted arithmetic average for price [CHF/kg].

$$\bar{p} = \frac{\sum_{i=1}^{n} p_i * m_i}{\sum_{i=1}^{n} m_i} \quad (2)$$

p_i = price of product i per kg [CHF/kg]; m_i = mass of product i [kg].

3. Results and discussion

3.1. Total food losses measured by weighing

The results given in this section are based on the weight of food waste immediately after it was collected. Thus PREP contained unprepared gross food, STORE contained mostly unprepared gross food (except canned or frozen food, for example), and SERV and PLATE included prepared net food. The data gained, especially for STOR and PREP, are not directly comparable with the results from the MFA, as the latter include a modification related to mass as described above.

Table 1
Allocation of 'difficult to classify' foods into food classes.

Food	Allocation/procedure
Mixed meal, separable (e.g. rice with vegetables)	Optical estimation of parts and partial allocation to the specific product group (in this example, vegetables and starch accompaniments)
Mixed meal, partly separable (e.g. pizza)	Separation into different groups if possible, otherwise procedure as for mixed non-separable meals
Mixed meal, non-separable (e.g. tortellini, schnitzel)	Where mass parts were equal, allocation to different groups (e.g. tortellini with spinach contain noodles and spinach – half the mass was allocated to vegetables and other half to starch accompaniments); where mass of one part is much higher than the other, allocation to the product group with the highest mass part (e.g. schnitzel to meat)
Vegetables, edible (e.g. broccoli stem, rocket stem)	Allocation to vegetables because edible, wasted due to preparation/cooking habits or preference for certain parts
Vegetables, partly or non-edible (e.g. lettuce stem, vegetable peel)	Optical estimation and allocation (e.g. separation of lettuce leaves, allocated to vegetables, and lettuce stem, allocated to unavoidable losses); allocation of vegetable peels according to regional consumption habits (e.g. potato peel is unavoidable, cucumber and carrot peel is avoidable)
Fruit, edible (e.g. apples with pressure marks or mould)	Allocation to fruit (e.g. because at one time the apples were edible and waste was therefore avoidable)
Fruit, partly or non-edible (e.g. apple stem)	Allocation to product group with highest mass portion (e.g. fruit or unavoidable loss)

Table 2
Selection of food, and related factors and prices (Bognár, 2002, modified). Average per class is a weighted arithmetic average of the specific class based on orders delivered to the respective company, A or B.

Food class	Type	Preparation	Factor	Price (CHF/kg)[a]
Meat/fish				
Fish filet	Fresh or frozen	Fried	0.80	–
Poultry escalope	Fresh or frozen	Fried	0.80	–
Pork escalope	Fresh	Fried	0.68	–
Sausages	Fresh	Fried	0.94	–
...				
Average company A	–	–	*0.86*	*15.69*
Average company B	–	–	*0.84*	*17.61*
Starch accompaniments				
Bread roll	Fresh	None	1.00	–
Noodles, without eggs	Dry	Cooked	2.10	–
Potatoes, sliced	Fresh	Fried	0.77	–
Potatoes, mashed, powder	Dry	Cooked	5.00	–
Rice, parboiled	Dry	Steamed	3.04	–
...				
Average company A	–	–	*1.14*	*7.56*
Average company B	–	–	*1.39*	*4.88*
Vegetables				
Cauliflower	Fresh	Steamed	0.95	–
Carrots	Fresh	Steamed	0.92	–
Mushrooms	Fresh	Steamed	0.82	–
Leaf lettuce	Fresh	None	1.00	–
Onions	Fresh	Steamed	0.83	–
...				
Average company A	–	–	*0.95*	*6.45*
Average company B	–	–	*0.93*	*5.26*
Fruit				
Average company A	–	–	*1.00*	*3.95*
Average company B	–	–	*1.00*	*4.15*
Desserts				
Average company A	–	–	*1.10*	*11.77*
Average company B	–	–	*1.00*	*9.39*
Other				
Cheese	Fresh	None	1.00	–
Sauce	Dry	Cooked	7.21[b]	–
Soup	Fresh or dry	Cooked	9.88[c]	–
Eggs	Fresh	Fried	0.91	–
...				
Average company A	–	–	*1.09*	*8.10*
Average company B	–	–	*3.13*	*7.67*
Unavoidable losses				
Average company A	–	–	*0.96*	*5.83*
Average company B	–	–	*0.97*	*4.71*

The italic values show a) the main group or b) the average value of the group and are therefore to get an better overview.
[a] Weighted arithmetic average of all food from orders delivered, value added tax included.
[b] Average of six powdered sauces.
[c] Assumption of 50% fresh product (with 80% vegetables) and 50% powdered soup (average of five powdered soups).

Within five days 202.066 kg of food waste was measured in company A, of which over 60% was SERV, about 25% PLATE, 10% PREP, and STOR was negligible (0.84%) (see Fig. 1). In company B, 321.634 kg of food waste was recorded over five days. The biggest percentage (38.21%) was SERV, similar to company A, closely followed by PREP (32.35%), PLATE (25.16%), and a small amount of STOR (4.29%) (see Fig. 2).

SERV made up the highest percentage of all losses and was almost completely avoidable in both companies (see Figs. 1 and 2). Other studies (Silvennoinen et al., 2012; SV Group, 2011; Wong, 2011) came to similar conclusions and found serving waste to be the greatest part of total food waste in the food service industry (sector education) and in restaurants. This implies that the bowls at the buffet and serving counter are fuller than necessary when food distribution has ended, and that large amounts of food remain at the buffet or serving counter. Quality assurance warranties stipulate that companies must dispose of leftover food once it has left the kitchen. The use of smaller serving bowls could be effective in reducing the potential amount of food waste. Towards the end of lunchtime, empty bowls should be replaced by half-full ones. The reasons for this measure should be communicated to consumers to increase their acceptance. Another solution to reduce food waste is donating leftover or surplus food to charities, which would not only have social value, but may also be useful for marketing purposes.

PLATE, at a level of approximately 25% in both companies, was mostly avoidable, whereas only a small amount (company A: 1.41%; company B: 1.44%) was unavoidable (see Figs. 1 and 2). Wong (2011) identified a similar level of plate waste (22.24%). In a Finish study the amount of plate waste was much higher (37%), but the study investigated only avoidable losses (Silvennoinen et al., 2012). This study detected plate waste as an important category, highlighting that consumers should be one of the main areas of focus in the drive to reduce food loss.

The largest proportion of unavoidable losses occurred in the process of preparation and concerned approx. two thirds of the

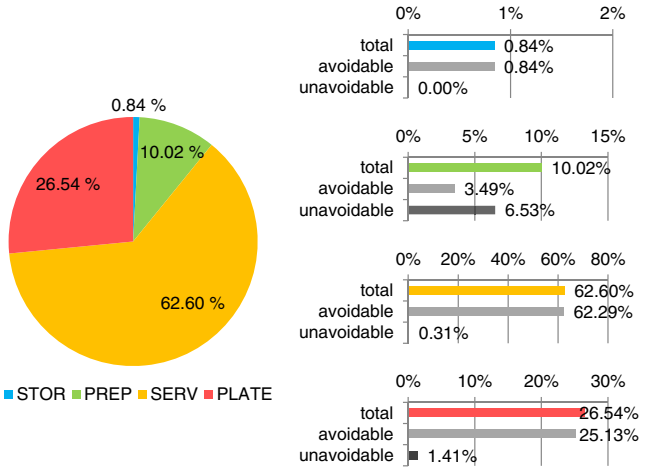

Fig. 1. Overview of food losses in company A, sorted by categories and food classes. Left: proportions of the four categories in relation to total food loss. Right: each category divided into avoidable (classes (1) to (6)) and unavoidable losses (class (7)). STOR = storage losses. PREP = preparation losses. SERV = serving losses. PLATE = plate waste.

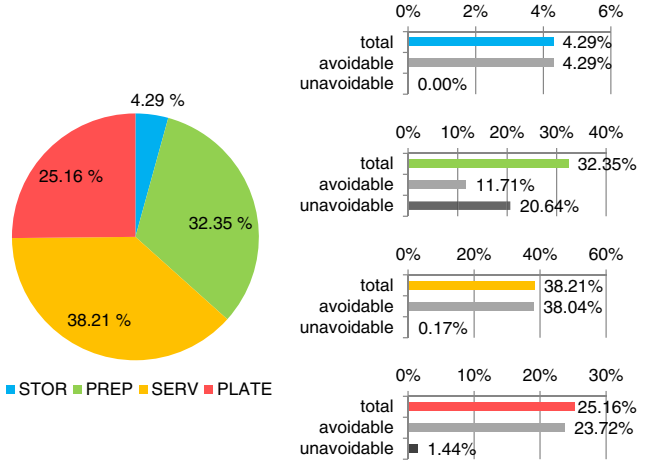

Fig. 2. Overview of food losses in company B, sorted by categories and food classes. Left: proportions of the four categories in relation to total food loss. Right: each category divided into avoidable (classes (1) to (6)) and unavoidable losses (class (7)). STOR = storage losses. PREP = preparation losses. SERV = serving losses. PLATE = plate waste.

total PREP (e.g. pineapple peel or lettuce stems). At 32.35% PREP was considerably higher in company B than in company A (10.02%), which was the result of less convenience food and more fresh products being used when compared to company A. Although a higher convenience-level leads to a decreasing amount of PREP, the waste is merely shifted to a previous stage in the value added chain (agricultural or processing industry). Consequently, the losses at the food preparation stage in the food service sector would be lower with the high convenience level, but the total food waste in the whole value added chain would be most likely the same. PREP has a low potential for food waste reduction, and only one third of PREP in company B is avoidable. Comparisons to other studies should be made carefully since unavoidable losses or preparation losses were not always investigated or preparation losses were not divided into avoidable and unavoidable losses. Wong (2011) calculated an amount of 18.55% for PREP (based on 100% losses), but did not specify avoidable and unavoidable levels. Engström and Carlsson-Kanyama (2004) identified that 3–8% of food delivered to schools and restaurants was wasted during meal preparation. This corresponds to 17–20% and 14–44% of total food wastage in schools and restaurants, respectively.

In company B STOR was slightly larger than in company A (4.29% versus 0.84%) because surplus salads were kept until the following day, and either served or disposed of after sensory quality evaluation. If the salads were discarded the day after preparation, they were classified as storage loss and not as serving loss. In total, storage losses were completely avoidable in both companies A and B, and therefore it is important that storage management is improved to avoid STOR completely. Regular controls of expiry dates and adaptation of menus to use food which is close to its expiry date are recommended. In general, it is essential to measure storage losses over a period of several weeks because of week to week variation.

A closer consideration of food classes shows that starch accompaniments (approx. 30%) and vegetables (approx. 27%) form the largest proportions of food waste (see Fig. 3). This result is confirmed by three other studies: In the Swedish education sector starch accompaniments accounted for over 50% of plate waste (Engström and Carlsson-Kanyama, 2004). Silvennoinen et al. (2012) identified potatoes, rice and pasta as the biggest components of plate waste (28%) in restaurants and Al-Domi et al. (2011) found rice the mostly wasted item. Cordingley et al. (2011) and Silvennoinen et al. (2012) derived similar values for vegetables, 20.39% and 26% respectively; confirming the result in this study of approx. 27%. However, Wong (2011) demonstrated the opposite: She found vegetables comprised the biggest part of waste, but was only able to separate half of all food waste because of time-related issues.

The highest accumulation of waste in both companies was analysed on a Friday, because store of food over the weekend is limited. A long-term analysis of meals sold would be helpful to adapt orders and cooked meals to the estimated number of customers. For this, the weekday, season and factors such as holidays or major events are important.

3.2. Customer survey

In company A 15.79% ($n = 356$) of the customers produced plate waste compared to 18.32% ($n = 382$) in company B. In each case the frequency of women producing plate waste was significantly higher ($p < 0.00$) than men (27.9% compared to 14.5%). Al-Domi et al. (2011) investigated the masses of plate waste and detected no significant differences between the amount of plate waste of women and men. An important aspect was portion size: if portion size was determined by staff rather than customers, plate waste was found significantly more often ($p < 0.00$), and 'portion served by staff too large' was the main reason for plate waste given in the questionnaire. Adapting portion sizes to the customers' requirements and preferred portion sizes is therefore recommended.

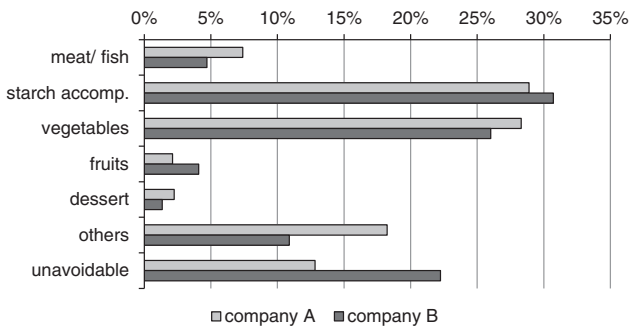

Fig. 3. Food waste sorted by class for company A and company B.

Besides portion size, 'lack of hunger' and 'ingredients I don't like' were other reasons frequently given for leftover food (see Table 3). Customers were predominantly content with meals in the canteens investigated (company A 57.1%, $n = 359$; company B 71.73%, $n = 382$). It was found that satisfied customers produced plate waste significantly less frequently ($p = 0.01$) than dissatisfied ones. This suggests that more importance should be attached to customers' requirements, which need to be analysed before any particular measures are implemented.

Plate waste was found to consist mainly of starch accompaniments (about two thirds) followed by vegetables (approx. 30%). This result is confirmed by Engström and Carlsson-Kanyama (2004) and Al-Domi et al. (2011), who also found starch accompaniments to be the largest group in plate waste. Meat and fish form the third highest class of plate waste (company A 18.18%, company B 24.64%). Considering the resources which are needed to produce meat and fish, it is a very important class and losses should be avoided. No plate waste was produced in respect of desserts and very little with fruit. The percentage of other food loss was about 9%.

The survey found positive attitudes towards the topic of food waste: 57.7% ($n = 737$) of participants considered the topic to be extremely or very important (see Fig. 4). Over 80% ($n = 741$) of the sample were aware of food waste prevention and were of the opinion that food waste is problematic (mainly for social and ecological reasons, and less for economic reasons). A survey carried out in Germany came to a similar result: 60% of persons interviewed were aware of the negative aspects of food waste for the environment, and 91% believed that an increase in awareness could reduce food waste significantly (Cofresco, 2011). In our study women claimed to avoid food waste significantly more often than men ($p < 0.00$). The food retail sector was considered to the main source of waste (company A 58.05%, company B 54.10%), followed by households and the food service industry. However, several studies have shown households to be the major cause of food waste (e.g. Gustavsson et al., 2011; Kranert et al., 2012; Beretta et al., 2013).

3.3. Losses in the food value added chain determined by material flow analysis (MFA)

In this section all quantities (unless denoted otherwise) are net weights, that is, any weight change during the cooking process has been taken into account (see Section 2.4). The results are not directly comparable with food losses arrived at by weighing (see Section 3.1).

Over the supply chain from delivery to consumption, 10.73% of all food was wasted in company A. Over five days there was a loss of 201.35 kg with a value of CHF 1,635.52 (see Fig. 5a). In total, the company processed 1,875.949 kg of food and, taking into account that 89.27% of it was actually consumed, STOR and PREP were small. The main category of waste was SERV, at 6.74% of all food delivered and an amount of CHF 1,027.02. Company B lost 7.69% over the value added chain (see Fig. 5b), which suggests 318.21 kg and CHF 1,637.86 CHF per week, the losses being shared consistently over PREP, SERV and PLATE. At 0.33% STOR was quite small. The percentages calculated for losses in the food service supply chain were much lower than most values found in previous studies, the only exception being a study of a German canteen, which found a similar amount of 9.65% food waste (Wong, 2011). The total loss in the food service industry in Switzerland is published as 18% (Beretta et al., 2013), in Sweden as 15–18% (Engström and Carlsson-Kanyama, 2004), and in Finland as 21–24% (Silvennoinen et al., 2012). Differences in elicitation of data, the assessment method, and the sector in the food service industry examined complicate a direct comparison of values, for which the development of consistent definitions and methods would be desirable. Additionally, as our study focussed only on two companies, the results are not representative but instead give a detailed insight into the sector.

Assuming that company A is open five days a week and 52 weeks a year, food waste of 10.47 tonnes (cost price CHF 85,047) would result. Under the same conditions, company B would have a loss of 16.55 tonnes of food (CHF 85,169 CHF) annually (please note Chapter 3.6 for monetary losses). These considerable amounts, which exclude the cost of food waste disposal and energy in terms of staff, electricity and water, illustrate the need for action.

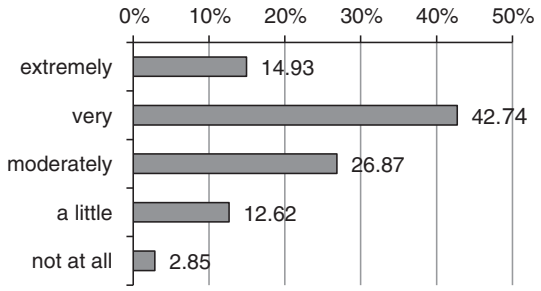

Fig. 4. Relevance of the topic of food waste to customers (n = 737). Results of company A and company B are combined.

Table 3
Reasons for plate waste – evaluation of the questionnaires.

Reason	Company A ($n = 57$) (%)	Company B ($n = 69$) (%)
Portion served by staff too large	42.11	43.48
Lack of hunger	22.81	23.19
Ingredients I do not like	22.81	11.59
Dish not liked	15.79	23.29
Too little/too much seasoning	17.54	13.04
Too fatty	12.28	7.25
Texture too soft/too hard	8.77	13.04
Served myself too much food	7.02	8.70
Other reasons	5.26	17.39
Malaise	1.75	5.80
Distraction	1.75	4.35
Time pressure	0.00	4.35
Stress	1.75	2.90

3.4. Further reflections

With consistent methods the variable 'food waste in g per meal' is a rational basis for comparison of food waste in companies, countries and research studies as well as to validate food waste measures already implemented. To calculate these variables in our study, the losses in all four categories (STOR, PREP, SERV and PLATE) were taken into account, in proportion to the meals sold (main dishes from serving counter or buffet, no side dishes). These values could serve as an indicator of efficient processes as regards food waste in a company, and ways of implementing different measures and their effectiveness could be established. Lower values would indicate highly efficient processes which avoided food waste. Because of transfer of waste to previous stages in a supply chain, the amount of convenience food used should be considered carefully. In this study company A's food loss amounted to 91.23 g (value CHF 0.74) per meal in contrast to company B, where the total food loss was 85.86 g (0.44 CHF) per meal. Out of this in company A 83.92 g and in company B 67.09 g would be avoidable per meal. With an assumption of approx. 450 g per meal, these figures suggest that about one fifth of a complete meal is thrown away. Moreover, in company A the food wasted was more expensive food

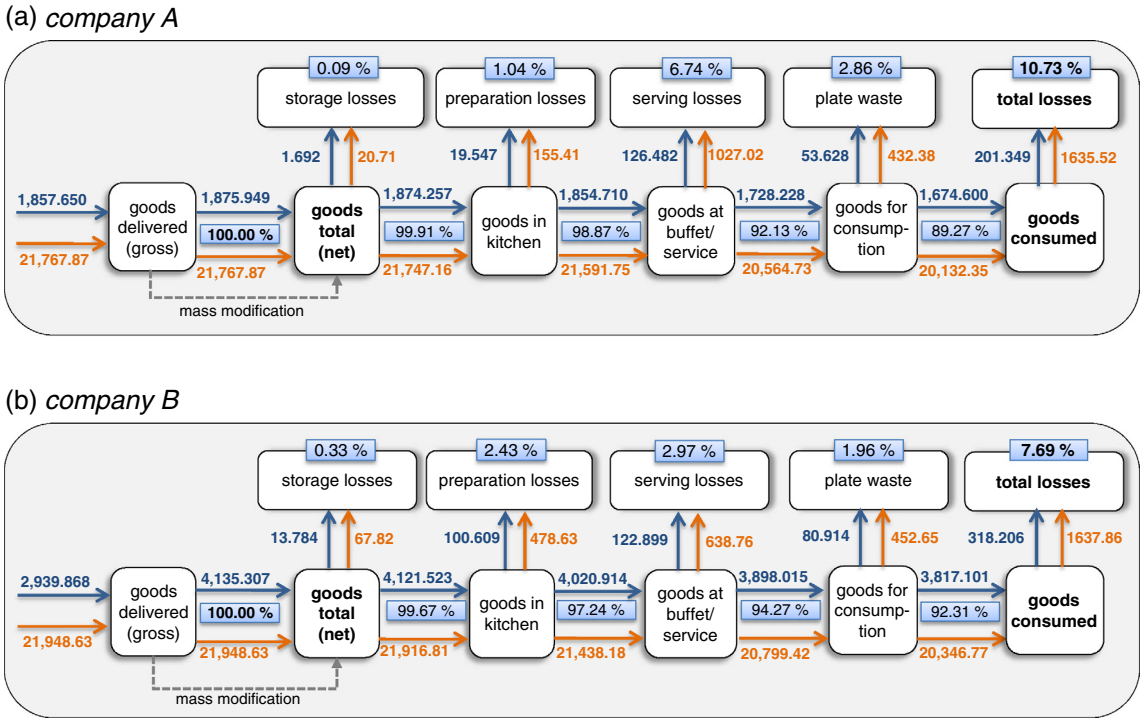

Fig. 5. Simplified material flow analysis (MFA) of FSC in a food service company. Upper box (a) shows result of company A, lower box (b) of company B. All blue values are quantities in kg, all orange values are cost prices (including value added tax) in CHF. Loss refers to total loss including avoidable and unavoidable losses. The term 'gross' is used for unprepared food; all others without denotation are net weights.

than in company B, which was due to the higher level of unavoidable losses in company B. However, values given in the literature are quite different, depending on the efficiency of the processes investigated. In Sweden, the UK and Jordan values range from 46 g to 191 g per meal (Engström and Carlsson-Kanyama, 2004; Al-Domi et al., 2011; Cordingley et al., 2011).

To date, reference of the financial impact of food waste has rarely been made in the literature. Engström and Carlsson-Kanyama (2004) calculated the loss of sales by dividing the quantity of avoidable food waste by the mass of one meal, and multiplying the result by the average retail price of the meal. In the four companies investigated, they calculated potential revenue of € 1800 for meals sold each day. Using their calculation, company A lost approx. CHF 580 daily (84 portions) and company B approx. CHF 1830 daily (113 portions). Eriksson (2012) detected economic benefit through reduction of food losses in value added chains in Sweden. In the sector of restaurants and catering, each kg was associated with a marginal benefit of € 1.30. Because of differences in living expenses and food prices, establishing a marginal benefit for each country would be useful. A large catering company in Switzerland might assume CHF 20 for 1 kg of food and a potential turnover of CHF 1.44 million in 2011 (SV Group, 2011). In this case company A would report a loss of CHF 193,000 and company B of 259,000 CHF annually.

To sum up, food losses are avoidable to a great extent (see Table 4). With over 90% avoidance, company A could save CHF 1,518.40 and 185.212 kg of food weekly (please note Chapter 3.6). In company B the values were lower because of fewer convenience products being used and more preparation of fresh food, but nevertheless about 80% of food waste could be avoided (248.648 kg of food and CHF 1,314.34 per week). Other studies have calculated similar levels of food waste avoidance, 86.38% (Wong, 2011) being in the middle of the results determined. The findings of Beretta et al. (2013) and Cordingley et al. (2011), at 75% and 77% respectively, are comparable with our results for company B.

Table 4
Avoidance and unavoidability of losses (by net weight).

Value	Avoidable	Unavoidable
Company A		
Mass value	91.98% (83.92 g/meal)	8.02% (7.31 g/meal)
Monetary value	92.84% (0.69 CHF/meal)	7.16% (0.05 CHF/meal)
Company B		
Mass value	78.14% (67.09 g/meal)	21.86% (18.77 g/meal)
Monetary value	80.25% (0.35 CHF/meal)	19.75% (0.09 CHF/meal)

3.5. Strategies for food waste reduction

An activity analysis and interviews with the chefs and staff revealed a potential for reduction of food waste in the companies investigated, and a few measures to reduce waste have already been implemented. An overview of all the measures recommended is given in Table 5. A major area relates to the staff: it is important to increase their awareness of the issue, e.g. by rewarding staff taking effective measures to achieve food waste reduction. In addition, the food service company needs to be more mindful of their waste, in particular the amounts involved and points of origin. Training is recommended to clarify problems and highlight potential for avoiding food waste. Furthermore, the cost of food waste disposal needs to be taken into account. After avoidance and reduction strategies have been employed, reuse and recycling are recommended. Energy production and food dumping should only be used as a last resort.

A number of opportunities for food waste reduction are described in the literature. Creedon et al. (2010) published guidelines to reduce losses in the catering sector, which give many useful tips for canteens. An association called United Against Waste e.V. was founded in Germany in 2012 and currently has more than 40 members from the food service industry. Its aim is to promote

Table 5
Measures for food waste reduction.

Storage/purchase
- Optimisation of storage management e.g. application of first-in-first-out principle and periodic control of date of expiry
- Direct use of food near date of expiry (flexible meal planning)
- Long-term analysis of meals sold in order to adapt food orders (with regard to weekday, season, and external factors such as holidays or major events)
- Enhancement of order interval and no stock buying

Preparation/cooking
- Development of strategies against overproduction (e.g. freezing)
- Reuse of leftovers (under consideration of legislation applicable)
- Control of preparation losses and training of employees
- Fast cooling down of food to avoid growth of microorganisms

Serving at counter/buffet
- No meals for presentation purposes only (use of photographs)
- Use of small serving bowls at the buffet (filling as needed)
- No complete filling of bowls towards the end of lunchtime
- Adaption of portion sizes to customer needs (supply of half portions and second helpings)
- Attractive presentation of meals

Consumers
- Sensitisation of customers to the field of food waste and the causes of food waste (e.g. using posters)
- Increasing tolerance of customers towards sustainability measures through communication
- Survey of reasons for plate waste using feedback sheets (and subsequent implementation of appropriate actions)
- Possible donation of food to local charities

awareness and develop solutions to minimise food losses by gathering data from their member companies. A service package with a tool and checklist helps detect starting points (United Against Waste e.V., n.y.).

Certification could be useful for marketing purposes. "The European Waste Reduction Award" is conferred for the best actions taken against food waste (EWWR, 2012). In addition, "Green Your Restaurant" (Green Restaurant Association, n.y.) and the "Green Seal Standard" (Green Seal, n.y.) provide certification for sustainable food service companies.

3.6. Limitations of the study

The complexity of an MFA excludes resource requirements such as cost of staff, transport, electricity and water. Our MFA only gives an overview of food waste and monetary losses (based on cost prices to show the loss for the company). It should be considered that the monetary losses were calculated based on cost prices. Income from meals sold was not evaluated. Hence, the actual monetary loss for each food service company would actually be lower than that calculated because the plate waste has already been paid by the customers.

Taken into account that it is not possible to avoid food waste completely, the calculated value of avoidance is a theoretical value. Food wastage should be avoided as far as possible, but it is not realistic to have no waste after food distribution in the buffet or serving bowls. Consequently it is important to examine to which extent losses are avoidable.

Furthermore, due to the amount of time required, recent studies (including this study) have often only investigated a few companies, so care should be taken in generalising about a specific sector. Valid definitions in the context of food waste and methods of measurement would be helpful to facilitate comparison of study results.

4. Conclusions

In companies A and B 10.73% and 7.69% respectively of total food delivered was lost over the value added chain. With 10.47–16.55 tonnes of annual food waste, a food service company has huge financial losses. In company A losses of CHF 78,957 and in company B of CHF 68,346 are potentially avoidable each year.

This study considered food waste in a small field, the food service sector. To illustrate the entire effects of food losses on the environment, society and the economy, all stages of the value added chain (including agricultural stage, processing industry, retail and consumers) should be considered. Food which is wasted in the later stages of the value added chain has a greater negative effect than food which is wasted in the agricultural stage, because additional resources (e.g. staff, transport and packaging) have been employed to prepare the food stuff for consumption. This is one main reason why the reduction of food waste at the end of the value added chain (including the food service industry) is of major importance.

The data collected for this research provides important knowledge about the composition and points of origin of food waste in the food service sector. The measures proposed are useful for the reduction of food loss. Serving losses, which are the main group of losses and almost completely avoidable, could be minimised by adapting portion size and using smaller serving bowls. The customer survey showed that the importance of this topic is known. Long-term implementation, control and evaluation of reduction measures are recommended. Furthermore, it is important to increase the awareness of staff as well as to sensitise customers to the issue of food waste avoidance in order to increase their tolerance towards measures taken.

To reach the goal of the European Parliament and halve food loss by 2025 (Gustavsson et al., 2011), more research at all stages of the food supply chain is required to understand the reasons for food losses, to determine their quantities, and to deduce solutions and implement them effectively in companies.

Acknowledgements

This article is based on Alexandra Betz's Master's Thesis entitled "Food losses in the food service industry – an investigation in selected Swiss organizations", which was written under the supervision of Dr. Claudia Müller of the Zurich University of Applied Sciences, Switzerland with Prof. Dr.-Ing. Elmar Schlich of the Justus Liebig University Giessen, Germany as the Thesis Advisor.

The authors would like to thank the Swiss catering company involved in this study for their assistance and for providing all the information that was necessary to conduct this research project.

Furthermore, the authors would like to acknowledge Stella Cook for her constructive comments regarding the scientific content of the text.

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