The opportunity of tracking food waste in school canteens: guidelines for Self-Assessment

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Abstract

Reducing food waste is one of the key challenges of the food system and addressing it in the institutional catering industry can be a quick win. In particular, school canteens are a significant source of food waste and therefore embody a great opportunity to address food waste. The goal of our research is the development of guidelines for audit and self-assessment in measuring and managing food waste produced at school canteens. The purpose of the tool is to standardise food waste audits to be executed either by scholars, school staff or by catering companies with the objective of measuring and reducing food waste at schools. We performed a research among public and private schools and catering companies from which we obtained the key performance indicators to be measured and then pilot-tested the resulting tool in four schools with over 2,900 pupil participants, measuring plate waste from over 10,000 trays. This tool will help managers in their efforts towards more sustainable organisations at the same time as the standardisation of food waste audits will provide researchers with comparable data. The study suggests that although there is low awareness on the amount of food wasted at school canteens, managers and staff are highly interested in the topic and would be willing to implement audits and reduction measures. The case study also showed that our tool is easy to implement and not disruptive.

Keywords

Food waste; School Catering; Self-assessment Tool; Sustainability Metrics; Food Waste Audit, Awareness building, Food waste prevention.

1. Introduction

The global food system still has to solve deep problems in order to be truly sustainable. One of the key sustainability challenges brought up by researchers (e.g. Clarke et al., 2015; Finn, 2014; Garrone et al., 2014) in the last few years is waste. In particular, reducing food waste (FW) would aid in the path towards a more sustainable global food system as it would imply a more efficient (and ethical) use of scarce natural resources at the same time as helping reduce its significant environmental footprint (Buzby and Guthrie, 2002). This is particularly challenging in developed countries, as food waste is very closely related to individual behaviour and cultural attitudes towards food (Godfray et al., 2010).

Business managers are at present considered the major actors trying to implement sustainable development, opposed to some years ago, when focus was put on local authorities (Dyllick et al., 2002). In fact, many companies and institutions, particularly schools (Rickinson et al., 2016), have initiated a full set of sustainable development initiatives to address the demands of public and private stakeholders. With regard to food waste, progress has been slow, mostly due to lack of awareness (Finn, 2014). Hence, increasing visibility and awareness on food waste through audits is an obvious place to start. Once food waste has come to light, people will probably be willing to act against it, managers will probably become more concerned about its financial impact and kitchen staff about its social implications (Goonan et al., 2014). In any case, food waste auditing should be the starting point of a food waste awareness campaign.

As schools are a natural place for education, and making the most of the near universal attendance of school by children and the fact that they are on the premises for many hours a day (Dehghan et al., 2005), addressing food waste at school canteens becomes noteworthy. However, regulators, school managers, and catering companies very rarely concentrate on reducing food waste. Instead, they usually focus on analysing how effective nutritional programmes are (Wilkie, 2015). For this reason, most researchers have limited their studies on food waste at schools to the analysis of plate waste (PW), concerned with the nutritional value of effective dietary intake. Our research has a broader purpose, offering a more holistic approach on school food waste. Indeed, standard criteria for measuring school catering food waste is novel in the literature, particularly as we propose to include both pre-consumer and post-consumer waste in our assessment tool, while most researchers in this area have focused their work on analysing plate waste (e.g. Adams et al., 2005; Byker et al., 2014; Cohen et al., 2013; Marlette et al., 2005; Rodriguez Tadeo et al., 2014). Moreover, through a standardised tool, researchers will be able to compare results and data from different studies. The goal of this research is to provide schools and educators as well as catering companies with a set of principles and tools that unveil and quantify food waste at school canteens and therefore facilitate the implementation of reduction measures and result tracking. With this purpose, we first analyse the nature and types of food wasted at schools as well as cafeteria managers´ attitudes toward food waste and end with the development of a self-assessment waste tool. This research has a very precise managerial implication. As a final outcome, a simple and easy to implement auditing tool has been developed. Through it, we aim to help managers and pupils in their efforts to increase the sustainability of the food system. The study is particularly relevant for schools with in-house kitchens, no matter if the service is outsourced - managed by a catering company - or not. Nevertheless, the tool could be applied to other business models too, with little modification. The scope of this research includes school canteens in both public and private schools. To achieve the goals of this research, we collected primary data from public and private schools in Spain.

2. Literature Review

2.1. The opportunity of addressing Food Waste in Institutional Feeding Systems.

Food waste can be defined as all the products that are discarded from the food chain while still preserving their nutritional value and complying with safety standards (Falasconi et al., 2015). Estimates on the amount of food wasted globally are striking: FAO estimates that up to one third of global food produce is wasted, a fact that places food waste as one of the top challenges for global sustainability (FAO, 2011). In Europe, despite acknowledging that food waste is a data-poor area across the main sectors in which it arises, the European Commission has quantified current average annual food waste at 200 kilos per capita, stating that this figure will increase significantly in the next years if no action is taken. They therefore recommend member estates to act, setting the objective of halving EU disposal of edible food by 2020 (European Union Committee, 2014).

On the other hand, researchers mention that a big impact may be achieved when addressing food waste at places where there are many individuals dining at the same place (Mirosa et al., 2016).This is especially true in the institutional catering industry (schools, hospitals and prisons) where, as underlined by Mirosa et al. (2016), many individuals dine similarly, and therefore both efficiency along the supply chain and plate waste can be addressed. Moreover, Goonan et al. (2014) state that food service institutions are big

producers of food waste, mostly during service, but also as a result of overproduction. In particular, researchers state that school canteens embody a significant source of food waste (Adams et al., 2005; Smith and Cunningham-Sabo, 2014) and represent an ideal opportunity for minimising food waste foot print (Wilkie, 2015). Food waste was found by Wilkie (2015) to be the predominant component in a school canteen waste audit in three schools in Florida (US): between 58% and 69% of total waste weight was food, far more than paper, plastic & glass wastage. The mean daily food waste per pupil was averaged between 60.1 and 95.33 g. in schools with an in-house kitchen in this research. Therefore we can state that the institutional catering industry represents an ideal opportunity to divert food waste from landfills thanks to their concentrated food waste stream due to the fact that they serve a high number of meals at a single location, resulting in food waste collected at only one location too (Wilkie, 2015). As a consequence, the institutional catering industry becomes crucial in the fight against food waste (Mirosa et al., 2016).

Food waste at school canteens could be reduced through educating pupils and staff in order to change behaviours that cause food waste (Wilkie, 2015). Youths concerned about food waste were found, by Principato et al.(2015), to be more likely to reduce leftovers. Furthermore, we can assume that these improved behaviours and habits will prevail into their adulthood (Guthrie and Buzby, 2002). Mirosa et al. (2016, p.12) found one of the key reasons for consumers not to waste food was a cultural tradition: “those who had grown up with the belief that they need to clean their plates” produced less plate waste. These more sustainable habits could be passed on further and have an effect on the amount of waste produced by future generations (Mirosa et al., 2016). There is evidence in the literature on the effectiveness of waste reduction initiatives. For instance, Ensgtröm (2004) carried out research aiming to measure the impact of a food waste reduction campaign in a school in Sweden resulting in a 35% reduction in plate waste compared to a baseline score. It is also acknowledged by researchers that people with a high knowledge of issues related to food waste are more likely to avoid waste (Principato et al., 2015).

Reducing Food Waste has obvious environmental and ethical benefits at the same time that it also has relevant economic implications as its associated costs are not only related to procurement of food ingredients, but also to disposal costs (Papargyropoulou et al., 2014). Moreover, both schools and families could save some money by reducing food waste: pupils who eat more at school are less likely to spend money on substitutive products outside the canteen (Cohen et al., 2013).

2.2. Food Waste Auditing and Reporting

Good sustainability performance is linked to a full and honest commitment of management to sustainability and to the adoption of incentives, something that should be done by setting appropriate goals, monitoring and evaluating progress (Székely and Knirsch, 2005). As stated by Gerbens (2003), measuring tools offering light on the sustainability performance of a firm turns out to be the very first move towards sustainability. More precisely, food waste inventories are claimed to be critical for the development of effective reduction initiatives and monitoring progress overtime (Hanson et al., 2016) . Conducting a waste audit in both the preparation and the display areas (kitchen and service line) as well as in the pupils’ canteen is the first step towards reducing food waste produced at schools (Bradley, 2011).

2.2.1. Framework

The World Resources Institute (Hanson et al., 2016) together with partners such as WRAP, UNEP and FUSIONS have developed a Global Food Loss and Waste Accounting and Reporting Standard aiming to provide guidance for governments and organisations to carry out inventories on food loss and waste. We have used this standard as a framework for waste auditing analysis.

As stated by the WRI, a Food Loss and Waste inventory must be based on the five principles of relevance, completeness, consistency, transparency, and accuracy (C. Hanson, B. Lipinski, K. Robertson, D. Dias, I Gavilan and J. Fonseca, 2016, p. 29). Relevance because it should contain the necessary information for the intended user to make decisions and because the quantification method should be selected based on the specific goals to achieve. Completeness because no relevant data or component should be excluded from the inventory, unless justified. WRI researchers go further adding that auditing methods should be consistent, allowing comparable measurements along-time in order to permit the identification of trends and the assessment on the performance of the audited institution. Transparency is gained by clearly reporting the quantification method. Finally, they acknowledge a trade-off between accuracy and completeness and cost and suggest choosing the optimal method based on the needs and resources of the institutions.

Regardless of the objective and scope of the audit, entities should report on the following four elements (C. Hanson, B. Lipinski, K. Robertson, D. Dias, I Gavilan and J. Fonseca, 2016) (World Resources Institute, 2016):

1. Time frame. Exact start and end date of the audit should be recorded. It is recommended to take seasonal variations into account when planning waste audits.
2. Boundary (organisation, geography, etc.) and particularities of the sample.
3. Scope (types of waste included). Records must include the type of food waste, the reason that caused it (e.g. overproduction, spoilage, trim waste…) as well as the estimate of loss (by weight or portions).
4. Waste destination (where waste goes after being discarded) must be accounted and reported because there are a wide range of possible destinations for food waste with very different associated environmental impacts.

The WRI Food Loss and Waste standard (World Resources Institute, 2016) establishes that methods, estimates and possible bias must be clearly documented and disclosed in a neutral manner. The auditing system should also register who recorded the data. Moreover, Bradley (2011) strongly recommends that the results of the audit are shared and discussed with the kitchen team and suggests that it could also be a great learning opportunity for pupils.

Due to their interest and particularities, in this section we shall further develop both the scope of the audit and waste destination.

2.2.2 Audit Scope and Categorisation

The scope of the audit must be clarified before beginning to measure food waste. Papargyropoulou et al. (2014) mention the relevance of distinguishing between avoidable and unavoidable food waste as a key factor in a food waste prevention strategy. Wrap's definition of avoidable food waste includes food discarded because it is unwanted or has been allowed to pass its best (Ventour, 2008), therefore avoidable food waste had previously been edible, although it might or might not be edible at the time of disposal. Papargyropoulou et al. (2014) explains that avoidable food waste includes foods or parts of food, usually considered edible, while unavoidable food waste is food that has never been edible, such as bones, fruit skins, etc. As described by Wrap, this includes waste from food that one would not expect people to eat (Wrap, 2011). Despite this classification being subjective, unveiling avoidable food waste reveals the substantial potential for food waste prevention (Papargyropoulou et al., 2014).

This leads us to the very first key characterisation when analysing food waste: whether it could possibly be avoided or not. Potentially avoidable waste might not have ended up as waste with better management

while inedible food conforms to unavoidable waste. Whether to quantify both food and associated inedible parts removed from the food supply chain when performing a waste audit, the choice of studying only food, or only associated inedible parts, is to be decided depending on the purpose of the waste audit (Hanson et al., 2016).

The vast majority of studies use some kind of further classification for the discarded food, usually related to the place or moment where waste is generated. Table 1 shows a few examples of classifications for avoidable and possibly avoidable waste used by researchers when analysing food waste.

Table 1. Characterisation of food waste by researchers, some examples

Author	(Derqui et al., 2016)	(Engström and Carlsson-Kanyama, 2004, p. 206)	(Ferreira, Martins, & Rocha, 2013, p. 1630)	(Falasconi et al., 2015)	(Clarke et al., 2015, p. 2)
Sector	Food Service	food service institutions	University Catering	School Catering	Consumer (Households)
Boundary	Spain	Sweden	Portugal	Italy	USA
Characterisation of food waste	PRE-CONSUMER WEIGHT	Storage losses	Weight of raw and cooked food not distributed ("leftovers")	"Avoidable" unserved food	Losses during cooking and preparation
		Preparation losses (mostly seeds, peel, etc. from fruits and vegetables)			
		Serving loss (left on serving dishes and in canteen kitchens and food wells)		"Physiological" unserved food (cooked in excess to ensure some extra portions)	Food discarded due to preparation of too much food, expired use-by/open dates, or spoilage
		Leftovers (prepared food never served)			
	POST-CONSUMER WEIGHT	Plate waste (what the diner leaves on the plate)	Plate waste (items returned at tray collection, after scraping of non-edible discards such as bones, peels, etc.)	Food served but not consumed ("serving dish leftovers")	Plate waste or loss

Additionally, as noted by Papargyropoulou (2014), distinguishing between food waste and food surplus is a must when addressing food waste: food surplus is food produced beyond our nutritional needs while food waste is a consequence of food surplus. Proper meal planning will help caterers minimise food surplus and therefore the planning process should in some way be included in a waste audit.

With regard to plate waste, there is consensus in the literature on its definition (Mirosa et al., 2016). The term plate waste is used by researchers to refer to the amount of food served to pupils that is finally discarded. Its measures have been used with two main purposes: in order to decide how much food to prepare or order and more importantly to judge how well pupils accept the meals offered (Buzby and Guthrie, 2002) and assess their dietary intakes.

On top of the above mentioned classifications, most researchers measure food types in each of the previous categories separately. Depending on the purpose of the study, food type classifications can be broad, like the one used by Byker et al. (2014) or Cohen et al. (2013) who classify food types into only four groups (main entree, fruit, vegetables and milk) or more detailed, like Marlette et al. (2005, p. 1), who mentions plate waste by the specific food item, such as applesauce, green peas, etc. using a more comprehensive

192 classification with 10 food type groups:(a) mixed dishes (b) meats(c) grains (d) milk (e) cheese (f)
193 vegetables (g) fruits (h) sweet snacks (i) savoury snacks and (j) beverages. Moreover, as mentioned before,
194 other researchers use the nutrient content of food for their analysis instead of food types (e.g. Bergman et
195 al., 2004).
196
197 **2.2.3 Waste Destination**
198 Whenever the goal of the audit might include an analysis of environmental impacts or at least an increase
199 of the awareness on food waste environmental footprint, waste destination should be recorded. The
200 environmental impact of food waste varies greatly depending on how it is discarded (Creedon, M.,
201 Cunningham, D., & Hogan, 2010)(Creedon, M., Cunningham, D., & Hogan, 2010; Papargyropoulou et al.,
202 2014). Typical destinations of food waste can be landfills, animal feed, anaerobic digestion, biomaterial and
203 compost, among others (C. Hanson, B. Lipinski, K. Robertson, D. Dias, I Gavilan and J. Fonseca, 2016). In
204 fact, destinations differ significantly, from the most favourable to the least favourable environmental option
205 in the waste management hierarchy (Papargyropoulou et al., 2014). Using the waste hierarchy as a
206 framework, Papargyropoulou et al. suggest different options for dealing with food surplus and food waste
207 where food surplus prevention is at the highest level of the pyramid. At the following step they suggest
208 redistribution for human consumption, animal feed and compost. Finally, at the lower levels, they list the
209 worst environmental options, such as energy recovery (e.g. anaerobic digestion) and disposing of food
210 waste in landfills - which they state should be used as the last option (Papargyropoulou et al., 2014).
211 Following the above-mentioned hierarchy, Creedon et al. (2010) state that from an environmental
212 perspective, the best way would be of course not to produce food waste or to prevent food waste from over
213 preparation, over trimming, etc. Secondly, he mentions reusing food for feeding people by reusing it in other
214 meals, donating to the needy, or even diverting it to feed animals. Thirdly, he states that food waste should
215 be recycled by composting or other processes. Finally, landfill disposal arises as the worst option for the
216 environment and is at present regulated in many countries (Creedon, M., Cunningham, D., & Hogan, 2010).
217
218 ## 2.3. Methods for measuring Food Waste
219 Most of the academic work on food waste in the catering industry has been conducted in schools or hospitals
220 (e.g. Cohen et al., 2013; Williams and Walton, 2011) and is often focused on plate waste (Adams et al.,
221 2005; Buzby and Guthrie, 2002), being researchers concerned with the nutritive intake of children as well
222 as with the efficiency of school nutrition programmes (e.g. Adams et al., 2005; Marlette et al., 2005; Smith
223 and Cunningham-Sabo, 2014). Quantification methods in the literature are diverse. Comstock (1979)
224 analysed and compared seven methods of measuring plate waste in the institutional food service, classifying
225 them into two groups: direct and indirect measures of waste, depending on whether waste was actually
226 weighed or estimated.
227 Direct (physical) measurement of plate waste is the most commonly used method by researchers, aiming
228 to measure food intake at schools by the actual weighing of food discarded by children (e.g. Bergman et al.,
229 2004; Cohen et al., 2013). Aggregate measures involve collecting all food waste and weighing the total bulk
230 amount for a population (e.g. all meals from one sitting), while individual measures record either the total
231 food remaining on each individual tray or the weights of each food component on each plate (Williams and
232 Walton, 2011). Individual weighing is reported by researchers to be more accurate, despite its high logistical
233 burden being a relevant disadvantage and it may make it difficult to implement without disrupting or delaying

normal foodservice operations (Comstock, 1979; Jacko; C. C.; Dellava; J.; Ensle; K.; & Hoffman; D. J., 2007). Furthermore, when measuring waste individually there is a high risk of children changing their consumption patterns if being observed, thus biasing results (Guthrie and Buzby, 2002; Jacko; C. C.; Dellava; J.; Ensle; K.; & Hoffman; D. J., 2007).

Moreover, individual or aggregate measurements can be done selectively, that is, differentiating the weight of each food component, or non-selectively. Comstock (1979) criticised aggregate non-selective plate waste for not providing enough information and actually recommended aggregate selective plate waste defending that it was fast, accurate and easy to learn while at the same time providing adequate information. Going further on aggregate measures of plate waste, Jacko (2007) recommends the plate-waste method, which he describes as follows: first the mass of food being served is measured by weighing each item in the menu; then, after finishing eating, pupils are asked to discard individual food items into different labelled plastic tubes for waste (e.g. #1 beans, #2 bread, #3 meat,…) Then, total weight per item is recorded (net of the tub weight) obtaining the total amount of food waste. The difference between mass of each item served and wasted is the estimated food intake. Jacko (2007) concluded from his research that there were no statistically relevant differences between the estimations on energy and nutrient intake in children at school obtained using aggregate selective or individual physical measurements of plate waste.

Indirect measures include both visual estimation and dietary recall (named self-estimation of plate waste by Comstock (1979). Although Comstock (1979) considered visual estimation by trained observers as being a non-obtrusive method, not too time consuming, they did not recommend it as its accuracy had not been adequately tested at that moment.. More recent researches (e.g. Rodriguez Tadeo et al., 2014) have concluded that it can be a valuable method. Visual estimation is done based on different grading scales for plate waste, Comstock's is the most commonly used, with 6 grades: full plate, almost full plate, ¾ plate, ½ plate, ¼ plate and empty plate (Rodriguez Tadeo et al., 2014). Despite Buzby (2002) mentioning that ratings can differ among observers as being a disadvantage of this method, Rodriguez Tadeo et al.'s (2014) research concluded that the visual scale was a reliable tool for measurement, although acknowledging the need for training catering staff as being inconvenient. Williamson (2004) performed research aiming to validate digital photography for measuring food portions (food served, food intake and plate waste) comparing it with direct visual estimations and weighed foods, concluding that both the direct visual estimation method and digital photography results were highly correlated with actual weighed food, and therefore, are valuable methods, although they acknowledge that both methods tended to slightly overestimate portion sizes compared to weighed food methods. Williamson (2004) supports the validity of both digital photography and direct visual estimation methods, based on the results of his research comparing results of both methods with actual weighing. He recommends digital photography for being less obtrusive and less disruptive in the eating environment.

On the other hand, when using the dietary recall method, children are asked about the type and amount of food eaten. Despite this method being easy to implement and low cost, results are highly biased by children's ability to recall (Jacko; C. C.; Dellava; J.; Ensle; K.; & Hoffman; D. J., 2007), as well as by the fact that children may want to please educators (Buzby and Guthrie, 2002). Comstock (1979) criticised both food preference questionnaires and self-estimation for not being reliable.

Table 2 summarises the pros and cons mentioned by researchers of the different measurement methods, based on Comstock's (1979) classification of methods in direct or indirect measures of waste.

Table 2. Methods for measuring food waste

	Method		Advantages	Disadvantages
DIRECT MEASURES OF WASTE	Individual Plate Waste		Accuracy Specific information provided (e.g. by sex, age, etc.)	High cost Time consuming Biased results
	Aggregate	Selective	Little disruption Easy to learn	No specific information provided by pupil
		Non Selective	Fast and easy	Little information provided
	Rubbish Analysis		Non-obtrusive	Highly inaccurate Time consuming
INDIRECT MEASURES OF WASTE	Visual Estimation	Direct Visual	Non-obtrusive Non-disruptive	Time Consuming Subjective ratings Need for training
		Digital Photography		
	Food preference		Easy to implement Low cost	Low accuracy Biased results
	Dietary Recall			

Actually, the most accurate method for measuring food intake has been reported to be weighing foods before and after eating although it is reported to be time consuming, costly and disruptive (Williamson et al., 2004). This said, it is interesting to recall Smith's (2014) research in which, in order to confirm observer reliability he weighed 20% of pupil trays after consumption and compared the result with visually estimated plate waste using digital photography, resulting in a 92% agreement. This is consistent with the Environmental Protection Agency - EPA (2014), which suggests that when there are space and time limitations, visual assessment may be more appropriate.

Jacko et al. (2007) in their research suggest that an accurate measure of plate waste at schools should be done without direct contact with the children because this could influence their behaviour and bias results. They therefore recommend the use of aggregated methods. Moreover, they compare aggregate vs individual methods to measure plate waste, finding no relevant statistical differences. They conclude that aggregated selective plate waste measurements provide accurate results for groups of children without the complexity of implementing actual weighed food measurements (Jacko; C. C.; Dellava; J.; Ensle; K.; & Hoffman; D. J., 2007). However, individual plate waste data would provide more specific information such as correlations between sex and age (Jacko; C. C.; Dellava; J.; Ensle; K.; & Hoffman; D. J., 2007). Therefore, even when using an aggregate method it might be useful to individually measure a small part of the sample. Furthermore, in order to generate useful comparators when using aggregate methods, total recorded kilos of waste are usually presented per pupil (Buzby and Guthrie, 2002).

2.4.Food Waste Research Objectives and Indicators in the Literature

Before going deep into the particularities of our research scope, school canteens, as a baseline we used general recommendations from researchers on measuring food waste. Nevertheless, food waste studies in the catering industry have been performed mainly in the education and health sectors.

Generally speaking, before performing a food waste audit, an entity should clearly define why it wants to quantify food waste. The results may be used for internal decision making, reporting to the institution stakeholders or to develop a Food Waste reduction policy or initiatives (C. Hanson, B. Lipinski, K. Robertson, D. Dias, I Gavilan and J. Fonseca, 2016). The way in which results are presented is closely related to the purpose of the audit, where the most recurrent research objectives observed in our review of the literature are assessing novel policies nutritional and analysing the efficiency of the food system.

Food waste audit results are typically expressed by researchers through one or a combination of the following indicators:

- Plate waste weight in grams per pupil (e.g. Ferreira et al., 2013; Wilkie, 2015), which can be calculated as the mean of individual measures or as a result of dividing total waste obtained in the audit when using an aggregate method by the number of diners. This output is useful when a comparison between different institutions is considered useful.
- Plate waste index, calculated as a percentage by weight on served food that is discarded or eaten (e.g. Byker et al., 2014; Rodriguez Tadeo et al., 2014). This more explicit indicator is very often used for its conclusiveness and clarity. Ferreira (2013) highlights the fact that the plate waste index shows the interaction between the diner and the food, regardless of kitchen or system efficiency. We find in the literature researchers that present their results in either of two ways: as percentage wasted (e.g. Marlette et al., 2005) or as percentage consumed out of total amount served (e.g. Cohen et al., 2013).
- Energy value of the waste, expressed as percentage of nutrients consumed against nutrients offered (e.g. Bergman et al., 2004). This indicator is used when the purpose of the study is assessing the dietary intake of pupils, without considering sustainability impacts of wasting food.
- Total kilos wasted (e.g. Wrap, 2011). This indicator is normally used together with average grams per pupil with the purpose of increasing awareness on waste as big figures (kilos, tons) are more impressive than grams.
- Monetary value of waste (e.g. Cohen et al., 2013) is very seldom used by researchers due to the fact that the research objectives are rarely related to cost. In order to determine the cost of plate waste, Buzby et al (2002) suggest multiplying the percentage waste estimate by the total budget allocation for food in the institution, although acknowledging this method does not adjust for differences in costs of food items wasted (e.g. bread vs meat or processed food).
- Efficiency of the food service system (e.g. Falasconi et al., 2015), a ratio of the relation between processed food (kg) and unserved food (kg and %). As stated by Ferreira (2013, p. 3), the “Leftovers index” relates all food discarded in the food service process to the quantity of food consumed.

3. Research Objective and Methods

3.1. Objectives and Scope of the Study

We conclude from the literature that there is relevance in measuring food waste and the need to provide a standardised method that can ease its measurement as well as track its evolution along time. The development of a food waste measurement reduction protocol has been highly recommended by researchers like Lipinski et al. (2013) who go further by suggesting the need to link it to setting reduction targets and supporting collaborative initiatives to reduce food waste. Moreover, Wilkie (2015) states that before any food waste reduction or recycling initiative can be implemented, it is necessary to know the amount of food waste that is generated. With regard to plate waste, Jacko (2007) observes that more and more schools are acting to prevent child obesity, initiating changes in dietary education programmes and lunch menus; consequently, he states that it is vital to have an accurate and cost effective validated method to measure and track plate waste through which changes can be assessed.

Provided that food waste seems to be a challenge for schools in their path towards sustainability, and since as stated by Szekely (2005), there is a need to establish clear, user-friendly methods and tools to measure

progress that companies are making toward sustainability (Székely and Knirsch, 2005, p. 1) the availability of a food waste self-auditing tool becomes valuable. A standard criteria for measuring school catering food waste is novel in the literature, particularly as we propose to include in our assessment tool both pre-consumer and post-consumer waste, while numerous studies on school food waste focus on analysing plate waste (e.g. Adams et al., 2005; Byker et al., 2014; Cohen et al., 2013; Marlette et al., 2005; Rodriguez Tadeo et al., 2014).

In order to contribute towards filling this gap, we conducted research in the catering industry at school canteens. The central objective of this study is to shed light on how initiatives and practices aiming to reduce food waste at schools can be measured and tracked. In order to attain this research goal, the following specific objectives were set for the research:

O1: To analyse how research measures, assesses and reports food waste at schools.
O2: Comprehend the level of awareness on food waste and its relevance for school and catering managers. To identify the elements that influence the generation of food waste at schools, understand its nature and the types of food being wasted as well as at which point waste is generated.
O3: To develop a self-assessment auditing tool to be used by educational centres and researchers to measure and track food waste at school canteens.
Our practical perspective is also novel, a fact that gives our research a very useful and precise managerial implication. Our aim is to develop an easy to implement self-assessment tool to be applied by school catering managers without the need of external assistance. Our auditing tool targets not only plate waste but also any losses before food is served with the purpose of assessing on the sustainability of the food service system.

3.2.Research on food waste at schools

With the purpose of doing an in-depth analysis of how research measures, assesses, and reports food waste at schools, our first research objective, we gathered over 20 studies by means of a Scopus search using as key search words - food waste and schools. Later, we found a few additional ones from bibliographies and citations. We analysed their objectives, methods, procedures and outputs in order to understand their strengths and weaknesses and then used the knowledge to create the foundations for the development of a standardised auditing tool.

Studies performed in order to quantify the amount of food that is wasted daily at school dining facilities (e.g. Byker et al., 2014; Falasconi et al., 2015; Smith and Cunningham-Sabo, 2014; Wrap, 2011) show the effect of pupils' preferences and behaviour, and the effect of the food service regime on food waste from school meals (Wilkie, 2015). Although research objectives are diverse (see Table 3), the vast majority (80%) of studies focus on analysing plate waste. However, most of these studies are not complete food waste audits and do not account for food waste from kitchen preparation, or waste from serving lines nor food pupils bring from home. Despite being plate waste the most frequently reported measure in school food waste studies, it is not the only source of food waste at schools. Interestingly, Falasconi et al.(2015) undertook research in 6 schools in Italy and found a significant level of inefficiency in school catering services: over 15% of the overall processed food was not served to the pupils, according to their measurement. Nevertheless, only a few of the studies found in the literature aim to measure the efficiency or sustainability of the school food system, as most of them are focused on pupils nutritional intake, and therefore limiting the analysis to plate waste.

Plate waste measures show a considerable variation between the different schools (Wilkie, 2015). Typical results range from 20% to 50% of the food served being wasted, with vegetables and fruit in the higher range (Wilkie, 2015). For instance, Rodriguez Tadeo et al. (2014) did a research in Spanish schools estimating leftovers by visual estimation, being up to 26% of total served food and Byker (2014) obtained a 45.3% of waste on total food served. Other studies mentioned by Wilkie (2015) give results that range between 52 g and 227 g per pupil per day. He explains such differences were likely due to the different ages of pupils and methods of food service (Wilkie, 2015). It is interesting to point out that there was significant variability in the amount of food wasted during the week, vegetables ranged from 26.1% to 80%, depending on the day. Although researchers acknowledge some plate waste is unavoidable (Cohen et al., 2013), they agree that in excess is a sign of inefficiency or even irresponsibility (Buzby and Guthrie, 2002).The wide range of waste generation rates shown in these studies also suggest the need for more standardised waste audit methods to measure waste produced at school cafeterias.

From our review of the literature (n=20), we present a summary in table 3 of the most relevant features of the studies performed by researchers quantifying food waste in school canteens as well as their weight on the analysed studies.

Table 3. Empirical research quantifying food waste in schools (% on total analysed studies)

Boundary	Research Scope	Research Objective	Methods	Indicators used
USA 75% UK10% SPAIN 5% ITALY 5% AUSTRALIA 5%	Plate waste 80% Kitchen and PW 10% Kitchen waste 5% Total Waste 5%	Dietary Assessment 40% Drivers of Plate waste 30% Method comparison 10% Economic cost of food waste 10% FS efficiency 5% Waste assessment 5%	Individual 69% Aggregate 31% Selective 94% Non selective 6% Weigh 69% Visual 31%	% waste on served 29% % Consumed on served 17% Nutrients consumed or wasted 21% Grams of waste per pupil 13% Waste economic value 13% Total kilos of waste 4% Food surplus 4%

3.3. Methods

The development of a standardised self-assessment tool should take into consideration the diverse frameworks in which school canteens operate which involve a set of complex social phenomena. In order to analyse this complexity, we designed research with an explorative/inductive approach through primarily qualitative data as proposed by Pratt (Pratt, 2009).

With the purpose of developing a useful and practical assessment tool, we designed exploratory research in two phases. First, we collected data through qualitative research with a range of stakeholders in order to understand the factors that generate food waste at school canteens. Semi-structured, individual interviews with 12 managers and staff of 9 different institutions and collectives that play a role in school meals were conducted (see appendix A for details).In this first phase of the research we obtained insights from managers, both at schools and catering organisations from which a first draft of the tool was designed. In the second phase of our research, once the assessment tool was pre-designed, we tested it in four of the participating schools in the former phase, in order to validate and improve it. At the same time as the tool was being tested, we gathered the opinion of canteen and school staff through 9 further individual interviews as well as the opinion of 8 pupils too. Data collection was performed during November and December, 2014.

The sample selection of the first part of the study followed a strategy of quotas according to the type of school (semi-public, public and private institutions) and catering organisation. Due to the nature of the research, all schools should satisfy the following criteria: offer in-house cooked meals in a canteen and a minimum of 300 pupils having lunch daily at school. Catering companies had to have a revenue in Spain of at least 10 M € in the last year and a significant market share in the institutional food service channel. To identify our sample, we explored their web sites and existing reports and visited their locations. The final sample was made up of 4 catering companies and 5 schools in Barcelona city. Semi-structured interviews with school principals, canteen managers and food service organisation management were carried out (see Appendix A for interview and organisation characteristics).Due to the complexity of an analysis of this kind of process, we have developed a protocol as a conceptual and practical guide on data collection during interviews. The protocol proposes a semi-structured interview design with open questions and unlimited time in order to capture possible unexpected results and redirect the interview according to the responses of the interviewee. The questions were grouped in three sections; the first one about the management system, followed by specific questions related to each production stage (procurement, kitchen, service and waste disposal) and finishing with questions on their interest in applying reduction measures and best practices. The interviews lasted an average of 60 min and all of them were conducted in places suggested by the interviewees to maintain their comfort and privacy. In addition, the interviews were recorded using an audio recorder. The protocol also suggests the annotation of interviewees' reactions (e.g. behaviour or non-verbal communication) when responding to questions. The transcript of the interviews was conducted following a process of double review by the authors. In the second phase of the research, more informal interviews with school and catering staff as well as professors and pupils were conducted.

The next step was the codification of the interviews through the methodological proposals of Bogdan and Biklen (1997) implementing a qualitative data analysis software (MaxQDA). The first step of interview coding was to identify the blocks or paragraphs where the interviewees spoke about one of the elements suggested by Bogdan and Biklen, such as Setting, Definition, Process, and Method. This first coding allowed us to define the starting point from which we analysed the structure of each interview. The second step of coding consisted in assigning to paragraphs (or a part of them) a list of preconceived codes from the theoretical framework of the research. The initial list of codes contained 7 codes (Players, Places, Food Type, Waste Drivers, Initiatives, Waste Hierarchy, Key Performance Indicators (KPIs)). The third and final step consisted in coding the paragraphs with a more inductive approach (encoding in vivo), recoding some of the interviews as new codes emerged. The final code book contains a total of 63 codes that classify data into 10 codes (the former 7 plus three new ones: Management, Resources and Culture).

After the encoding process, we analysed each interview and later we analysed them all in block following the suggestions of Miles and Huberman (1994) and Jurgenson (2005) with the goal of obtaining a specific vision of each case and a final conclusion for all cases. The first step of this part of the analysis was to build a checklist matrix to coherently organise several components for every case. These matrices showed the different sources of data (interviews) in rows and the topics or codes (both the codes from the second and the third step of the coding process) in columns. The matrices allowed us to display the interviews of the codified elements and their reliability and importance according to the number of sources that corroborated them.

From each case, we generated a Time-Ordered Matrix that showed the several processes throughout the study period. Based on the matrices, we re-analysed the assessment tool that we had previously developed.

After the analysis of each case, we carried out a Cross-Case Analysis in order to enhance generalisability and potential self-execution of the outcome. Following a code-oriented strategy, we developed a Case-Ordered Effects Matrix (based on Miles and Huberman,(1994), which allows us to see how the effects play out across the seven interviewees. In other words, we could sort the seven cases and show the diverse effects for each case in the same picture. The matrix has the cases in rows and the main features of the school, their strategies and point of view on sustainability, the point of view of the catering company, and some short-run effects. From this matrix, we were able to start analysing the relationship between schools and food waste.

Once a first draft of the tool was developed based on the insights obtained from the qualitative phase of the research, we addressed 4 schools in Barcelona in order to test its performance and improve its deficiencies. The test lasted three to five consecutive weekdays at each school with the objective of comprising different menus and therefore avoiding potential bias due to meal preferences. The schools were selected so as to ensure different catering arrangements, medium to large size schools, public and private institutions and a mix of socio-economic statuses. The four selected schools for the trial each had an in-house kitchen in which daily meals were prepared managed by a specialised firm because this is the most common procedure at Spanish schools, as mentioned by C4 (see Appendix A) in our research. We weighed and measured waste from their canteens during 11 school days, in the four schools (Table 4). School staff cooperated in the audits through setting aside the waste collected from the different areas and providing access to the areas where collection stations were placed. The schools in our sample had different cafeteria layouts but their lunch schedules were similar. Meals were composed of a starter (legumes, rice, pasta or vegetables), main dish (meat or fish), white bread and a dessert (fruit or yoghurt) and tap water. Children did not have the option of choosing their menu, except for secondary graders in school C.6 where they chose from two different options for each course. Special regime meals were usually also offered on demand. None of the schools offered a la carte items such as potato chips, as this very rarely happens in Spanish schools. Pupils in the study ate in one common lunchroom in three of the schools, while one of the schools had seven different lunchrooms. This latter school had 4 serving lines, two of the schools had one single serving line, and in one - school children were served by the staff at their tables. With regard to serving lines, food was presented in stainless steel containers (called Gastronorm) in the serving lines and kitchen staff served students on their trays when they passed by.

According to Engström (2004), food waste at the canteens was collected and aggregately weighed separately depending on the point where it had been produced (pantry, kitchen, service station or plate waste), distinguishing whether it was avoidable (e.g. out of date ingredients, plate waste) or unavoidable (e.g. bones, peels) waste. Research assistants weighed the aggregated discarded food at each step in the process every day, recording total kilos as well as the approximate % of the different types of food. For this purpose, we used industrial transparent plastic bags (100 litres) so that research assistants could visually estimate the percentage of the different types of food once the bags were full. This was possible because, as mentioned before, the variety of dishes usually offered at school canteens in Spain in one day is limited, typically one entrée plus one main dish and one dessert or at the most two options of each, resulting in no more than three to five different food types per meal.

Research assistants arrived at schools three hours before lunchtime, in order to prepare collection bins and track kitchen preparation tasks. Bins were placed in different spots, labelled in order to collect food at each stage. First of all they measured food wasted during meal preparation, making a note of its alleged cause.

"potentially avoidable" waste was differentiated from "unavoidable" waste such as egg shells, bones, etc. and only potentially avoidable waste was weighed. For this purpose, rubbish bags were placed at different points of the kitchen with specific labels. We therefore used 6 differently labelled bins and placed them at the different collection stations: 1) "Out of date or damaged raw ingredients"; 2) Unavoidable "kitchen scraps"; 3) Potentially avoidable "kitchen scraps"; 4) "Service line leftovers"; 5)Unavoidable "Plate waste", and 6) Potentially avoidable plate waste. Once the audit was finished, only four of them were weighed (using a Pelouze scale in all but one school where we used a Campesa K3 balance), as we did not measure unavoidable waste, in accordance with Papargyropoulou et al.'s (2014) suggestion.

We decided to combine a direct measure of waste method, aggregately weighing waste at the different collection stations with a less accurate method to measure food typology shares. Once total weight was measured, research assistants visually estimated the approximate percentage of total weight per food category. We opted for the aggregate selective method for its easy execution and simplicity, as schools should be able to implement it without external help later on.

Table 4 shows the total number of trays included in the trial as well as the number of days the audits lasted in each school. Overall, we measured the aggregated avoidable waste weight of over 10,000 trays, and 2,991 children took part in the audit.

Table 4. Trays and pupils audited

	Participating pupils	Trial Duration (# Days)	Elementary Pupils' trays	Secondary Pupils' trays	Total Audited Trays
School C5	986	5*	2,815	2,113	4,928
School C7	465	2	534	396	930
School C6	1,316	3	1,881	2,067	3,948
School C8	225	1	225	0	225
TOTAL	**2,991**	**11**	**5,455**	**4,576**	**10,031**

*(secondary pupils were present 4 four days only)

During the audit days, we interviewed 9 canteen and school staff in order to get insights from those who work closely with the day to day operations of the canteen. We also performed 9 quick interviews with children eating in the canteen. The interviews in this case lasted 20 minutes on average with staff and 10 minutes with pupils and we encoded the transcripts following the same method and codes as in the former phase of the study.

The number of pupils actually eating lunch in the canteen each day was registered in order to be able to estimate the average weight per pupil and day, as this was the measure found by Wrap (2011) to be the most meaningful way to compare data from different schools. This figure was compared with the planned number of diners, a figure that we asked the cooks each audit day in order to assess potential food surpluses as suggested by Papargyropoulou et al.(2014).

It is important to recall that the primary objective of the auditing tool is to analyse and track food waste produced at schools, not the amount of food going in, nor the nutritional intake of pupils. Therefore, the output is given in grams of waste per pupil and not as % of waste on food prepared or served nor percentage of energy or nutrients consumed vs offered. Nevertheless, the tool can be easily adapted for these purposes.

4. Results and Discussion

4.1. Perspectives on food waste by school caterers and canteen managers

We found a very low real awareness of managers on the amount of waste produced in the canteens. Only one of the schools in the sample had ever performed a waste audit at the canteen and only one of the participating catering companies does waste audits in the kitchens they operate in on a regular basis. This said we nevertheless found a high interest on the topic, especially among public funded school managers and personnel: we appreciated that many school managers would be willing to implement initiatives to measure and minimise the amount of food wasted at their canteens, especially after observing our pilot-test results. It was acknowledged by the interviewed managers that food waste is a data-poor area and therefore when suggested, a waste inventory was reflected as the starting point for the application of reductive initiatives. They largely agreed on the fact that it would be useful to increase awareness on waste through the measurement and tracking potential of reduction initiative results.

Consistent with the literature (Wrap, 2011), avoidable food waste accounted for the greatest amount of waste generated at schools in our pilot test. Plate waste accounts for the biggest source of food waste, followed by food from serving lines. Average weight of food wasted per elementary school pupil in Barcelona ranged between 40 and 100 grams per meal and pupil. Secondary pupils' average waste was higher in two of the three secondary schools analysed, exceeding 80 grams daily waste per pupil in two of the four studied schools.

In our trial of the auditing tool, school's institutional and pedagogical principles showed a very direct influence on the amount of food wasted at the canteen. Some schools consider the canteen as part of their learning project and therefore try to educate children in finishing their food through different activities, training, and workshops. These schools resulted in lower levels of waste, and especially of plate waste. Conversely, whenever top management of the school did not consider food waste a priority, plate waste ratios were higher, at the same time as the level of awareness on the amount of food wasted was very low. Just one school mentioned they regularly performed initiatives with the purpose of reducing food waste. In fact, in this school we found the lowest rate of plate waste in our pilot-test. We concluded this was due to the fact that its management had a strong focus on reducing food waste and this strong focus was translated into multiple ongoing initiatives.C6.1*:"We settle specific objectives every year. At present we are focusing on three food types: lentils, fish and oranges. Last year we achieved an important reduction on discarded bread. We are also currently focused on reducing dairy packaging, as its disposal costs are high".*

Moreover, schools with a stronger management focus on sustainability, or with wider pedagogical objectives showed high interest in the results of our pilot audit at the same time as they declared their purpose of repeating the audit in the near future.

On the other hand, we also found food service providers with very different perspectives and visions on food waste. One of the food service managers interviewed, who worked for a catering company with a strong sustainability culture mentioned that school managers' scepticism and lack of awareness was a barrier for improving results:C1.2 "*Implementing sustainable initiatives is difficult sometimes, as schools are often not very sustainability conscious; We have had customer complaints when trying to reduce food waste arguing that our only purpose was to reduce our costs!".*

She nevertheless recalled that when they had formerly performed waste audit assessments in schools, the results had been touching for both organisations and stated that it had been easier to introduce reduction initiatives in those institutions since then. We concluded from this that increasing visibility and awareness on food waste is crucial: C1.2*"We recently measured aggregated plate waste in one of our customers, one*

big sized school in Madrid resulting on a daily average of 350 kilos of food discarded. Then they launched an awareness campaign by putting together 350 kilos of packaged food ingredients at the entrance of the lunchroom with the purpose of increasing awareness on food waste among children"

Moreover, we observed very different attitudes toward plate waste among canteen and school staff. Such attitudes range from strict control on pupils so that they completely finish their meal, to passiveness, acceptance or even denial of the real situation regarding plate waste. These diverse attitudes are also related to dissimilar school management ideologies regarding school meals: from those considering the canteen as a fringe service offered to the parents (with no educational responsibility by the school), to those who consider it as part of the school´s pedagogical mission. This is very closely related to the means and resources dedicated to minimise plate waste, such as the number of caretakers and their role regarding leftover control and pupils eating habits as well as food waste reduction awareness campaigns.

We concluded from these observations that the role performed by school top management is the most relevant factor influencing sustainability issues such as the level of canteen food waste. Those institutions with a strong focus on sustainability or which were at an advanced stage on "greening" their organisations usually allocated more resources to reducing food waste and were thus more likely to be looking for performance indicators and initiatives to reduce waste. This was confirmed in our pilot-test, as the one school with a clear focus on sustainability recorded the lowest plate waste rate. The higher management focus on sustainability was translated into diverse procedures impacting the different waste driver areas, resulting generally in lower waste rates. Moreover, green conscious managers tend to be concerned not only with food waste but also with related packaging waste. An informative campaign addressing public funded schools with the purpose of increasing awareness on food waste could therefore be highly efficient. Actually, as mentioned by Papargyropoulou et al. (2014) we verified that food waste arises at all the different stages as a result of very diverse causes and thus the ways to tackle them must be different too. We concluded from our research that food waste drivers can be categorised in three groups. First, those related to management practices such as the meal planning process or procurement practices. Secondly, infrastructures and equipment also impact food waste levels, especially at the storage and serving stages. Finally, human resources issues, such as staff awareness (or lack of awareness) on food waste is also reflected at the different levels of food waste in canteen operations. In the next paragraphs we shall develop these drivers, relating them to adequate indicators that will allow managers and researchers to measure and track performance in their related areas.

Regarding management practices, cooks and caterers mention communication between school and kitchen as key in order to accurately plan the number of menus to elaborate. As mentioned by C1.2, this is absolutely relevant for special regime diets such as allergenic: C1.2 "*Special menus such as diet or allergenic produce higher amounts of waste per pupil than regular ones as they are more difficult to plan".* From this insight we can infer the relevance of tracking deviations between planned and real numbers of diners.

Also related to management practices we found menu planning closely related to food waste. In fact, many of the pupils interviewed complained about the quality of the food offered. Pupils' acceptance of food can be increased by menu planning policies. As suggested by C12: "*The different acceptance rates of dishes by pupils makes a difference. We try to balance our menus: if the first course is "difficult" (like for example chickpeas), the main course should be "easier" (for instance not offering fish)".* Pupils' acceptance of meals can also be enhanced by giving them the option of choosing between more than one alternative for each course. Only one of the schools studied offered the pupils different dish alternatives to choose from.

On the other hand, procurement policies were admitted as closely related to waste. Suppliers' delivery frequency and product formats are managed to prevent pantry losses. Public policies were highlighted as a key potential tool to entice good purchasing practices at schools, although this was not clearly related to the generation of waste and should be tracked by selective measures of plate waste. C2.1: *"Public procurement policies are aimed to guarantee that children have a diverse and complete diet, but effective food intake by children varies a lot between schools, closely related to school management priorities and consequent child education on food habits and supervision during meals".*

Research also shows that kitchen food waste is strongly influenced by school infrastructure and equipment. Caterers need to adapt their processes to school facilities and often complain that some of them are very old. They recognise this fact as a limitation: C2.1:*"It is really hard sometimes".* Furthermore, the availability of recycling facilities strongly determines the destination of waste. C8.*"Since we own a vegetable garden , we compost most of the kitchen scraps and peels we generate*". Recording regularly the destination of food waste as well as its disposal costs might increase awareness on potential improvements. Waste bins at schools in our sample were normally emptied into dumpsters. Although three schools in our sample had a vegetable garden, only one of them composted food waste from the canteen.

Better storage facilities was mentioned by cooks as a way in which they could reduce the amount of raw materials that had to be discarded, at the same time as it could also be a way of permitting excess cooked food to be stored for later consumption. We also found a relevant source of waste related to the number of serving lines in which children were served or where they could help themselves to food. Whenever there is one unique serving station, waste at this stage was significantly lower than when there were several. Schools with more than one service line tend to generate more food waste per pupil at this stage. This was due to the fact that all types of food needed to be displayed until the end of the service time at all service stations, inevitably causing a certain amount of waste at each station. One of the schools where we pilot-tested the auditing tool had four serving lines. Waste at this stage in this school varied significantly among the dates studied and we weighed over 70 kilos of cooked food not served that was discarded in one day. Bread has a relevant role here. In our case study plate waste accounted for the greatest part of food waste in three of the schools studied and serving waste in the fourth one. Moreover, due to the fact that bread is low priced, no attention was paid in general to the amount discarded. In most serving lines, bread was placed at the beginning, together with the trays and cutlery, and diners used to take it before knowing whether they were going to like the menu. Bread was in our test one of the food categories with highest waste.

Finally, the role of canteen supervisors was emphasised as crucial, the lack of control on pupils leftovers being a relevant driver of plate waste. It was acknowledged that plate waste is closely related to effective supervision. Actually, schools with the lowest rates of food waste in our pilot were those where there was stricter control by canteen supervisors on top of a wider educational perspective. Measuring and tracking plate waste can be used by managers to encourage caretaker supervision. Managers therefore will find it useful to unveil the amount of plate waste as this will allow them to set reduction objectives and measure their effect or even compare results with other schools.

Tracking and disseminating these key performance indicators will facilitate school managers when choosing the most adequate correction measures and evaluating results. Necessary correction measures are different depending on the cause and the place where waste is generated. Table 5 summarises the most relevant school canteen food waste drivers and the indicators or variables that might be useful for running a diagnosis and describing the main improvement areas and help in the management of each of them.

Table 5. School food waste drivers and key performance indicators (KPI)

Related Area	Food Waste Driver	
Institution Culture and Values	Top Management (low) Focus on Sustainability	
	Pedagogical Vision	
Management Practices	Communication between Kitchen and School staff	
	Meal planning process	
	Menu planning (and acceptance of food by pupils)	
	Procurement practices	
Infrastructure	Kitchen equipment and facilities	
	Recycling & Reuse facilities	
	Canteen Layout	
Human Resources	Supervision by caretakers	

Age is highlighted as a relevant factor too. Canteen staff and caretakers agree on the fact that children of different ages usually have different eating patterns. There was a consensus on the fact that younger children produce less plate waste, as stated by C.5.4a *"The younger they are, the more they eat. Three to five year olds leave no plate waste at all!"* This insight shades light on the relevance of measuring waste from different collectives separately. Interestingly, even though the amount of waste generated per pupil varied a lot among the different schools, food wasted by elementary pupils was much lower than by secondary graders in our research. This result is consistent with the outcome of the first stage of our research although we found opposite results in several of the studies (e.g. Guthrie and Buzby, 2002; Niaki et al., 2016).

It is interesting to note that catering and school staff did not consider the proposed auditing method disruptive. On the contrary, cafeteria staff, teachers and caretakers who collaborated in the trial were proud to share their experience with other colleagues. They were often impressed by the results and willing to collaborate when ideas for FW reduction were brought up. Research findings strongly support the relevance of sharing results with canteen staff, as suggested by the World Resources Institute (C. Hanson, B. Lipinski, K. Robertson, D. Dias, I Gavilan and J. Fonseca, 2016).

4.2. Self-assessment food waste auditing tool

Based on our research, we can group the information to be measured and tracked when auditing food waste at school canteens, into four categories: accuracy of the planning system, physical measure of waste, waste destination and economic cost of food waste. In the following paragraphs we develop the four categories and describe related key performance indicators that should be included in a waste audit.

4.2.1.Accuracy of the planning system. Conformity between real versus planned number of diners should be measured, with the objective of analysing and tracking actual deviations between the information used by cooks when preparing food and the final amount of food needed at lunchtime. Differences between these two figures are often the cause of generation of food surplus (excess food cooked). In order to assess the accuracy of the planning system, we suggest using the following indicator: **deviation rate between planned and served meals.**

A daily estimation of the difference between planned meals and the real final number of diners should be tracked. For this purpose, a deviation rate should be recorded daily, noting both the number of planned diners before the cooking process begins and the actual number of effective pupils that eat at the canteen each auditing day. Deviations should be recorded in % of actual vs planned diners per sitting (whenever there is more than one). Special menus such as allergenic or diet lunches should be recorded separately too. If there is a known cause for the deviation it should also be briefly explained in the record. Needless to say, elementary versus secondary grades should be recorded separately.

4.2.2.Physical measure of waste. Different food categories (e.g. fruit, bread, etc.) should be recorded separately in order to be able to assess the efficiency of the food service system as well as dietary and nutritional intake and food acceptance and preferences. This measure will shed light on the potential improvement that can be achieved by performing reduction initiatives and will be helpful for their design. Due to the nature of the physical measure of waste, we suggest two indicators, weight of food waste and number of zero waste trays, discussed below.

(a)Aggregate and Selective weight of food waste at each different stage of the process. This should be measured at each collection station, in order to differentiate the four typologies of waste:pantry loss, cooking loss, prepared food surplus and plate waste, as explained in section 2.2. At each stage, potentially avoidable food waste should be measured separately from unavoidable waste, which does not need to be included in this record. Collection stations must differentiate the place and stage in the process where waste has been generated and categorised food should be recorded at each collection station. We suggest estimating the share (percentage on total food waste) of each food type by visual estimation. For this purpose we recommend the use of transparent rubbish bags or bins for the aggregate measurement, recording the approximate % of each food category after weighing. To do this, we suggest using the classification used by Betz et al. (2015): meat/fish, starch, vegetables, fruit, desserts (e.g. yoghurt), and others, adding bread and legumes as separate additional categories. As mentioned before, unavoidable waste such as peels, bones, etc. must be separated at collection stations and withdrawn before weighing. Recording total weight of unavoidable waste is optional.

We shall therefore measure four different waste indicators in this section, one per each stage of the process:

A. Pantry loss: food waste generated in raw ingredient storage (mostly out of date produce). We shall record the total kilos wasted at this stage, the approximate % of total weight per food type and the place where it occurred (e.g. pantry, fridge, etc.) as well as its alleged cause (e.g. out of date, spoilt, etc.).

B. Cooking loss: waste produced during the cooking process. Unavoidable waste should be discarded separately at this stage because only potentially avoidable waste needs to be weighed. Total kilos of avoidable waste should be recorded, as well as the approximate % per food type, the place of generation and the reason that probably caused it (e.g. burnt, aesthetics, etc.).

C. Prepared food surplus: food cooked but not served. This comprises waste produced at serving lines or other means of distribution or display. Here, total weight of cooked food not served to the pupils should be recorded as well as the approximate percentage per type of food, noting the most probable reason that caused it as well as its most likely end: reuse (e.g. staff meals, soups, donations,…), recycling (e.g. compost), or disposal.

D. Plate Waste: Food Served but not eaten. We recommend measuring plate waste using the aggregated and selective method, once having withdrawn inedible food or parts of food. Again, total

kilos of waste should be recorded before noting the approximate percentage per food type which will be measured by visual estimation.

We suggest weighing discarded food without separating the different types of food at each collection station, as categorisation can be visually estimated after collection by the use of transparent rubbish bags. This suggested method will ease audit implementation despite possibly being less accurate. This is consistent with the literature, as Smith (2014), in a study measuring individual plate waste, concluded that visual estimation was close enough to selective weighing when measuring plate waste. Due to the nature of the audit we prioritise easy execution over accuracy.

Nevertheless, plate waste usually being the main source of waste at school cafeterias, it can be helpful to deepen the analysis in a small sample of pupils, in order to get insights on the reasons that caused leftovers. This sample should be taken at random and it is recommended to take digital photos of these pupils' trays, both before they start dining and when they return their trays. The amount of plate waste found in this study is consistent with plate waste reported in previous research in schools although high differences were found among them. Moreover, most food waste types in our pilot study were legumes, vegetables and bread. This is consistent with the literature, as most studies highlight the high waste of vegetables.

Although the aggregated method is recommended for its convenience, results should also be given in grams per pupil, calculating the ratio between total waste amount and the number of real diners, using the figure of real diners previously recorded. We must consider that using this ratio will only be comparable among schools with the same catering system. Using this method, only plate waste ratios will be comparable among schools with different catering systems. Whenever it is possible, a measure of efficiency would also be recommended, recording the percentage of wasted food related to prepared food. This ratio is particularly relevant for transported meals catering systems.

(b) Number of zero waste trays, as a percentage of total trays. Tracking how many pupils empty their trays completely will shed light on meal acceptance and caretakers' control. Moreover, the study suggests the dissemination of this information may encourage other pupils to reduce plate waste. C.6.1: *"Since we started the zero tray project (a contest among classes in which the class with a higher percentage of fully empty returned trays were rewarded), plate waste has been reduced significantly".*

4.2.3.Waste destination or use. Improvement opportunities can also arise by noting and tracking the destination of waste from the canteen. Good sustainability initiatives could include setting objectives of reducing waste sent to landfills and reducing food waste footprint by reducing waste that is discarded at the lower levels of the waste hierarchy pyramid. The indicator proposed to manage waste destinations is simple. We recommend recording the way food waste is discarded (e.g. rubbish bin, compost) or reused. The waste destination indicator implies noting the approximate % of waste which will probably end in landfills, compost or that will be reused, recording its intended purpose in this case. Whenever more than one disposal method is used, the approximate % on total waste weight of each one should be recorded.

4.2.4.Economic cost of food waste. An economic estimation of food waste is recommended as it will increase the relevance that school and catering managers give to tracking and measuring waste as a means of reducing food waste could be seen as a potential profit increase. As mentioned by one of the caterers in our sample C1.1: *"Canteens are a source of business for schools, they make profit out of them"*. School managers with a low focus on sustainability, and therefore not motivated to reducing food waste for sustainability related reasons, may find an attractive incentive in this indicator. The approximate cost of

waste can be calculated in different ways. We suggest using an average cost per meal estimated on a year basis (including procurement and service) and multiply it by the equivalent of meals thrown away. This can be calculated by dividing the total kilos of waste by the average weight of meal (g) and multiplying the result by the average cost per meal. This should be done with the support of the financial manager. Although this method may not be accurate as it does not distinguish the diverse cost of different food ingredients, we prioritise ease of execution over accuracy due to the purpose of the measurement.

By tracking appropriate KPIs related to the above mentioned four areas and their probable causes, school caterers and managers will be able to diagnose and describe main improvement areas. Materials needed in order to perform the audit include a scale, six labelled waste bins or waste containers and transparent rubbish bags.

Table 6 summarises the four main data categories, relating them to the goal of the analysis and their related KPI. You will find the auditing tool in Appendix B.

Table 6: Summary of selected KPIs and their purpose.

Data Category	Purpose	Food Waste Indicators short list
Accuracy of the planning system	Better adjustment of quantities cooked	1. Planned vs real number of meals
Physical measure of waste	Assess system efficiency & dietary intake	2. Selective aggregate food waste by type of food 3. Zero waste trays
Waste destination	Reduce environmental impact	4. Food waste destination
Economic cost of food waste	Increase awareness of Food Waste Relevance to management	5. Total Euros/Dollars/Pounds in cost of food waste

Kitchen and service staff highlight that there are some dishes which typically generate low or no plate waste, such as rice or pizza, while others such as fish or vegetables generate high plate waste rates. Despite menu planning often taking this into consideration, we found a wide range of plate waste ratios on different dates, a fact that we attributed to the different acceptance of the menus. Plate waste one day in a specific school could double or even triple a previous day's ratio. For this reason auditing a full school week is urged in order to include diverse meals and avoid bias due to different meal acceptance from pupils. Strong differences were also found among the sample schools in our pilot-test.

Once the audit is finished, it is recommended to share the results with professors, supervisors and pupils as this would contribute to increase awareness on the issue. Lack of visibility and therefore lack of awareness is one of the key reasons for the low level of measures taken to reduce food waste in the food service channel (Derqui et al., 2016). The first measurement will be used as a baseline and the reference for improvement goals. Successive measurements will shed light on the efficiency of initiatives as well as on the room for improvement. We suggest that the audit project be led by a "project leader", a person in charge who will be responsible for coordinating the different players needed for the success of each improvement initiative.

5. Conclusion

As suggested by Gerbens-Leenes et al. (2003), it is important to bridge the existing gap between theoretical scientific knowledge and practical company knowledge in measuring sustainability. Nevertheless, as they

state, this is in general difficult, as research as a rule emphasises accuracy and completeness while business needs easy to handle, practical and cheap tools to assess their sustainability performance (Gerbens-Leenes et al., 2003).Through our research, we designed a self-assessment tool that can be easily used by schools and caterers to measure and track food waste at school canteens yet comprehensive and accurate. In addition, through the implementation of the tool, academics will have further relevant quantitative and comparable data as well as visibility to food waste, a field of information which is not widely available. Moreover, managers and researchers can adapt and use the tool in different countries and environments in order to obtain metrics and insights on food waste and benefit from benchmarking and shared experiences under homogenous criteria and standardised concepts.

Our paper provides new contributions to the literature on food waste. Firstly, a standardised and easy to implement self-assessment tool is developed to be implemented at school canteens. Secondly, it sheds light on the potential good acceptance that sustainable initiatives may get from school managers and staff. Finally, it relates food waste drivers to key performance indicators that would help managing potential initiatives to address them. On the one hand, our main contribution for researchers is the availability of a standardised tool that will permit the comparison of food waste assessments in schools among different cities and environments. On the other hand, we provide school and food service managers with an easy to implement tool that will help them along their path towards more sustainable organisations.

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APPENDIX A. Sample characteristics

INSTITUTION	Type of organisation	Number of employees/pupils	Profile & Number of people interviewed
C1 SODEXO	Food service	18,000 Million € Global Revenue 420,000 employees Operates in 80 countries Headquarters in FR	C.1.1 Marketing Manager C.1.2 Opex Manager C.1.3 Social Responsibility Manager
C2 CATSCHOOLS	Food service	Headquarters in Spain, operates regionally (Barcelona only)	C.2.1 Sales Managers C.2.2 Purchasing Manager
C3 EUREST (Compass Group)	Food service	Headquarters in the UK. 17,000 million pounds in 50 countries (group)	C.3 Regional Sales Manager
C4 ARAMARK	Food service	14,329 billion USD revenue 270,000 employees in 21 countries. Headquarters in the US	C.4 Regional Sales Manager
C5 SAGRAT COR SCHOOL	Elementary & Secondary School	1,500 pupils eat daily 2 dining rooms and two service lines	C.5.1 Canteen manager C.5.2 Cook C.5.3 a & b: 2 kitchen assistants C.5.4 a, b & c: 3 caretakers C.5.5 a to e:5 pupils
C6 ESCOLA PIA SCHOOL	Private Elementary & Secondary School	1,500 pupils eat daily Seven dining rooms and 4 service lines Compost facilities	C.6.1 Canteen manager C.6.2 a&2b supervisors C.6.3 a to d: 4 pupils
C7 ISABEL DE VILLENA SCHOOL	Private Elementary & Secondary School	670 daily diners	C.7.1 Canteen coordinator C.7.2 Cook
C8 ESCUELA JUNGFRAU SCHOOL	Public Elementary School	250 daily diners Pupils are served at their table	C.8 Canteen coordinator
C9 COSTA LLOBERA SCHOOL	Public Elementary & Secondary School		C.9 Canteen coordinator

Appendix B SCHOOL CANTEEN FOOD WASTE AUTO – ASSESSMENT TOOL

A. Record the number of planned meals and the real number of diners

	Planned number of diners	Actual Diners	% Deviation	Deviation causes
1st shift				E.g. excursions, sick kids,…
2nd shift				
Allergenic menus				
Diet menus				

B. Selective weight by stage of the process

PANTRY LOSS (Out of date and damaged food): **BIN #1**

1. TOTAL KILOS (Approx.): …… Kg

1.b TOTAL POTENTIALLY AVOIDABLE KILOS (Estimate) …… **Kg**

FOOD TYPE	WEIGH % on total (% Approx.)	PLACE WHERE IT OCCURRED	CAUSE
E.G.: fruit, bread…		e.g. pantry, fridge…	

COOKING LOSS (Kitchen Waste):

2. TOTAL KILOS (Approx.): …… Kg

2.a UNAVOIDABLE WASTE: **BIN#2**

E.G. potato peels, egg shells, etc.: …… Kg

2.b POTENTIALLY AVOIDABLE WASTE: Cooked but not served, burnt, damaged, etc. (indicate type) **BIN#3**

…… % Approx.

FOOD TYPE	WEIGH % on total (% Approx.)	PLACE WHERE IT WAS PRODUCED	CAUSE
		E.g.while cooking, already cooked ….	E.g.burnt food; less dinners than expected,..

PREPARED FOOD SURPLUS (Display): **BIN#4**

3. TOTAL KILOS (Approx.): …… Kg

3.b TOTAL POTENTIALLY AVOIDABLE KILOS (Estimate) …… **Kg**

Record cooked food that is not served

FOOD TYPE	Quantity (kilos)	Cause	Most probable end (disposal or use)
E.g. Roasted chicken			E.g. Staff meals, soup, donations, etc.

PLATE WASTE:

4. TOTAL KILOS (Approx.): …… Kg

4.a UNAVOIDABLE WASTE **BIN#5**

e.g. Banana peels, bones, ….: Grams / STUDENT

4.b POTENTIALLY AVOIDABLE WASTE **BIN#6**

……Kg Grams / STUDENT

FOOD TYPE	WEIGH % on total (% Approx.)	KG		
E.g. Vegetables, legumes, etc.				

C.- Waste Economic Cost

TOTAL KILOS WASTED (1+2+3+4)	
TOTAL AVOIDABLE KILOS (1b+2b+3b+4b)	
C.1 Average per pupil	
C.2 Average weight of meal served per tray (g)	
% waste on food served (C.2 / C.1)	
Average cost/meal (including preparation cost) (€)	
Equivalent of meals thrown away (Total food waste kilos / weight of meal)	
Cost of food waste (€) (Equivalent meals thrown away * average cost per meal)	

D. Waste Destination

How it was discarded	KG	Approximate % on total weigh
Garbage Bin		
Reuse (Mention for what purpose)		
Compost		

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