Article

Inadequacy of Meals Served and Food Waste in a Portuguese University Canteen

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Abstract: This study aims to evaluate food waste and the adequacy of portions served in a Portuguese university canteen. The sample included 10278 meals. Portions served and food waste (plate waste and leftovers) were measured through physical weighing. Portion inadequacy was determined, considering the Dietary Reference Values proposed by the European Food Safety Authority. The portions of all meal components served were inadequate. Meat, fish, salads and vegetables were those in the most inadequate portions (p < 0.001), with the quantities of meat and fish served being well above the recommended level (+77%) and the quantities of salad and vegetables below the recommended level (-37.7%). During the study period, 1253.6 kg of food was wasted, representing a daily average of 65.9 kg of food waste (20.8%). It was estimated that 126.6 g of food was wasted per consumer per day. Salads and vegetables represented the food category with high food waste values (41.4%), mainly from plate waste (29.6%). Our findings show an inadequacy in terms of the portions served for all meal components. High food waste values were found, for vegetable soup, vegetables, salads and fruit; these were the items most rejected by consumers, compromising the achievement of nutritional goals for the lunches served in the university canteen.

Keywords: canteen; food waste; sustainable food consumption; sustainable food management; university students

1. Introduction

Food waste has become a top priority in the government’s agendas and economic sectors due to its negative environmental and social impacts and its contribution to substantial economic losses [1,2]. For instance, this issue is recognized in the United Nations 2030 Agenda in Sustainable Development Goal (SDG) 12, which aims to “ensure sustainable consumption and production patterns” [3]. As educational institutions, universities have a responsibility to address this sustainability-related issue and may have a crucial role in assessing its causes and creating effective approaches to mitigate its noxious effects [1,4].

Throughout the past decade, university students have been identified as an emerging at-risk population for food insecurity and poor dietary habits, due to various factors, including inadequate levels of food literacy [5,6], lack of culinary skills [7], busy schedules [8] and increased food prices and accommodation costs [9,10]. Evidence has demonstrated that the typical university student’s diet is generally poor in foods likely to contribute to optimal dietary patterns and perceived as healthier choices, such as vegetables, fruits, pulses, whole grains and dairy products and rich in fatty, sugary and salty foods, in
addition to a high consumption of alcoholic beverages, which is unlikely to be conducive to good health [11]. Moreover, it has been shown that students with healthy eating habits show greater commitment and better academic performance [12], while poor eating habits are associated with fatigue [13].

Despite the efforts exerted to enhance food quality and the environment within university campuses [14,15], high values of food waste have been reported in university canteens in different countries [16–18], representing a particularly important setting for reducing food waste [19]. In Portugal, nationwide-level studies are lacking on food waste and nutritional status in university settings, although efforts have been made to address this issue at the regional level. Studies that analyzed food waste in Portuguese university canteens have found high food waste levels, above acceptable limits [20,21], with economic losses and high ecological footprints [16]. Due to the considerable amount of time that young people spend at university (between 5 and 30 h per week or more), the university canteen is recognized as a vital “home away from home” that can significantly influence students’ food intake. Consequently, it plays a substantial role in shaping their dietary habits [22–25].

Garg et al. demonstrated the need for students to have meals available at universities that are both healthy and correspond to their needs and dietary choices and trends, emphasizing the importance of offering vegetarian meals [26].

In addition to the importance of ensuring the provision of healthy meals, the portions served in university canteens must be tailored to the nutritional needs of university students. Studies suggest that adjusting portion sizes to individual energy and nutritional requirements, as well as minimizing food waste, contributes to a more sustainable and healthier dietary pattern [27–29].

In the long term, improvements in dietary habits will contribute to reduce the burden of chronic diseases, which is increasing significantly [23].

In the absence of specific guidelines in Portugal regarding portion sizes for university students, it becomes imperative to establish them in order to mitigate food waste during meal consumption, thereby contributing to the efficient use of limited natural resources [30]. Therefore, the aim of this study was to evaluate food waste and the adequacy of portions served in a Portuguese university canteen.

2. Materials and Methods

2.1. Ethics and Sampling Characteristics

This study was performed in the canteen of a Portuguese university, attended by approximately 7000 university students.

The consent of the University’s Social Services, who manage the canteen, was obtained beforehand. This study was carried out in accordance with all the principles of the Declaration of Helsinki. Data collection did not involve direct participation of canteen users.

The final sample included all the meals served for lunch in the canteen for one month (19 weekdays), comprising a total of 10,278 meals.

2.2. University Canteen and Meal Characteristics

Staff serve a single main course of the user’s choice. The daily meals are cooked based on recipes tailored to weight specifications. Menus consist of a vegetable soup, along with a choice of four main courses (meat, fish, pasta or vegetarian), an optional dessert (three different varieties of fruit were available daily, and sweet desserts were available four times a week) and a beverage (tap water or juice). Mixed bread or cornbread is also available.

The portions served are not standardized, being served according to the consumer’s request.
Prior to the start of the study, a 2-day observation of the canteen service and food waste management took place in order to adjust the collection procedures. The canteen supplies around 550 meals a day, cooked on site, at discounted prices and without prior booking. During the academic year, it is mainly attended by students of both sexes, aged between 18 and 22 years old.

2.3. Data Collection

Data collection was carried out by five training researchers for one month to obtain a wide variety of preparations. Portions served and food waste were measured by physical weighing on a calibrated digital scale to the closest gram (g) (Baxtran® model FFN, Giropès, Vilamalla, Spain) and a maximum capacity of three kilograms (kg).

2.3.1. Portions Served Assessment

The weighing procedure was carried out randomly on the service line when the meals were being served to consumers. A total of 1984 components were evaluated. After consumers ordered, plates were weighed empty and after plating each component. The portions for each meal component were determined by the weight difference \[31\].

Portion inadequacy was determined, considering the Dietary Reference Values for nutrients proposed by the European Food Safety Authority and characteristics of the target population \[32\].

2.3.2. Food Waste Assessment

Food waste was measured by physical weighing and comprised leftovers and plate waste. As described previously \[16\], leftovers were defined as the food that was produced but not served, and plate waste was defined as the food that was served to the consumer but not consumed \[33,34\].

Initially, all food produced was weighed according to its food category. After the meal, plates were gathered, non-edible items were removed and edible plate waste was sorted by category and weighed. Food categories included vegetable soup, rice, potato, pasta, pulses, quinoa, salads and vegetables, fruit dessert, sweet dessert and bread. Non-edible components like meat and fish bones, as well as peels (considered unavoidable waste), were excluded from plate waste.

Leftovers (%) were calculated by the ratio of leftovers per food item produced. Plate waste (%) was calculated by the ratio of food discarded per food served. Total food waste (%) was calculated by the ratio of plate waste and leftovers per food produced.

The average per capita consumption was obtained from the ratio of the difference between food produced and food waste and the number of meals served.

The average food waste per consumer was obtained from the ratio between total food waste and the number of meals served.

2.4. Data Analysis

IBM SPSS Statistics version 27.0 and Excel Microsoft Office Program Professional version 2308 were used for data analysis. Means, standard deviations (SDs) and maximum and minimum values were used for descriptive analysis.

T Student and Wilcoxon tests were used to detect variations among the inadequacy of portions served by meal components and recommended portions.

Mann–Whitney and Kruskal–Wallis tests were applied to evaluate differences in food waste by food category. The confidence level was defined as 95%.

3. Results

During the study period, a total of 10,278 meals were evaluated, representing an average of 541 meals served per day, ranging from 315 to 640 meals served daily.
Table 1 shows information on the portions served at lunch in the university canteen during the study period and the prevalence of inadequacy compared to the reference values for the target population. It was observed that the portions served of all meal components were inadequate. Meat and fish dishes and salads and vegetables were those present in the most inadequate portions \((p < 0.001)\), with the portions of meat and fish served being well above the recommended level (+77%) and the portions of salad and vegetables below the recommended level (−37.7%), considering the Dietary Reference Values for nutrients proposed by the European Food Safety Authority.

Table 1. Portions served at university canteen by meal component and inadequacy of portions served according to the reference values \((n = 1984)\).

<table>
<thead>
<tr>
<th>Food Category</th>
<th>Portions Served (g)</th>
<th>Reference Values (g) [35,36]</th>
<th>Inadequacy (g)</th>
<th>Inadequacy (%)</th>
<th>(p^*)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ± SD</td>
<td>Minimum</td>
<td>Maximum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meat, fish ((n = 555))</td>
<td>177.7 ± 50.8</td>
<td>33.2</td>
<td>416.7</td>
<td>100</td>
<td>77.7</td>
</tr>
<tr>
<td>Rice ((n = 444))</td>
<td>150.4 ± 32.5</td>
<td>42.3</td>
<td>397.9</td>
<td>165</td>
<td>−14.6</td>
</tr>
<tr>
<td>Potato ((n = 78))</td>
<td>234.5 ± 85.1</td>
<td>135.9</td>
<td>877.7</td>
<td>180</td>
<td>54.5</td>
</tr>
<tr>
<td>Pasta ((n = 39))</td>
<td>178.5 ± 31.6</td>
<td>122.1</td>
<td>235.5</td>
<td>165</td>
<td>13.5</td>
</tr>
<tr>
<td>Salads and vegetables ((n = 234))</td>
<td>97.3 ± 51.0</td>
<td>10.8</td>
<td>551.9</td>
<td>135</td>
<td>−37.7</td>
</tr>
<tr>
<td>Bread ((n = 88))</td>
<td>175.6 ± 39.7</td>
<td>115.8</td>
<td>262</td>
<td>50</td>
<td>5.9</td>
</tr>
<tr>
<td>Fruit ((n = 201))</td>
<td>55.9 ± 4.9</td>
<td>44.1</td>
<td>80.7</td>
<td>160</td>
<td>15.6</td>
</tr>
<tr>
<td>Vegetable soup ((n = 345))</td>
<td>222.1 ± 35.2</td>
<td>86.5</td>
<td>385.2</td>
<td>250</td>
<td>−27.9</td>
</tr>
</tbody>
</table>

\* \(p\) values according to the tests Student and Wilcoxon at a confidence level of 95%. SD—Standard Deviation.

Table 2 presents the food waste data. During the study period, a total of 6071.0 kg of food was produced, and a total of 1253.6 kg of food was wasted, representing a daily average of 65.9 kg of food waste (20.8%). The daily average of leftovers was 11.3 ± 4.4%, while the daily average of plate waste was 10.7 ± 4.0%. It was estimated that 126.6 g of food was wasted per consumer per day.

Table 2. Total food waste in lunch served in university canteen during the study period \((n = 10,278\) meals).

<table>
<thead>
<tr>
<th>Food Produced (kg)</th>
<th>Leftovers (kg)</th>
<th>Plate Waste (kg)</th>
<th>Food Waste (kg)</th>
<th>Leftovers (%)</th>
<th>Plate Waste (%)</th>
<th>Food Waste (%)</th>
<th>Average Consumption per Capita (g)</th>
<th>Average per Capita Food Waste (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>6071.0</td>
<td>678.8</td>
<td>573.9</td>
<td>1252.6</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>319.5 ± 44.3</td>
<td>35.7 ± 14.0</td>
<td>30.2 ± 12.2</td>
<td>65.9 ± 16.9</td>
<td>11.3 ± 4.4</td>
<td>10.7 ± 4.0</td>
<td>20.8 ± 4.9</td>
<td>474.9 ± 72.3</td>
</tr>
<tr>
<td>Maximum</td>
<td>391.0</td>
<td>67.0</td>
<td>51.0</td>
<td>98.0</td>
<td>21.0</td>
<td>18.0</td>
<td>27.56</td>
<td>580.4</td>
</tr>
<tr>
<td>Minimum</td>
<td>242.0</td>
<td>12.0</td>
<td>12.0</td>
<td>27.0</td>
<td>3.0</td>
<td>4.0</td>
<td>7.96</td>
<td>355.7</td>
</tr>
</tbody>
</table>

The values for vegetable soup, sweet dessert, and bread were not included. SD—Standard Deviation.

Table 3 presents the results for food waste, plate waste and leftovers by meal option (fish, meat and vegan). The highest values of plate waste and food waste obtained were for the meat option (12.6% and 18.6%, respectively). Nevertheless, the vegan option presented the highest value of food waste per capita (71.0 g versus 40.4 g for fish dish and 43.6 g for meat dish).
Table 3. Food waste in lunch served in university canteen during the study period, according to the meal option.

<table>
<thead>
<tr>
<th>Meal Option</th>
<th>Leftovers (kg)</th>
<th>Plate Waste (kg)</th>
<th>Food Waste (kg)</th>
<th>Leftovers (%)</th>
<th>Plate Waste (%)</th>
<th>Food Waste (%)</th>
<th>Average Consumption per Capita (g)</th>
<th>Average per Capita Food Waste (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fish dish (n = 2401)</td>
<td>30.4</td>
<td>66.6</td>
<td>970</td>
<td>5.2</td>
<td>12.1</td>
<td>16.7</td>
<td>201.3</td>
<td>40.4</td>
</tr>
<tr>
<td>Meat dish (n = 6917)</td>
<td>111.3</td>
<td>190.3</td>
<td>301.6</td>
<td>6.9</td>
<td>12.6</td>
<td>18.6</td>
<td>190.5</td>
<td>43.6</td>
</tr>
<tr>
<td>Vegan dish (n = 768)</td>
<td>19.6</td>
<td>34.9</td>
<td>54.5</td>
<td>5.8</td>
<td>10.9</td>
<td>16.1</td>
<td>370.9</td>
<td>71.0</td>
</tr>
</tbody>
</table>

Table 4 shows the results for food waste by food category—vegetable soup, carbohydrate side dish (rice, potato, pasta, pulses, quinoa), vegetable side dish, fruit, sweet dessert and bread. Vegetable soup and fruit presented high food waste (27.4% and 43.8%), mainly resulting from vegetable soup produced that was not served (20.5%) and fruit prepared that was not served (24.4%). On the other hand, salads and vegetables presented high food waste values (41.4%), mainly from plate waste (29.6%).

Table 4. Food waste in lunch served in university canteen during the study period, according to the food category.

<table>
<thead>
<tr>
<th>Food Category</th>
<th>Leftovers (kg)</th>
<th>Plate Waste (kg)</th>
<th>Food Waste (kg)</th>
<th>Leftovers (%)</th>
<th>Plate Waste (%)</th>
<th>Food Waste (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetable Soup</td>
<td>356.6</td>
<td>119.0</td>
<td>475.6</td>
<td>20.5</td>
<td>8.6</td>
<td>27.4</td>
</tr>
<tr>
<td>Rice</td>
<td>118.0</td>
<td>82.5</td>
<td>200.5</td>
<td>9.2</td>
<td>7.1</td>
<td>17.2</td>
</tr>
<tr>
<td>Potato</td>
<td>41.2</td>
<td>37.6</td>
<td>78.7</td>
<td>10.9</td>
<td>11.2</td>
<td>23.4</td>
</tr>
<tr>
<td>Pasta</td>
<td>2.1</td>
<td>5.7</td>
<td>7.8</td>
<td>3.7</td>
<td>10.4</td>
<td>14.2</td>
</tr>
<tr>
<td>Pulses</td>
<td>1.9</td>
<td>0.8</td>
<td>2.7</td>
<td>11.0</td>
<td>5.2</td>
<td>17.5</td>
</tr>
<tr>
<td>Quinoa</td>
<td>0.0</td>
<td>1.8</td>
<td>1.8</td>
<td>0.0</td>
<td>20.2</td>
<td>20.2</td>
</tr>
<tr>
<td>Salad and vegetables</td>
<td>64.8</td>
<td>164.0</td>
<td>228.7</td>
<td>10.5</td>
<td>29.6</td>
<td>41.4</td>
</tr>
<tr>
<td>Fruit dessert</td>
<td>280.2</td>
<td>99.8</td>
<td>380.0</td>
<td>24.4</td>
<td>11.5</td>
<td>43.8</td>
</tr>
<tr>
<td>Sweet dessert</td>
<td>-</td>
<td>23.8</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Bread</td>
<td>-</td>
<td>13.4</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

4. Discussion

This study intends to evaluate food waste and the adequacy of portions served in a Portuguese university canteen.

Our results show that the portions served were inadequate for all the meal components considering the reference values [32,35]. It was observed that the portions of meat and fish, pasta, potato, fruit and bread served at the university canteen exceeded the recommended values [32,35]. It is important to note that meat and fish represented the food category with the highest inadequacy values (77.7%), being offered in a quantity much higher than the recommended value. According to the last National Food, Nutrition and Physical Activity Survey, young adults are the age group with the highest consumption of meat and fish in relation to the recommended values, which may be influenced by the inadequate portions served in some institutional canteens, such as university canteens [36].

It is well known that meat consumption presents a high environmental footprint [37]. Reducing meat consumption was identified as an increasingly important strategy for minimizing the impact of climate change. Some studies explain that changing to more sustainable eating patterns, with lower meat consumption, could reduce greenhouse gas (GHG) emissions by up to 55% [38]. In addition to the urgent need to reduce the consumption of animal-based foods, increasing adherence to the Mediterranean diet can significantly contribute to reducing total CO₂ emissions, thus protecting the environment as well as individual health [29,39].

This study also shows that salads and vegetables (−27.9%) and vegetable soup (−11.2%) were the meal components that fell furthest away from the recommended quantity in the opposite direction; i.e., the average portion was significantly lower than
recommended. The low availability of salads and vegetables on the plate could be explained by the weak preference of university students for these food items, not requesting them during the plating moment. These results seem to be in line with studies that suggested that university students have a low intake of vegetables, pulses, fiber-rich foods and a high consumption of energy-dense foods [40–44], and they are also in accordance with the results of the National Food, Nutrition and Physical Activity Survey [36].

The low offer of plant-based foods and high offer of animal-based foods observed in this study demonstrate the need to reverse this trend, with a focus on better individual health and better health for the planet. It is, therefore, important to promote a healthy and sustainable diet, with a greater consumption of fruit, vegetables, nuts and pulses, along with small portions of meat, in order to achieve the Sustainable Development Goals, namely SDG 12—sustainable consumption and production [45,46].

The high standard deviation observed for food served, especially in the meat and fish, vegetable and potato components, reveals a lack of standardization in the portions served. These results can be explained by the fact that students can request the quantity they want during plating, but also because of a lack of standard utensils for plating, as well as a lack of training and definition of standard portions. Cooks should be sensitized to the impact and consequences of food waste and receive ongoing training sessions [21,47]. In addition, the lack of a meal booking system means that the portions of each meal option are not planned properly. The quantities of food to be prepared result from an estimate based on the previous year’s sales and could be affected by daily fluctuations in the number of consumers, due to assessment periods and school absences, among others [21].

This study found a value of food waste greater than 15% (20.8%), which, according to the classification of Nonino-Borges et al., defines the food service as “bad” and points to the need for optimization procedures in its management [48]. The observed value of food waste is concerning, surpassing the acceptable thresholds. It should be emphasized that the amount of food waste may be even higher than observed, as it was not possible to assess all the vegetable soup, sweet desserts and bread wasted. Another study stated that the plate waste index should be lower than 10% for healthy users [49] and, according to Vaz, should not exceed 7% or 25 g of food waste per capita [50]. In our study, the plate waste index (10.7%) was very close to the acceptable value. However, when we compared food waste per capita with the reference value, it was perceived that food waste was much higher (126.7 g per capita) than the reference value (25 g) [50], representing high economic and environmental losses. The importance of reducing food waste is highlighted for its critical role in promoting access to sufficient nutrients and establishing a sustainable food system for the entire population. The emphasized benefits include positive impacts on the environment, health and social aspects, along with economic gains [51].

Concerning the food waste by food category, the highest food waste values were observed for plant-based food, namely fruit (43.8%), salad and vegetables (41.4%) and vegetable soup (27.4%). According to this, it is important to promote plant-based meals and the Mediterranean diet, encouraging healthy and sustainable eating habits in university students [29,47].

University canteens are an ideal setting to promote healthy eating practices and habits [52,53]. Moreover, university students are receptive to health promotion tools like educational tools that raise awareness about the healthiest choice, as well as to an increase in menu variety with the availability of different healthier options [54,55].

Food waste is inversely related to the consumer acceptance of meals, and high food waste can represent dissatisfaction with the meal, the service or inadequate and/or poorly executed planning [56]. It can also be related to the sensory quality of the food prepared and the user’s commitment to the meal served. Food waste represents a decrease in the possible profit for the institution and a consequent increase in costs [57]. In this way, it is worth highlighting the role that measuring food waste on an ongoing basis play in improving the effectiveness and efficiency of food service. Strategies should, therefore, be
adopted to minimize these losses and identify the sources of the main economic losses so that they can be redirected towards the purchase of higher-quality products with a reduced environmental footprint, emphasizing seasonal and locally produced products [51]. Also, the implementation of a pre-meal booking system, which allows for better planning and management, could be a strategy to adopt, as it allows you to prepare and cook an adequate amount of food for the number of consumers and can help reduce food waste [46].

In this study, the highest plate waste values represent, simultaneously, the component with the highest and most inadequate portions served compared to the reference values.

Considering the principles of a sustainable diet, namely reducing meat consumption and food waste, it is urgent to adjust the portion of meat served according to the guidelines to promote more sustainable consumption and also to reduce the waste associated with this component. According to McKay et al., students prefer medium portions to large portions, so adjusting portions is a strategy that is generally well accepted by students [58]. On the other hand, other authors have shown that although meat is an important component of university students’ diets, their motivation and interest in environmental issues may help to reduce the demand for meat-based meals and the quantities consumed of this type of food [59]. The results from this study show that there is an urgent need to adjust the portions of the different components of meals, especially meat and fish, since they also present a high level of food waste.

To promote healthy eating, it is known that food literacy is an important determinant of eating behavior. In this sense, universities present an opportunity to increase the food literacy of their students by developing awareness-raising activities and culinary workshops [60,61]. Additionally, different strategies have been described to promote a healthier eating pattern with a low footprint and to reduce food waste in university canteens, namely increasing the availability of healthy food at low prices, including nutritional information on food items and menus, offering balanced and sustainable menus, improving the canteen’s environment and providing different portions tailored to students’ needs [34,46,54,58,62,63].

Some limitations were identified in this study. Vegetable soup, sweet desserts and bread were not considered in total food waste, as it was not possible to obtain detailed information on the number of complete meals or meals that included these components. The initial quantity of bread and sweet desserts was not assessed, so it is only possible to present the quantity of food waste (g) and not the food waste index (%). It was not possible to determine side dish and vegetable food waste per consumer, as it was not possible to assess the number of consumers choosing each of the different options.

5. Conclusions

Our findings show an inadequacy in the portions served in the university canteen under study, with the portions of plant-based foods (vegetable soup, vegetables, salads and rice) being much lower than recommended and the portions of animal-based foods (meat and fish) being excessive compared to the reference portion. Additionally, high values of food waste were found for all meal components, with vegetable soup, vegetables, salads and fruit being the items that presented the highest values of food waste. These results reinforce the inadequate consumption of these food groups, which, consequently, results in a failure to meet the nutritional goals associated with the lunch served in the university canteen. A positive food environment at the university canteen that raises a healthy food pattern should be promoted through food literacy; involving students and staff is key to improve the adequacy of the meals served and reduce food waste in this setting.

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**Conflicts of Interest:** The authors declare no conflicts of interest.

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