

# FORUM

Submitted 03.30.2020. Approved 03.31.2021

Evaluated through a double-blind review process. Guest Editors: Luciana Marques Vieira, Marcia Dutra de Barcellos, Gustavo Porpino de Araujo, Mattias Eriksson, Manoj Dora, and Daniele Eckert Matzembacher

Original version | DOI: <http://dx.doi.org/10.1590/S0034-759020210507>

## FOOD WASTE: EVIDENCE FROM A UNIVERSITY DINING HALL IN BRAZIL

*Desperdiço de alimentos: Evidências de um refeitório universitário no Brasil*

*Desperdiço de alimentos: Evidencias de un restaurante universitario en Brasil*

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### ABSTRACT

Studying the causes of food waste and potential interventions for minimizing it is one of the main concerns of those who work with food on all levels. Food in the education sector, which includes dining halls in higher education institutions, is among the sectors that deserve attention, since its consumers generate significant amounts of food waste. There is still a lack of studies, however, addressing the problem of food waste in dining halls. The general objective of this study is to investigate food waste in a Brazilian university dining hall, and consumer perceptions of the meals. By means of a questionnaire, it was possible to investigate the main perceptions of consumers, and what might be behind the waste generated. Spearman's correlation was performed in order to verify the correlation between consumer food waste and consumer perceptions as to the reasons behind the food waste that is generated. It was found that average waste was 68g/consumer. It was also observed that consumers who placed their food in trays wasted more food than those who chose to eat from a dish. All the collected information was used to propose potential interventions to reduce food waste in university dining halls.

**KEYWORDS** | Food waste, university, dining hall, perception, consumers.

### RESUMO

O estudo das causas do desperdiço alimentar e das potenciais intervenções para a sua minimização está entre as preocupações centrais daqueles que trabalham com alimentos. A alimentação na educação, que inclui os refeitórios das universidades, está entre os setores que merecem atenção, uma vez que quantidades significativas de alimentos são desperdiçadas pelos consumidores. Entretanto, ainda há uma escassez de estudos que abordem o problema. Este estudo teve como objetivo geral investigar o desperdiço de alimentos em um refeitório de uma universidade brasileira, bem como a percepção dos consumidores em relação às refeições servidas. Por meio de um questionário, foi possível investigar quais as principais percepções dos consumidores, e o que poderia estar por trás da geração do desperdiço. Utilizou-se a correlação de Spearman a fim de verificar a correlação entre o desperdiço alimentar e a percepção dos consumidores sobre as razões por trás da geração do desperdiço. Verificou-se um desperdiço médio de 68 g/consumidor. Além disso, foi observado que os consumidores que colocavam os alimentos em bandejas desperdiçavam mais alimentos do que aqueles que optavam por comer em pratos. As informações coletadas foram utilizadas para propor potenciais intervenções voltadas à redução do desperdiço de alimentos em refeitórios universitários.

**PALAVRAS-CHAVE** | Desperdiço de alimentos, universidades, refeitório, percepção, consumidores.

### RESUMEN

El estudio de las causas del desperdiço de alimentos y las posibles intervenciones para reducirlo al mínimo son algunas de las preocupaciones centrales de quienes trabajan con alimentos. La alimentación en la educación, que incluye los restaurantes de las universidades, es uno de los sectores que merecen atención, ya que los consumidores desperdician cantidades importantes de alimentos. Sin embargo, todavía hay escasez de estudios que aborden el problema. Este estudio tenía el objetivo general de investigar los residuos de comida en una cafetería de una universidad brasileña, así como la percepción de los consumidores sobre las comidas servidas. Mediante un cuestionario se pudo investigar cuáles eran las principales percepciones de los consumidores y cuáles podían estar detrás de la generación de desechos. La correlación de Spearman se realizó con el fin de verificar la correlación entre el desperdiço de alimentos y la percepción de los consumidores sobre las razones que motivan la generación de desechos. Se verificó un promedio de desperdiço de 68g/consumidor. Además, se observó que los consumidores que ponían comida en bandejas desperdiciaban más comida que los que elegían comer en los platos. La información reunida se utilizó para proponer posibles intervenciones para reducir el desperdiço de alimentos en los comedores universitarios.

**PALABRAS CLAVE** | Desperdiço de alimentos, universidades, restaurante, percepción, consumidores.

## INTRODUCTION

It is estimated that 1.3 billion tons of food are lost or wasted annually, which is equivalent to 30% of the world's food production, with a monetary value that equates to US\$ 750 billion (FAO, 2013). As food production is resource intensive, food losses and waste are indirectly accompanied by an extensive variety of environmental, social and economic impacts (Schanes, Dobernig, & Gözet, 2018).

Food waste is commonly grouped into three categories (Richter & Bokelmann, 2016): (i) avoidable, (ii) possibly avoidable, and (iii) unavoidable food waste. Some studies argue that only the avoidable and possibly avoidable waste comprises food that is considered edible under normal conditions (Grandhi & Singh, 2016). Unavoidable food waste is the waste from food that is inedible under normal circumstances (e.g., bones) (Brancoli, Roustia, & Bolton, 2017). Papargyropoulou, Lozano, Steinberger, Wright and Ujang (2014) mention the relevance of distinguishing between avoidable and unavoidable food waste as a key factor in any food waste prevention strategy.

The amount of food lost or wasted diverges between countries and can be influenced by factors such as income levels, industrialization and development (Chalak, Abou-Daher, Chaaban, & Abiad, 2016). Different definitions and a lack of standards for data collection around the world make it difficult to understand the scope of food losses and waste. Food losses are generally attributed to inadequate agricultural practices, technical constraints, financial and labor constraints, and inadequate infrastructure for storage, processing and transportation (Chaboud & Daviron, 2017; Gustavsson, Cederberg, Sonesson, Otterdijk, & Meybeck, 2011). For some authors, food waste is mainly driven by consumers' values, behaviors and attitudes (Chaboud & Daviron, 2017; Gustavsson et al., 2011).

Brazilian food waste started being studied in a more intense way in the late 1990s, when food security became more widely debated in Brazilian society (Porpino, Parente, & Wansink, 2015). In 2003, the *Fome Zero* (Zero Hunger) program was created to ensure the implementation of food security policies (Porpino et al., 2015), and in 2014 Brazil was removed from the World Hunger Map for the first time. The number of undernourished people in Brazil fell by more than 80% in ten years. The new status was achieved through a combination of public policies and an increase in food supply in the domestic market, as a result of the excellent agricultural production performance in Brazil (Porpino et al., 2015).

No in-depth food waste studies in university settings have ever been carried out (Stockli, Dorn, & Liechti, 2018). Deliberador, Batalha, Mozambani, Müller and Fontenelle (2018), for example, conducted an extensive systematic review of the literature in the management area using five databases and found few articles that address food waste in university dining halls. Their findings did show, however, an evolution in the number of publications over the years and potential areas of study. In order to reduce food waste, it is necessary to quantify the waste generated (Eriksson et al., 2018). Any examination of food waste in service institutions, however, calls for accurate data (Eriksson et al., 2018). Some studies are based mainly on qualitative observations (Hanks Wansink, & Just, 2014). Indeed, the scope and research methods used for quantifying food waste in previous studies vary.

Food waste research was initially performed in the education and health sectors (Miroso, Munro, Mangan-Walker, & Pearson, 2016). Here, the education sector was considered as an object of study. A number of studies have previously been carried out in the education sector, with different objectives. For example, Thiagarajah and Getty (2013) investigated how changing the service system could reduce food waste in the Indiana University (United States) dining hall; Babich and Smith (2010) tried to understand the University of Southern Illinois' dining hall sustainability process (United States); and Jagau and Vyrastekova (2017) proposed implementing an information

campaign to increase awareness of the food waste problem in the Radboud University (Netherlands) dining hall. In Brazil, [Siqueira, Cavalcante, Leme, Santos and Oladeinde \(2007\)](#) carried out an educational project to minimize food waste in the São Paulo University (São Carlos) dining hall. As a result, food waste in trays reduced from 83.1g to 60.1g.

Higher education institutions' food service operations provide an opportunity to obtain data from a controlled environment. Once service operations become the subject of management practices, it is possible to facilitate interventions more readily for reducing food waste ([Costello, Birisci, & McGarvey, 2016](#)). [Gao, Tian, Wang, Wennersten and Sun \(2017\)](#) suggest observing university dining halls because they consume significant amounts of resources, mainly energy and water, and generate large amounts of food waste ([Babich & Smith, 2010](#)). As [Babich and Smith \(2010\)](#) state, higher education institutions perform a fundamental role in the development of sustainable food policies.

Food waste threatens the main purpose of university dining halls, which is to provide its consumers with a proper, balanced daily meal ([Boschini, Falasconi, Giordano, & Alboni, 2018](#)). Large amounts of food waste commonly indicate operational deficiencies, for example, poor food quality, inadequate portion sizes and menu inefficiency ([Al-Domi et al., 2011](#)). Higher education institutions can be considered to be smaller versions of cities, and their activities have potential financial and environmental implications ([Boschini et al., 2018; Marais, Smit, Koen, & Lötze, 2017](#)). Knowing the amount of food wasted, therefore, and proposing effective interventions can result in financial savings and be of benefit to the environment ([Eriksson, Ghosh, Mattsson, & Ismatov, 2017](#)).

This research was conducted in a Brazilian federal university dining hall. This university has 39 undergraduate courses and 63 graduate courses, and is one of the 10 biggest universities in Brazil. Its academic community is divided into 8,486 undergraduate students, 3,259 graduate students, 903 professors, and 745 administrative officers.

In Brazil, 88.8% of the federal universities have at least one dining hall ([Deliberador, 2019](#)). The objective of this study was to answer the following questions: (1) What amount of food is wasted in total and *per capita* in a Brazilian university dining hall? (2) What are the consumers' perceptions of the reasons behind the food waste generated? (3) Which reasons most influence food waste generation in Brazilian university dining halls? (4) Which potential interventions could be recommended for reducing food waste generation in Brazilian university dining halls?

The research is organized as follows. In Section 1, we present a contextualization of the study. The materials and methods are presented in Section 2. In Section 3, the measured food waste generation is presented. The consumers' perceptions of the reasons behind food waste generation and a correlation analysis are presented in Section 4. Potential interventions for reducing food waste are discussed in Section 5. Section 6 concludes the study.

## MATERIAL AND METHODS

### Study area

The study took place in the dining hall of a federal university in Brazil. The dining hall was inaugurated in August 1979 and is the main food facility on the university campus. At present, the facility has 85 employees and distributes about 4,500 meals a day (3,000 meals at lunch time and 1,500 meals at dinner) to students, professors, trainees,

staff, and other members of the academic community. The main objective of the dining hall is to provide those who use it with healthy, low-cost meals, in a way that makes it easy for them to stay at the university throughout the day.

The meals that are provided to the dining hall's customers include rice, beans, side dishes, leafy salads and vegetables. There are also two dietary options available: one derived from animal protein, and one that is vegetarian (plant-based protein). The meals are accompanied by desserts, which can be a fruit or a sweet dish. The consumers are allowed to serve themselves. The two diet dishes available, however, are served by the dining hall's employees, who place the meat or the plant-based protein on the consumer's plate in standard portions.

From Monday to Friday, the facility serves lunch from 11:15 a.m. to 1:30 p.m., and dinner from 5:15 p.m. to 7:00 p.m. On Saturdays, the dining hall serves only lunch and operates from 11:30 to 1:00 p.m. Access to the facility is computerized and users are obliged to present an institutional identification card, which is personal and non-transferrable. The meal prices in US dollars (1USD = 3.81 BRL) for each category considered are as follows: scholarship students = \$0.00; undergraduate and graduate students = \$0.47; administrative officers & trainees = \$0.58; professors = \$0.71; and visitors = \$0.68.

## Sampling strategy

The study verified the amount of food wasted by consumers in a Brazilian university dining hall during lunch time, and explored the factors that have an influence on variations in the amount of food wasted. The sample was calculated based on the estimate of the population that eats there on any one day (3,000 consumers). For this calculation, a 95% confidence level ( $Z_{\alpha/2}$ ) and a 5% sampling error (E) were considered. This resulted in 342 consumers participating in this study.

As the dining hall operates over a period of 2 hours and 15 minutes, at least three consumers per minute were approached, meaning that more than 342 participants were randomly selected. The large number of consumers approached is justified because some questionnaires might be returned with incomplete information; some participants might not return the questionnaire at all; and the confusing mixture of plates/trays from different consumers might make it impossible to associate the amount of food wasted with the questionnaire completed by the corresponding consumer.

## Data collection

The study was conducted in the second semester of 2018 over the course of three days, when there were different menus at lunchtime. Ethical clearance for the study was obtained from the São Carlos Federal University Ethics Committee. To avoid tendentious eating behaviors among consumers during data collection, they were not told about the imminent study beforehand. Data were collected in two stages: first, the questionnaires were delivered to the consumers to gain their insights into self-identification and their perceptions of the reasons behind food waste; second, consumers were invited to hand over their questionnaires when they returned the plate or tray they had used during lunch. The questionnaire was divided into two sections: the consumers' characteristics and the consumers' perceptions.

Section 1 collected information about the institution's consumer category, sex, age group, dishware used for the meal (plate or tray), and the protein chosen (animal or plant-based). Section 2 was based on the outcome of a systematic literature review that was undertaken in line with the guidelines in [Tranfield, Denyer and Smart \(2003\)](#), and involved the five databases (Engineering Village, ProQuest, Scopus, Web of Science and Scielo) used

by Deliberador et al. (2018). Based on the results of this systematic literature review, twelve items/questions were formulated by the authors to evaluate the consumers' perceptions of the reasons behind the food waste generated (Table 1).

**Table 1. Reasons behind food waste generation**

Variable	Perception	Reference
	Quality	
FW1	Taste	Betz et al. (2015); Miroso et al. (2016); Painter et al. (2016); Jagau and Vyrastekova (2017); Lorenz et al. (2017); Alias et al. (2017); Qi and Roe (2017); Lorenz and Langen (2018); Youngs et al. (1983); Kuo and Shih (2016); Marais et al. (2017).
FW2	Odor	
FW3	Appearance	
FW4	Texture	
FW5	Temperature	
FW6	Preparation/Cooking	Youngs et al. (1983); Betz et al. (2015); Rizk and Perão (2015); Zotesso et al. (2016); Lorenz et al. (2017); Marais et al. (2017); Lorenz and Langen (2018).
FW7	Menu Composition	Babich and Smith (2010); Miroso et al. (2016); Zotesso et al. (2016); Kuo and Shih (2016); Lorenz et al. (2017); Lorenz and Langen (2018).
	Portion Size	
FW8	Amount of protein served by the dining hall employees	Youngs et al. (1983); Al-Domi et al. (2011); Betz et al. (2015); Miroso et al. (2016); Painter et al. (2016); Kuo and Shih (2016); Jagau and Vyrastekova (2017); Lorenz et al. (2017); Marais et al. (2017); Lorenz and Langen (2018).
FW9	Amount of other food served by the dining hall consumers	
	Satiety	
FW10	Degree of satiation of the consumers before they had the meal	Bankson (2009); Betz et al. (2015); Miroso et al. (2016); Painter et al. (2016); Lorenz et al. (2017).
	Time	
FW11	Time available to consumers to have the meal	Al-Domi et al. (2011); Betz et al. (2015); Miroso et al. (2016); Painter et al. (2016); Lorenz et al. (2017); Lorenz and Langen (2018).
	Emotion	
FW12	Consumer stress level during the meal	Randall and Sanjur (1981); Al-Domi et al. (2011); Betz et al. (2015); Miroso et al. (2016); Lorenz and Langen (2018); Rizk and Perão (2015); Jagau and Vyrastekova (2017); Marais et al. (2017).

A five-point Likert scale was used in the second section of the questionnaire. Responses could range from 1 to 5 points, where 1 point corresponded to a less relevant alternative, and 5 points referred to an extremely relevant alternative. Consumers were asked to express their perception of each of the twelve items. Likert scales are scales of psychometric responses used predominantly in questionnaires aimed at evaluating participants' opinions about certain affirmations/questions (Joshi, Kale, Chandel, & Pal, 2015). The questionnaire is shown in Table 2.

Table 2. Research questionnaire

Category	<input type="checkbox"/> Scholarship Students <input type="checkbox"/> Undergraduate & Graduate Students <input type="checkbox"/> Administrative Officers & Trainees <input type="checkbox"/> Professors <input type="checkbox"/> Visitors				
Gender	<input type="checkbox"/> Male <input type="checkbox"/> Female				
Age	<input type="checkbox"/> 18 <input type="checkbox"/> 19 – 25 <input type="checkbox"/> 26 – 30 <input type="checkbox"/> 31 – 40 <input type="checkbox"/> ≥ 41				
Which dishware did you use today in your meal?	<input type="checkbox"/> Plate <input type="checkbox"/> Tray				
What protein did you consume today?	<input type="checkbox"/> Plant-based protein <input type="checkbox"/> Animal				
Please answer the following questions, where: (1) poor – (2) fair – (3) good – (4) very good – (5) excellent.	<b>Source</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b> <b>5</b>
<b>FW1:</b> How would you rate the taste of the food offered today?	Jagau and Vyrastekova (2017)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>FW2:</b> How would you rate the odor of the food offered today?	Lorenz et al. (2017)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>FW3:</b> How would you rate the appearance of the food offered today?	Lorenz et al. (2017)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>FW4:</b> How would you rate the texture of the food offered today?	Betz et al. (2015)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>FW5:</b> How would you rate the temperature of the food offered today?	Marais et al. (2017)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Please answer the following question, where: (1) strongly disagree – (2) somewhat disagree – (3) neither agree nor disagree – (4) somewhat agree – (5) strongly agree.	<b>Source</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b> <b>5</b>
<b>FW6:</b> In general, do you consider that the food offered today was prepared/cooked correctly?	Betz et al. (2015)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Please answer the following question, where: (1) poor – (2) fair – (3) good – (4) very good – (5) excellent.	<b>Source</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b> <b>5</b>
<b>FW7:</b> How would you rate the menu options offered today?	Betz et al. (2015)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Please answer the following questions, where: (1) insufficient – (2) somewhat insufficient (3) – neither insufficient nor sufficient – (4) somewhat sufficient – (5) sufficient.	<b>Source</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b> <b>5</b>
<b>FW8:</b> How would you rate the amount of protein that was served by the dining hall employees to you today?	Lorenz and Langen (2018)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>FW9:</b> Regarding the other food that you served yourself with, do you consider the quantity was:	Lorenz and Langen (2018)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Please answer the following question, where: (1) not hungry – (2) slightly hungry – (4) moderately hungry – (4) very hungry – (5) extremely hungry.	<b>Source</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b> <b>5</b>
<b>FW10:</b> Before having lunch, you were:	Mirosa et al. (2016)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Please answer the following question, where: (1) insufficient – (2) somewhat insufficient (3) – neither insufficient nor sufficient – (4) somewhat sufficient – (5) sufficient.	<b>Source</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b> <b>5</b>
<b>FW11:</b> How would you rate the time you had available for lunch today?	Marais et al. (2017)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Please answer the following question, where: (1) not at all – (2) slightly – (3) moderately – (4) very – (5) extremely.	<b>Source</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b> <b>5</b>
<b>FW12:</b> How would you rate your stress level today?	Mirosa et al. (2016)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

For the second stage of the data collection, a digital scale (5g of precision) was used as a measurement instrument. The inevitable unavoidable food waste (e.g., bones, banana and orange peel, etc.) was separated from the avoidable waste. When the participants handed back their plates or trays, two volunteers removed the cutlery and all the food that was considered to be unavoidable and inevitable waste, so only the avoidable waste was measured. To ensure participant anonymity, names were not collected during either stage. Participants were selected by simple random sampling.

## Data analysis

The statistical software SPSS® (Statistical Package for the Social Sciences) version 21.0 was used in this study for data analysis. A descriptive analysis of the collected data was conducted to verify the central and dispersion tendency measures of the sample. Mean, median, standard deviation and coefficient of variation were used in this study. Daily food waste was calculated from the sum of all the food waste generated by the consumers who took part in the research. The *per capita* mean food waste was also calculated by dividing the daily food waste by the number of consumers in the sample. A T-test was conducted to compare the food waste means of consumers who used plates and trays; consumers who ate animal and plant-based proteins; and male and female consumers. Finally, Spearman's correlation was performed to establish the correlation between consumer food waste and consumer perceptions of the reasons behind the generation of food waste.

## Study limitations

The limitations of this study lie in the fact that only one dining hall was analyzed, which means that the results can only be generalized for the place we studied. Data were collected on only 3 days, and involved 3 different types of menu. Moreover, by separating the types of waste (avoidable and unavoidable), only avoidable food waste was quantified. Time limitations and access to the study object made it difficult to measure unavoidable food waste and replicate the research on other days and in other facilities. As with any questionnaire research, the reliability and accuracy of the data may have been compromised by various limitations, such as the reliability of the memory and the honesty of participants (Hallström & Börjesson, 2013).

Among the major limitations of this study one stands out: the time available for collecting data. Considering the minimum sample size (342 consumers) and the time that the dining hall operates during the lunch period (2 hours and 15 minutes), it was necessary to approach at least three consumers per minute to achieve the objectives, even though we were able to count on the collaboration of a team of six people.

## FOOD WASTE GENERATION AND CONSUMER PERCEPTIONS

Table 3 highlights the findings relating to the food waste generated, according to sex, choice of dishware and protein consumed. Measurement resulted in food waste of 68g per consumer. It is important to emphasize that this study only considered avoidable and possibly avoidable food waste during measurement. The literature considers that 7 to 25g of food waste per consumer/meal is common (Vaz, 2006).

Male consumers accounted for 57.04% of the sample. With regard to the dishware available, trays were used the most by the consumers (54.65%). The larger percentage for trays is an interesting result, since a number

of studies in the literature (Babich & Smith, 2010; Kim & Morawski, 2013; Lorenz & Langen, 2018; Marais et al., 2017; Miroso et al., 2016; Painter, Thondhlana, & Kua, 2016; Qi & Roe, 2017; Thiagarajah & Getty, 2013; Wansink & Just, 2013) present cases of dining halls that, by replacing trays with plates, managed to reduce food waste by a significant amount.

**Table 3. Food waste generation**

		Results				
Variables		Consumers (n)	Consumers (%)	Food Waste (kg)	Food Waste (kg)/n	Food Waste (%)
Category	Scholarship Students	269	24.75	21.216	0.079	28.84
	Undergraduate & Graduate Students	746	68.63	47.286	0.063	64.28
	Administrative Officers & Trainees	53	4.88	3.915	0.074	5.32
	Professors	10	0.92	0.546	0.055	0.74
	Visitors	9	0.83	0.600	0.067	0.82
	Total	1087	100.00	73.562	0.068	100.00
Sex	Male	620	57.04	41.221	0.066	56.04
	Female	467	42.96	32.341	0.069	43.96
	Total	1087	100.00	73.562	0.068	100.00
Dishware	Tray	594	54.65	53.405	0.090	72.60
	Plate	493	45.35	20.157	0.041	27.40
	Total	1087	100.00	73.562	0.068	100.00
Protein	Plant-based protein	97	8.92	7.365	0.076	10.01
	Animal	990	91.08	66.197	0.067	89.99
	Total	1087	100.00	73.562	0.068	100.00

Although the presented result of 68g per consumer seems high, this value is similar to that found in other studies carried out in Brazilian university dining halls at lunchtime, as can be seen in Table 4. It is noteworthy that some of these dining halls have adopted measures to reduce food waste. Such is the case with the University of São Paulo, which, after an awareness campaign, reduced food waste from 83.1g to 66.7g.

**Table 4. Food waste generation in Brazilian university dining halls**

Location	Per capita food waste generation	Reference
University of São Paulo	83.1g	Siqueira et al. (2007)
South Fluminense Region (the university's name was not disclosed)	9.02g	Lopes and Fonseca (2013)
Federal University of Santa Maria (Centro)	Between 37 and 92g	Zanini (2013)
Federal Rural University of Amazon	Between 20 and 40g	Paredes, Ladeira and Sá (2014)
Federal University of Technology - Paraná (Campo Mourão)	Between 65 and 102g	Vieira (2015)
São Paulo/SP (the university's name was not disclosed)	63.30g	Domingues et al. (2016)

Source: Santos (2016), adapted by the authors.

Food waste generated by male (66g) and female (69g) consumers was analyzed statistically by way of a T-test. When performing the T-test for equality of means, the p-value identified was higher than 0.05 (p-value (2-tailed) = 0.550). Therefore, with a 95% confidence level, the food waste generated by male and female consumers cannot be considered to be different. Similarly, after comparing food waste from consumers of plant-based (76g) and animal (67g) protein, with a 95% confidence level (p-value (2-tailed) = 0.260), the T-test for equality of means showed that there was no difference in the waste generated by either. However, when comparing the mean food waste generated by consumers who used trays (90g) and plates (41g), with a 95% confidence level (p-value (2-tailed) = 0.000), the T-test outcome confirms that the amount of food wasted in the dining hall was greater for consumers using trays rather than plates.

## Consumer perceptions

Consumer perceptions as to the reasons behind the food waste generated, and the mean, standard deviation, coefficient of variation, median, maximum and minimum values were calculated and are shown in Table 5.

**Table 5. Consumers' perception on the reasons behind food waste generation**

Variable	Likert Scale - Consumers (%)					Standard Deviation	Coefficient of Variation	Median
	1	2	3	4	5			
Taste	1.29	23.64	47.01	24.84	3.22	0.814	0.267	3.00
Odor	1.66	24.29	52.81	17.30	3.96	0.800	0.268	3.00
Appearance	3.22	24.01	43.51	24.10	5.15	0.903	0.297	3.00
Texture	2.85	25.85	45.35	22.26	3.68	0.862	0.289	3.00
Temperature	1.20	16.47	44.80	29.71	7.82	0.868	0.266	3.00
Preparation/Cooking	1.01	6.07	14.26	36.61	42.04	0.939	0.227	4.00
Menu Composition	4.32	26.13	41.03	23.18	5.34	0.938	0.314	3.00
Amount of protein served by the dining hall employees	7.18	22.17	57.77	8.83	4.05	0.849	0.303	3.00
Amount of other food served by the dining hall consumers	1.47	7.08	79.39	8.83	3.22	0.587	0.192	3.00
Degree of satiation of the consumers before they had the meal	0.58	25.02	41.40	18.68	4.32	0.999	0.356	3.00
Time available to consumers to have the meal	1.29	6.35	42.32	29.25	20.79	0.926	0.256	4.00
Consumer stress level during the meal	20.24	31.09	27.87	11.50	9.29	1.198	0.463	2.00

The coefficient of variation values for 11 out of 12 variables were higher than 20%, which means that there was no homogeneity in the responses obtained. The maximum and minimum values corroborate the explanation of the coefficient of variation values. All maximum response values were 5 points, and the minimum values, 1 point. This means that there were respondents who considered both extremely irrelevant and highly relevant alternatives for all variables. For the descriptive analysis, the median was considered to be a measure of central tendency.

The variables of taste (FW1), odor (FW2), appearance (FW3), texture (FW4) and temperature (FW5) gave a median value of 3, which is considered good according to the questionnaire alternatives. Food preparation/cooking (FW6) obtained a median value of 4, which indicates that the dining hall consumers partially agreed that the food was properly cooked/prepared. Menu composition (FW7) was assessed as being good. Both the amount of protein served by the dining hall employees (FW8) and the amount of other food that consumers served themselves (FW9) were considered neither insufficient nor sufficient.

The degree of satiation of consumers before they had the meal (FW10) obtained a median of 3, indicating that consumers considered themselves to be moderately hungry before having lunch. Regarding the availability of time for the meal (FW11), the consumers' responses obtained a median value of 4, meaning that consumers usually had more than enough time to eat. Finally, when verifying the emotional stress (FW12) of the participants, it is possible to observe from the median that users had lower levels of stress.

The degree of association of the variables and waste was measured using the Spearman correlation coefficient ( $\rho$ ). The Spearman correlation ( $\rho$ ) considers a range from +1 to -1. In this study, correlations with a statistical significance of  $p \leq 0.05$  were considered. Those outcomes that consider just the significant correlations are shown in Table 6.

**Table 6.** Spearman correlation of consumer's perceptions and waste amount

	Variables							
	Taste	Odor	Appearance	Texture	Temperature	Preparation/Cooking	Menu Composition	Degree of satiation of the consumers before they have the meal
<i>Spearman Correlation (<math>\rho</math>)</i>	-.132**	-.108**	-.067**	-.088**	-.094**	-.124**	-.112**	-.078*
<i>p-valor</i>	.000	.000	.027	.004	.002	.000	.000	.010

Notes: \*Significant correlation for  $p < 0.05$ ; \*\*Significant correlation for  $p < 0.01$ .

## DISCUSSION

The correlation analysis found that the relationship between food waste and the variables identified in the literature was the possible cause of waste in the dining hall. The outcomes revealed that the correlations were a mostly weak and weak to moderate relationship, with a negative sense of covariance. These correlations can be explained by elements found in the literature.

Correlations of taste, odor, appearance, texture and temperature corroborate the studies of [Alias, Mokhlis and Zainun \(2017\)](#), [Betz, Buchli, Göbel and Müller \(2015\)](#), [Jagau and Vyrastekova \(2017\)](#), [Kuo and Shih \(2016\)](#), [Lorenz and Langen \(2018\)](#), [Lorenz, Hartmann and Langen \(2017\)](#), [Marais et al. \(2017\)](#), [Miroso et al. \(2016\)](#), [Painter et al. \(2016\)](#), [Qi and Roe \(2017\)](#) and [Youngs, Nobis and Town \(1983\)](#), all of who highlight these five variables as potential causes of food waste in dining halls. Such negative correlations indicate that when an item was assessed as being satisfactory, food waste tended to be lower, at a significance level of 5%

Sensory responses to the taste, odor, appearance, texture and temperature of food have a tendency to determine consumer food preferences, and their acceptance or rejection habits ([Bhuiyan, 2015](#)). Considering, therefore, how the different sensorial characteristics of food influence food behavior contributes to the development of new meals and eating habits that could be used to promote a reduction in food waste ([McCrickerd & Forde, 2016](#)).

The correlation between taste and waste supports the studies of [Miroso et al. \(2016\)](#), who pointed out that taste is the main cause of the behavior that causes food waste. Different sensory receptors in the tongue are responsible for tasting, which plays an important role in the conclusions drawn about each type of food ([Mennella, 2014](#)). Taste is one of the most important sensory characteristics influencing food choice/disposal. The consumers in our study who assessed taste to be satisfactory tended to waste less food.

Consequently, the relationship between taste and odor is one of the main determinants of food preferences. The characteristics of the food - mainly taste, but also odor and appearance - are a central dimension of quality for consumers ([Ensaft et al., 2015](#); [McCrickerd & Forde, 2016](#)). The correlation of waste and odor complements what was discussed by [Boesveldt and Graaf \(2017\)](#). Odor mainly plays an anticipatory and appetizing role in food behavior, as it is able to generate a specific appetite for the food in question, and depending on other external or internal factors, to develop food preferences ([Boesveldt & Graaf, 2017](#)).

As identified by the correlations, appearance can also be considered in the discussion of food waste ([Aschemann-Witzel, Hooge, Amani, Bech-Larsen, & Oostindjer, 2015](#)). The appearance of food is a key factor that influences food preferences ([Laan, Ridder, Viergever, & Smeets, 2012](#); [Vilaro et al., 2018](#)). The appearance of food is the first impression a consumer gets. The impact of color on the consumer's perception of quality was widely studied by [Francis \(1995\)](#). [Francis \(1995\)](#) noted that color, as an aspect of appearance, has to be within an expected range for the food to be accepted, and the degree of acceptability is judged within that range. If the color is unacceptable, other major quality factors, such as taste and texture, are unlikely to be considered.

Texture includes the physical properties of food, including shape ([Gibson & Cooke, 2017](#); [Jeltem, Beckley, & Vahalik, 2015](#)). The correlation between waste and the consumers' perceptions of texture is in line with what was discussed in the studies of [Chambers and Bowers \(1993\)](#) and [Aschemann-Witzel et al. \(2015\)](#). Today's consumers are much more sensitive to subtle differences in texture than in taste, and tend to use texture as the main limiting factor for the acceptability of food ([Aschemann-Witzel et al., 2015](#); [Chambers & Bowers, 1993](#)).

As observed, waste was also correlated with the temperature of the food. These results indicate that the temperature of the food has implications for food consumption preferences, which is reinforced by the studies

of Zellner, Stewart, Rozin and Brown (1988) and Stroebele and Castro (2004). These studies demonstrate that the temperature at which food is consumed is affected primarily by the individual preference of each consumer. Consumers can accept certain foods at certain temperatures, but not at others. Temperature preferences are a reflection of an experience with a particular product. According to Zellner et al. (1988), these preferences may be based on a direct taste experience, socially disclosed information about taste, or general ideas about food.

In addition to these correlations, waste was associated with food preparation/cooking, meaning that there was a tendency among consumers who positively assessed this variable to waste less food, as confirmed by Betz et al. (2015), Lorenz and Langen (2018), Lorenz et al. (2017), Marais et al. (2017), Rizk and Perão (2015), Youngs et al. (1983) and Zotesso, Cossich, Colares and Tavares (2016).

This correlation can also be justified by what was discussed by Murimi, Chrisman, McCollum and McDonald (2016), who tried to understand consumer perceptions about menu options and to determine what could influence their food choices. The study found that in addition to consumers wanting the food to be properly prepared/cooked and always served hot, there was a concern that employees would not comply with food safety guidelines.

The correlation between menu composition and waste supported the findings of the studies of Babich and Smith (2010), Kuo and Shih (2016), Lorenz and Langen (2018), Lorenz et al. (2017), Miroso et al. (2016) and Zotesso et al. (2016). In these studies, the authors consider that waste observations can help identify which food consumers avoid eating. The negative correlation indicated that consumers who judged the food to be satisfactory, tended to waste less. This information allows managers and/or nutritionists to modify the menu to satisfy consumers and, consequently, generate less waste.

The correlation between waste and the time that consumers had for eating their meal corroborates what was found in the studies of Al-Domi et al. (2011), Betz et al. (2015), Lorenz and Langen (2018), Miroso et al. (2016) and Painter et al. (2016). According to these studies, the amount of time available for lunch is directly related to food waste. This correlation also complements the results of the Bergman, Buerger, Joseph and Sanchez (2000) research, which found that students with a shorter lunch period wasted, an average, 43.5% of their food, while those with a longer lunch period wasted 27%.

## POTENTIAL INTERVENTIONS FOR FOOD WASTE REDUCTION

In our study, waste is strongly related to the amount of protein that is placed in a standard quantity on the consumer's plate by an employee. This study recommends therefore, that portion sizes be reduced. Employees can ask those eating if the amount of food served is actually sufficient. The literature indicates that large portion sizes are related to unconscious increases in food consumption and increases in waste left in dishes (Al-Domi et al., 2011; Betz et al., 2015; Jagau & Vyrastekova, 2017; Lorenz et al., 2017; Marais et al., 2017; Miroso et al., 2016; Painter et al., 2016).

The descriptive analysis exposed that variables of taste, odor, appearance, texture, temperature, and menu composition were assessed as being good by consumers, indicating that improvements can still be made. Improving the quality of meals is a way to reduce avoidable food waste in dining halls (Betz et al., 2015; Lorenz et al., 2017; Marais et al., 2017; Miroso et al., 2016; Painter et al., 2016; Zotesso et al., 2016). Periodic quality reviews of the food can be a way of reducing waste. Choice of suppliers also influences quality and food waste (Zotesso et al., 2016). Therefore, suppliers should be chosen according to pre-established quality standards. Improving

menu composition has already been mentioned in other studies (Betz et al., 2015; Marais et al., 2017; Miroso et al., 2016; Painter et al., 2016). According to Betz et al. (2015), food waste is reduced when menus are flexible.

Another recommended potential intervention is to eliminate the use of trays and use only plates. As shown in Table 3, it has been confirmed statistically that consumers who take trays instead of plates waste more food. The substitution of trays for plates was investigated in other studies (Babich & Smith, 2010; Lorenz & Langen, 2018; Marais et al., 2017; Miroso et al., 2016; Painter et al., 2016; Qi & Roe, 2017; Wansink & Just, 2013). Thiagarajah and Getty (2013), for example, identified a reduction in food waste of 23g/consumer in the Indiana University dining hall.

Providing nutritional information about the food available on menus can also be a way of reducing food waste. Nutritional information may allow consumers to align their behaviors according to the interpretation of value-based information. The implementation of information campaigns is believed to be a sustainable way of informing consumers about the negative impacts of food waste (Jagau & Vyrastekova, 2017; Lorenz & Langen, 2018; Lorenz et al., 2017; Marais et al., 2017; Rizk & Perão, 2015).

Zawawi, Rosli, Bustami, Mispan and Ramli (2015) have suggested starting campaigns that emphasize the importance of reducing, recycling and reusing. Dining halls can use campaigns to advise consumers to take only what they really want to eat. Since there are no extra costs to the consumer if they do waste food, there is no incentive for them to be conscientious in the amount of food they place on their plate. Here, we also suggest the implementation of information campaigns as a way of verifying the amount of food waste that could be reduced from what we have presented.

Coercion is suggested. There are several methods of coercion, initiatives that seek to increase the possibility that consumers will not leave leftover food on their plates. We suggest that caution is exercised before implementing penalties in dining halls. Given the importance of the benefits that consumers derive from the dining experience, some stress could be caused as a consequence of the introduction of a penalty system, which might compromise any benefits derived. To conclude, food waste management interventions can be used and involve techniques, such as composting (Babich & Smith, 2010; Zawawi et al., 2015), thus enabling economic and environmental impacts to be minimized.

## CONCLUSIONS

Food waste has significant economic, environmental and social impacts. The magnitude and complexity of this problem has been addressed by several studies. Literature and empirical evidence emphasize the significant importance of assessing the amount of food waste that occurs in subsidized food service establishments. Underlying causes need to be better understood, and the potential interventions that can be introduced to encourage behavioral changes should be identified. The objective of this study was to examine food waste in a Brazilian university dining hall.

In order to study food wasted in the dining hall, the uneaten food from the plates and trays of the consumers was measured. Structured questionnaires were used to identify the characteristics of the sample and the consumer perceptions regarding the variables that are considered the possible causes of food waste. Knowing the amount of food wasted by each consumer and verifying their respective perceptions corroborated the differentials of this research.

The amount of food wasted was 68g/consumer, on average, over the three days of the study. This amount is higher than is considered acceptable in the literature (7 to 25g per consumer), but is similar to other Brazilian university dining halls. One of the most expressive findings of this study is that the use of trays contributes more to food waste than plates. It was suggested that only plates be made available to consumers. Removing trays also brings other benefits for the dining hall, since this not only reduces food waste, but also the amount of energy, and the water and chemical products used during the washing and sanitizing phases.

Future research should help expand the data to include other types of restaurants and different menu options. It is also important to emphasize that the results of the correlation analysis represent a trend, and not necessarily a cause and effect. Thus, we consider that there is a demand for new research to investigate the reasons for the situation we found.

Analysis of the waste from overproduction and unprepared food that never reaches the consumer and the causes of this can be included in future work. This study can also be replicated in other public sector food services, such as hospitals, schools, etc. Aspects related to the impact of food waste on the environment may also be topics of interest in future studies for improving university sustainability. Finally, it is suggested that studies be carried out of the action-research type, with the aim of verifying a possible reduction in food waste due to the application of better service practices and consumer awareness campaigns.

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## AUTHORS CONTRIBUTIONS

Lucas Rodrigues Deliberador worked on the conceptualization and theoretical-methodological approach, theoretical review, data collection, and data analysis. Mário Otávio Batalha and Aldara da Silva César were the supervisors of the work and collaborated on the conceptualization and theoretical-methodological approach, and the theoretical review. The theoretical review was also conducted by Michelle Chung. All authors worked together in the writing and final revision of the manuscript.