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Chapter

Management of Organic Solid Waste in Meal Production

Luciléia Granhen Tavares Colares,
Gizene Luciana Pereira de Sales,
Aline Gomes de Mello de Oliveira
and Verônica Oliveira Figueiredo

Abstract

In Brazil, 31% of household food expenses are spent on meals eaten outside of the home. The food service sector is a major consumer of resources (water, energy, food, and other materials), and generator of solid waste (SW) food, being a focus of concern of national and international organizations, given their potential economic, social, and environmental impacts caused by the final disposal of solid waste. This work problematizes the generation of solid waste during the production of meals for collectivities and presents the study carried out in three community restaurants located in Rio de Janeiro, Brazil. The solid waste generated in all stages of the meal production process was weighed. Food leftovers and food scraps were the solid waste generated in greater quantity in the three restaurants studied, showing the need for better planning of the menus and the quantities of preparations produced, since these residues are closely related to the acceptance of the menu and to the waste of food. An organic solid waste management plan has been proposed based on environmental performance evaluation during large-scale meal production.

Keywords: organic solid waste, meal production, waste management, waste of food, community restaurants

1. Introduction

The increasing generation of municipal solid waste (MSW) is influenced by several factors such as population growth, urbanization, and lifestyle changes [1, 2].

The food service sector has contributed to the increase in solid waste (SW) generation, which corresponds to roughly 20% of all waste generated, as compared to households that account for approximately 50%. The final destination of this SW is therefore of great concern to municipalities and states [3].

According to the Brazilian Institute of Geography and Statistics, in Brazil, 31% of household food expenses are spent on meals eaten outside of the home [4], which boosts this economic sector as it generates direct and indirect jobs (210,000) and involves large sums of money (51 billion reals/year) related to the commercialization of foods and meals, as well as the consumption of significant quantities of fresh

and processed foods [5]. However, the food sector contributes substantially to the production of solid waste, especially those that are organic-based.

The generation of organic solid waste (OSW) in the food service sector is closely related to food wastage. Although food losses and wastage are present throughout the food chain (production, harvesting, transportation, marketing, and consumption), large-scale meal production is a major factor contributing to food waste in the process flow due to menu planning that does not prioritize food from the crop, a lack of control of receipt and storage of food, and improper prepreparation practices and preparation, as well as other sources.

It is known that the solutions to the problems associated with solid waste generation in any human activity involve not only reduction at the source, but also the reuse or recycling of the discarded materials and the final environmental disposal of the tailings. For this, the efficient management of SW is necessary to contribute to more sustainable livelihoods [6].

The objective of this chapter is to problematize the generation of solid waste during the production of meals for collectivities and present a management plan that will contribute to the minimization of food waste and the environmental impacts caused by the final disposal of OSW.

2. Organic solid waste generated during the production of meals

In recent years, the Research and Extension Group on Sustainability in Meal Production (LASUPRE, Brazilian acronym) of the Federal University of Rio de Janeiro, Brazil, has studied the issue of food waste, the generation of OSW, and management strategies that can be employed during the production of large-scale meals in the food service sector [7–11]. Organic solid waste has been gaining prominence in research since it participates with more than 50% of the waste generated in all human activities in developing countries, and it is necessary to apply technology that reduces the losses and waste of food produced and consumed, as well as the final disposal of solid waste generated, which is environmentally sound.

Other important issues related to food loss and waste include resource use, solid waste generation, and energy-related emissions for transportation, storage, processing, and consumption, as well as wasted food calories, causing significant economic, social, and environmental impacts [3].

Albisu [12] emphasizes the need to differentiate the terms "food loss" and "food waste," since the former refers to the quantity of edible food that is not consumed after its harvest and the second is related to consumption itself. The seriousness of this issue is notorious, since 1.3 billion tons of food are wasted every year, while 800 million people are still starving [13].

According to Canali et al. [14], approximately a quarter of the total food calories produced globally are wasted, causing environmental impact related to the emission of greenhouse gases including approximately 3.3 GT of carbon dioxide (CO_2) equivalent.

The strategies for mitigating the problems of food loss and food waste are very important, yet different. While the first involves the supply chain from the production, harvesting, transportation, and distribution of food, the second involves the acquisition for individual or collective consumption. The Food and Agriculture Organization (FAO) [15] proposes various measures including (a) increasing the awareness of producers and consumers through information and communication campaigns, especially on agricultural and veterinary practices in the primary stages of production, as well as good manufacturing and hygiene practices in the preparation of food in the acquisition and consumption phases; (b) investing in small-scale agriculture, with training in processes and strategies for the

conservation of harvested products, in addition to strengthening family farming through policies and programs on quality and safety; (c) improving transportation, energy, and marketing infrastructure, as well as developing technologies that contribute to the reduction of food losses and waste; (d) including education at all levels on the theme "Food and Nutrition Security (FNS)" and ways to avoid food losses and waste; and (e) encouraging South-South cooperation in all of the above measures.

Several countries have attempted to determine appropriate solutions for the final destination of organic solid waste such as incineration, anaerobic treatment with biogas, or energy generation and aerobic treatment with organic fertilizer production, in order to minimize the social, economic, and environmental impacts caused by the high generation of solid waste [16].

The Brazilian Solid Waste Policy (BSWP) emphasizes the difference between solid waste and tailings and recommends a hierarchy of solutions for solid waste management, starting with reduction at the generating source, treatment or recycling, and only then, the final disposal of tailings in an environmentally appropriate manner [17].

For the various stages of producing large-scale meals in the food service sector, sanitation controls have been established by legislation to prevent potential damage to food and distributed meals, thereby minimizing the risk of foodborne diseases [18–20]. However, certain documents already highlight the importance of assessing the environmental performance of organizations, taking into account the impacts of their activities [21] such as the high levels of water consumption and the generation of gases that contribute to the destruction of the ozone [22]. The inclusion of this theme in the production of meals is necessary since throughout the meal production process, resources (water, energy, food, and other materials), solid food, and nonfood solid waste are generated [10].

Figure 1 shows the production process flow of meals with their controls (process and hygienic sanitary) and the main types of solid waste that are generated. Colares and Figueiredo [8] evaluated the solid waste originating from a food service that produced and distributed 1500 meals a day. They found that 88% of the solid residues generated were organic waste, produced mainly in the prepreparation stage (34%), and during distribution of the meals (66%), which was represented by leftovers (meals produced and not distributed) and food scraps (distributed and nonconsumed meals). Similar to these results, when quantifying the solid waste generated in a university restaurant in the city of Maringá, Brazil, Zotesso et al. [23] found that over 21 d, 40,650 meals were served and 6.5 t of solid waste was produced (161 g of waste for each meal served). They observed high quantities of solid waste during the prepreparation stage (43%) from peeling and cutting, and food waste (47%). These results demonstrate the need for food service management to be more focused on minimizing food waste and the environmental impacts caused by poor solid waste management and disposal.

This work presents a study carried out on three community restaurants located in the city of Rio de Janeiro, Brazil, where a solid waste generation diagnosis was performed. A management plan that prioritizes the environmental performance evaluation during the production of meals in order to minimize food waste and associated environmental impacts is also proposed.

The Community Restaurants Program is a Food and Nutrition Security policy instrument that is implemented through a formal agreement between the Ministry of Social Development and Fight Against Hunger (MDS, Brazilian acronym) and the respective State. They promote the Human Right to Adequate Food (HRAF), especially for workers who purchase meals in the urban centers of the country. The municipalities are responsible for the administration and maintenance of the equipment [24].

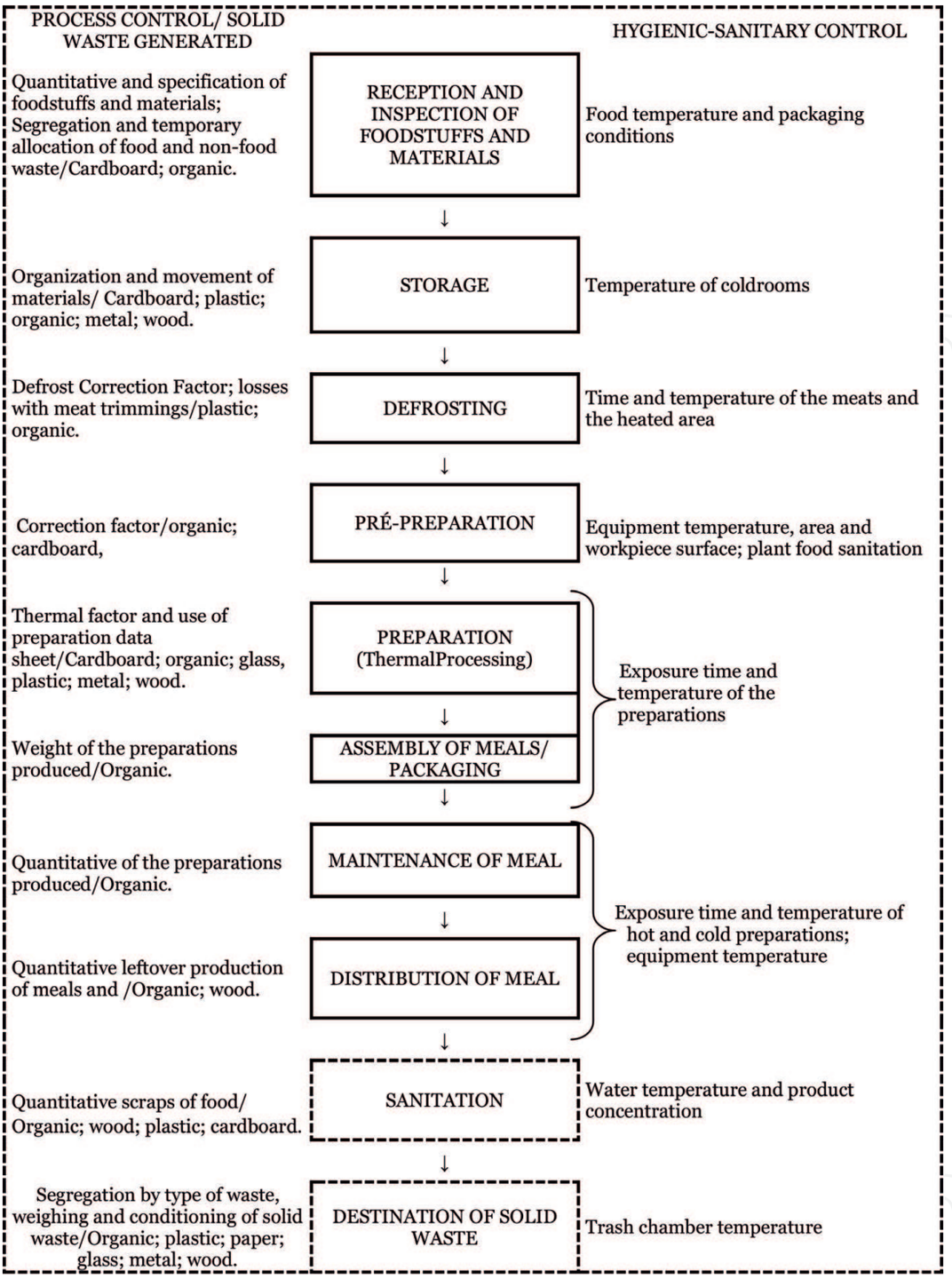

Figure 1.
Flowchart of the food production process with hygienic sanitary process controls and solid waste generation.

Currently, in the city of Rio de Janeiro, Brazil, there are three community restaurants in operation producing and serving approximately 6000 meals a day, including breakfast and lunch.

To implement these, restaurants, municipalities and states must meet the eligibility criteria specified in the call notice, which can be translated into geographical aspects. They must also have FSN or social assistance-related programs or instruments in place that will act in an integrated manner. The target audience is primarily low-income formal and informal workers, the unemployed, students, the elderly, and populations at social risk in urban centers and their peripheries. These restaurants should be deployed in high-volume areas of low-income workers such as the central areas of cities that are preferably close to mass transit [24].

3. Materials and methods

This quantitative cross-sectional study was conducted in three community restaurants in Brazil, and the methodology adopted in this study involves some steps.

3.1 Generation of OSW during the production and distribution of meals in community restaurants

The study was conducted over the period of 1 month in 2008 in three community restaurants located in the city of Rio de Janeiro (R1, R2, and R3), which together produced an average of 7500 meals/d for the socially vulnerable population, with the following menu: soup, salad, rice, beans, main course (protein), main course option, garnish, dessert (fruit or sweet), refreshment, bread, coffee, and tea.

The research was approved by the Research Ethics Committee of the Institute of Public Health Study of the Federal University of Rio de Janeiro (IESC-UFRJ) Opinion No. 03/2007, in compliance with Resolution 196/96 of the National Health requirements for conducting research with human beings.

3.1.1 Quantification and gravimetric composition of solid wastes generated

For 1 month, in the three community restaurants, the solid waste generated in all stages of the meal production process was weighed on a mechanical scale, model ruler, with a capacity of up to 150 kg and precision digital scale capacity of up to 5 kg (TGK-2261 model). A direct weighing technique was used (**Figure 2**). The mass balance was used in the prepreparation stage of the vegetables, whose peeling was done in the equipment "tuber peeler" [7]. The gravimetric composition of the generated residues was performed using Eq. (1).

$$\text{Gravimetric composition} = \frac{\text{weight of solid waste by type}}{\text{total weight of solid waste generated}} \times 100 \quad (1)$$

For the analysis of organic solid waste, the total production of the preparations to be served at meals, the leftovers (prepared and undistributed preparations) and the food scraps (preparations distributed and not consumed by the diners) were weighed. From this analysis, the percentage of leftovers (Eq. (2)) and index of food scraps (Eq. (3)) were calculated.

Figure 2.
Direct weighing of solid waste generated during the production of meals.

$$\text{Leftovers\%} = \frac{\text{Leftover weight}}{\text{Weight of meal produced}} \times 100 \quad (2)$$

$$\text{Index of food scraps} = \frac{\text{Weight of food scraps}}{\text{Distributed meal weight}} \times 100 \quad (3)$$

4. Characterization of organic solid waste in meal production

The amount of waste generated during the study period varied according to the number of meals produced in the three community restaurants, as can be seen in **Table 1**.

Among the solid residues, organics were generated in greater quantities, followed by recyclable residues (**Table 1**). Similar results were obtained by Zotesso et al. [23] and Colares and Figueiredo [8], who found that 82% and 88% of the residues produced were of organic origin, respectively.

Table 2 shows the gravimetric composition of the solid waste generated in the three restaurants. It was observed that of recyclable waste, there was more plastic, followed by cardboard. The carton came from boxes of primary, secondary, and tertiary packaging of meats, ice creams, tea, processed dessert, sugar, eggs, cups, and disposable napkins, among other materials.

The amount and type of waste generated in community restaurants were related to the planned menu and specificity of meal production.

Failure to plan the menu, caused by repeating meals in a short time and replicating cooking techniques on the same menu, can lead to nonacceptance by consumers, and consequently, food waste by the increase in leftovers and remains. **Table 3** presents the average amount of meals produced in the three community restaurants and the generation of residues from leftovers and food scraps.

At the menu planning stage, it is essential to use preventive measures that reduce the generation of solid waste. For example, using food directly from the harvest and diversifying preparation techniques can positively influence the formation of healthier eating habits by consumers, as well as a more sustainable menu through the reduction in food waste and solid waste [25, 26].

There was a failure at the menu planning stage in the community restaurants evaluated in this study. This occurred due to the presence of the same type of vegetable (potato) in two meals of the same menu (in the entree and in the garnish), which led to an excess in food remains that day (R1). Similarly, an excess of

Types of solid waste	Community restaurants					
	R1		R2		R3	
	kg	%	kg	%	kg	%
Recyclable	1772.0	9.2	1843.3	10.4	1254.8	10.3
Organic food waste	17,391.8	89.9	15,578.0	88.3	10,818.7	88.9
Residual waste	174.6	0.9	224.2	1.3	98.8	0.8
Frying oil	325.0	1.7	272.0	1.5	134.0	1.1
Total	19,338.5	100	17,645.5	100	12,172.3	100
Produced meals/month	62,700	—	60,000	—	51,000	—
RS per capita (Kg)	0.308	—	0.294	—	0.239	—

Table 1.
Solid waste generated and the number of meals produced per month in the three community restaurants.

Solid waste	Gravimetric composition					
	R1		R2		R3	
	kg	%	kg	%	kg	%
Paper	41.4	2.3	33.7	1.8	53.5	4.3
Cardboard	465.6	26.3	543.2	29.5	359.61	287
Wood	3.6	0.2	2.0	0.1	1.85	0.1
Plastic	1022.9	57.7	1058.3	57.4	741.37	59.1
Metal	191.7	10.8	160.5	8.7	96.1	7.7
Rigid plastic	46.8	2.6	45.8	2.5	2.4	0.2
Total recyclable	1772.04	100	1843.31	100	1254.83	100
Vegetable waste	2824.5	16.0	2106.4	13.3	2583.2	23.6
Meat waste	603.6	3.4	734.4	4.6	96.7	0.9
Coffee and tea drag	106.0	0.6	87.0	0.5	56.1	0.5
Food leftovers	5160.1	29.2	5843.5	36.9	3202.3	29.3
Food scraps	8697.6	49.2	6806.7	43.0	4880.3	44.6
Frying oil	292.5	1.7	244.8	1.5	120.6	1.1
Total organic food waste	17391.8	100	15,577.9	100	10818.7	100
Wet paper	102.2	58.5	146.1	65.2	44.0	44.5
Dirty paper	60.2	34.5	75.1	33.5	53.0	53.6
Sealing tape	12.2	7.0	3.04	1.4	1.8	1.8
Total residual waste	174.6	100	224.2	100	98.8	100
Total	19,338.5	—	17,645.5	—	12,172.3	—

Table 2.
Gravimetric composition of the solid waste generated in the three community restaurants over the period of 1 month.

Daily result	Average amount (kg) ± standard deviation (SD)					
	R1		R2		R3	
	kg	SD	kg	SD	kg	SD
Produced meals	3843.2	28.0	3054.7	331.3	2454.2	213.4
Food leftovers	271.6	118.8	292.2	178.3	188.4	72.5
Leftover %	7.1	3.0	10.1	7.6	7.6	2.8
Distributed meals	3571.6	328.8	2762.5	434.3	2272.6	199.1
Consumption per person	1.09	0.1	1.0	0.09	0.9	0.1
Food scraps	419.3	53.6	312.2	62.7	276.9	24.9
Index of food scraps	11.7	1.1	11.4	1.8	12.3	1.4

Table 3.
Weight of meals produced daily, meals consumed, leftovers, and food scraps.

sauce (mixed meat and meatballs of chicken) was observed in certain meals, resulting in a high quantity of leftovers and food scraps.

Regarding the frying oil, a high level of consumption was observed since the frequency of frying was quite high in the three community restaurants. Although

contributing from 1.1 to 1.7% of organic solid waste (**Table 2**), during the data collection period, it was observed that this oil was used for many days before being changed, which constitutes an improper practice. It was also observed that on the day of the oil change, a large amount of metal residue was found in the fryer since the oil was conditioned in this vessel. In spite of this, the used oil was sent to a recycling company for biodiesel production.

A solution for reducing the production of these residues would be to diversify the preparation technique, for example, through the introduction of roasting techniques, which would reduce the need to fry the food [7].

In this present research, the factors that contribute to food waste were observed throughout the production process, and consequent generation of solid waste in the corresponding stages is shown in **Table 4**.

4.1 Receiving and storing raw materials

Failure to receive food and materials due to the lack of adequate physical space was observed in this study. Sometimes the various food types were received without proper inspection because they did not have adequate space.

After receiving, the raw materials or ingredients should be stored according to their perishability characteristics, under ambient temperature or in cold units such as cold rooms and freezers [18, 27].

The storage area was visibly inadequate in the three restaurants evaluated in this study, and there was excessive stacking of materials, which is in violation of the sanitary legislation [18]. These conditions were also verified by Ricarte et al. [27], who discussed food wastage as a result of inadequate storage conditions.

Solid waste	Stages of the meal production process					
	Reception and inspection of food stuffs and materials	Storage	Prepreparation of meats	Prepreparation of fruits and vegetables	Preparation/ cooking	Distribution
Paper	x	x				x
Cardboard		x	x		x	x
Wood						x
Plastic		x	x		x	x
Rigid plastic					x	
Metal					x	
Vegetable waste				x	x	
Meat waste			x			
Food leftovers					x	x
Food scraps						x
Frying oil					x	
Coffee and tea drag					x	
Wet paper					x	x
Sealing tape	x	x				

Table 4.
Identification of the solid waste generated at the various stages of the meal production process.

With respect to storage, cardboard-type residues were observed in this study, which came from the packaging of the food received. In order to minimize the generation of cardboard-type waste, food services should have an adequate area to receive inputs. This study showed that food was received on the sidewalk of the restaurant, which made it difficult to transfer the items from the carton to the plastic box.

Considering that cardboard was one of the most recyclable types of waste generated in the three food services (**Table 2**) and that this residue was present in several stages of the meal production process (**Table 4**), adequate processes or protocols for receiving raw food materials would aid in reducing it.

4.2 Prepreparation of meats and prepreparation of fruits and vegetables

The prepreparation stage is divided into two areas, one for the prepreparation of meat (poultry, fish, beef, and pork) and the other for the prepreparation of fruits and vegetables.

In the meat prepreparation stage, the following actions were carried out: clean, cut, or grind the meats. A low percentage of meat residues (skin, sebum, nerve, and bones) were observed in in the three community restaurants (**Table 2**).

The prepreparation of fruits and vegetables required the removal of damaged leaves, barks, and stalks, as well as cleaning and cutting. There was a higher level of residue generation from fruits and vegetables than that observed during the prepreparation of meats in the three restaurants involved in this study (**Table 2**). A similar result was obtained by Zotesso et al., who also observed greater volumes of organic solid residues from the fruits and vegetables in the prepreparation stage in a university restaurant [23].

Various factors may be related to food waste, and consequently, to solid waste generation in this stage, such as [7].

1. Poor quality of the raw material received;

2. Absence of preventive maintenance of the equipment (**Figure 3**);

3. Lack of training of food handlers to perform activities and reduce excessive removal of edible parts during the prepreparation of fruits and vegetables (**Figure 4**).

Andreatti et al. [28] and Ricarte et al. [27] also established that food was wasted during the prepreparation of fruits and vegetables in the restaurants that they

Figure 3.
Food waste due to the lack of equipment maintenance.

Figure 4.
Excessive removal of edible food parts.

studied. The authors indicated that the waste was related to the failure to receive materials and the procedure adopted for cutting, which involved excessive removal of barks and shavings.

These factors not only cause food wastage but also increase the cost of serving meals. Therefore, measures should be taken to adapt the menu, provide specific training for food handlers, monitor the activities carried out, and implement preventive and corrective maintenance of the equipment.

4.3 Preparation/cooking

At the cooking stage, heat was used in the preparation of food that was distributed to consumers. Food wastage was related to factors that led to low acceptance of meals by consumers, such as:

1. Preparation of large quantities of food at one time, causing a surplus in production;

2. Lack of monitoring of the activities performed, compromising the presentation of the meals;

3. Conditioning of meals that would be consumed hot, at room temperature;

4. Inadequacy of the use of the cooking technique, altering the sensorial characteristics of the meals.

It is worth noting that due to the inadequacy of the physical structure of the restaurants evaluated in this study, cardboard and plastic residues were generated (**Table 4**). This occurred because certain products such as industrialized breaded meatballs and chicken went from the storage area to the preparation area to be cooked with their secondary and tertiary packaging.

4.4 Distribution of meals

The organic waste generated at the distribution stage for the three community restaurants was related to the leftovers (meals produced and not distributed) (**Table 4**).

Vaz [29] acknowledged an acceptable level of leftovers of up to 3% since high percentages may indicate excess production, and consequently, food wastage. In this present study, the percentage of leftovers for all three restaurants was above the recommended level at 7.1, 10.1, and 7.6% for R1, R2, and R3, respectively (**Table 3**). Busato et al. [30] evaluated the percentage of leftovers in a community restaurant in Chapecó-Santa Catarina, Brazil, and observed that it was within the recommended level (1%). The authors emphasized the importance of leftover control in meal production, not only for assessing food waste and cost, but also as an indicator of the quality of the meal served and level of acceptance of the menu offered.

In contrast to Venzke [31], who identified the prepreparation area as one of the largest sources of organic waste, in the present research, it was observed that the largest generation of organic waste occurred at the distribution stage and was represented by leftovers and food scraps (**Table 2**).

Considering the quantity of leftovers from the restaurants under study (**Table 3**), 272, 292, and 188 additional daily meals could be served, respectively, at R1, R2, and R3. The excess of leftovers indicates a failure in the planning of the menu [32].

To minimize the quantity of leftovers, it is necessary to organize the work process, correctly plan for the number of meals and quantities per capita, monitor meal distribution with specific training for correct portioning, increase awareness, involve the team, and prepare smaller quantities where possible.

In this research, the following factors were observed related to the high levels of solid waste produced during the meal distribution stage:

1. Inadequate physical space, making it difficult to replace the meals on the distribution counter and compromising the presentation of the meals served to consumers;

2. Damaged equipment, making it difficult to maintain the temperature of the meals served;

3. Incorrect serving size of utensils, making it difficult to portion the meals;

4. Lack of care with exposure of the meals (**Figure 5**);

5. Inadequate planning with respect to the quantity of meals to be distributed.

Figure 5.
Lack of care with exposed meals.

Process flow step	PDCA cycle			
	Plan	Do	Check	Act
	Development of indicators	Data collection and analysis	Critical review based on benchmarks	Improvement in environmental performance assessment
Reception and inspection of food stuffs and materials	• Quantity of materials purchased per meal produced • Quantity of secondary and tertiary packaging per meal produced • Quantity of food discarded by week	• Buy only the necessary • Train workers • Reduce purchases with secondary and tertiary packaging • Recyclable Material Spreadsheet • Worksheet of non-conformities of genres • Comparison with patterns determined by the organization	• Control charts • Inspection during the process • Inspection of measuring Equipment • Audits and quality reviews Cost related to quality and solid waste management	• Establishment of targets for reduction of nonconformities: exchange of suppliers, visit to new suppliers, establishment of new standards • Integration between the waste management system and the management of hygienic sanitary quality and productive process of meals • Quantification and segregation of solid waste
Storage	• Quantity of food discarded by week	• Control the quantity of food stuffs necessary for food production • Shelf life of food • Suitable storage (under refrigeration and at room temperature)		
Prepreparation of meats	• Percent of defrosting meats • Quantity of meat shavings per kilo of meat • Number of portions produced by net weight			
Prepreparation of fruits and vegetables	• Amount of vegetable residues per volume processed • Edible parts indicator (correction factor)	• Control of the amount of vegetables necessary for the production of meals • Edible parts control worksheet (correction factor) • Number of operational stops due to equipment problems per week		

Process flow step	PDCA cycle			
	Plan	**Do**	**Check**	**Act**
	Development of indicators	**Data collection and analysis**	**Critical review based on benchmarks**	**Improvement in environmental performance assessment**
Preparation/cooking	• Water footprint per meal produced • Amount of water spent in the preparations • Number of preparations produced by number of meals planned • Number of operating stops due to problems with equipment for meals sold	• Control the water footprint of the planned menu • Equipment maintenance • Daily water consumption worksheet • Control of visible water losses • Training of workers for the rational use of water • Cooking temperature control of the preparations • Control of operational stops		
Distribution of meals	• Percentage of leftovers • Index of scraps of food • Quantity of leftovers per meal produced • Quantity of food scraps per meal sold • Queue time for the meal • Percentage of acceptance of preparations • Bounce rate per preparation	• Equipment maintenance • Training of workers for the rational use of water • Temperature control of preparations and equipment for maintenance and distribution • Stops control during meal distribution due to lack of preparation • Indicator control worksheet		

Table 5.
Management plan for organic solid waste generated in the production of meals.

Castro and Queiroz [33] indicated an ideal index of food scraps of less than 5%. In this present study, the incidence of remains above 10% detected at the three community restaurants (**Table 3**) may be related to planning failures such as monotony and repetitiveness in the supply of meals. Chamberlem et al. [34] identified potential causes of the generation of food scraps as the absence of new meals, monotony in the consistency of the meals served, inadequacy of the temperature of the prepared meals, and the above-standard portioning. In addition, inadequate ambient temperature and insufficient seating in the cafeteria may impact the amount of food wasted by consumers.

In the community restaurants assessed in this study, the separated OSW was stored in a refrigerated room before final disposal; however, the handling of the recyclable waste was carried out in an inadequate manner, as many residues were temporarily stored at room temperature in an uncovered area, and the cartons were mixed with plastic bags containing traces of blood from meat packaging. This form of waste handling and separation may lead to the proliferation of rodents and insects, in addition to making it difficult to recycle [7]. The better the separation, the greater the possibility for suitable treatment and/or disposal for the different types of waste generated [35].

In light of the above, the management of solid waste generated during the production of meals, especially the organics, is necessary to assist in the production of more sustainable meals.

5. Management processes

There have been many questions surrounding the issue of food waste throughout the food chain (from production to consumption), and some solutions are related to the improvement of food and solid waste legislation [36].

Organic solid waste management based on environmental performance evaluation during large-scale meal production can be an effective strategy to minimize the environmental, social, and economic issues arising from its generation [37]. As a proposal, based on the flow of the production process, it is possible to choose operational performance indicators using the Plan, Do, Check, Act (PDCA) cycle [38, 39] for the management of OSW, as shown in **Table 5**.

The prevention of food waste is the first priority in the proposed hierarchy of management of OSW, as emphasized by Andriukaitis [40]. In this sense, it is necessary to evaluate which losses are avoidable in order for the plan to be feasible. This is because inevitable losses must follow the second priority in the management hierarchy, which is the treatment (organic solid waste) or recycling (recyclable) of waste and will depend on the technology, infrastructure, incentives, finances, and markets that are available [40].

Finally, the management of OSW during the production of meals should include the planning of menus, logistics of supply of foodstuffs and materials, and the entire flow of production. These actions are critical since wasting water, energy, and calories accompany food waste.

6. Conclusions

The volume of food wasted during food production is of great concern and has implications for both food safety and the environment. Although food losses occur along the food production chain, it is necessary to study food waste both at the

household and collective levels in restaurants (a specific segment of the food supply chain), in order to minimize this problem.

Community restaurants are a food safety mechanism utilized in the city of Rio de Janeiro, Brazil, designed to feed socially vulnerable populations. However, they still require management improvements in order to provide safe and sustainable food.

The assessment of solid waste generation in the three community restaurants allowed for the elaboration of a management plan based on the selection of environmental performance indicators for the various stages of the food production process, which facilitated the collection and analysis of comparable data with established goals.

It is therefore concluded that the management of restaurants cannot be isolated from the social, economic, and environmental issues resulting from the production of meals.

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Conflict of interest

We declare that we have no conflict of interest of a financial, commercial, political, academic, or personal nature.

Author details

Luciléia Granhen Tavares Colares[1*], Gizene Luciana Pereira de Sales[2], Aline Gomes de Mello de Oliveira[1] and Verônica Oliveira Figueiredo[1]

1 Federal University of Rio de Janeiro, Rio de Janeiro, Brazil

2 Oswaldo Cruz Foundation, Bio-Manguinhos, Rio de Janeiro, Brazil

*Address all correspondence to: lucolares@nutricao.ufrj.br

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