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CRediT authorship contribution statement

Tanes Kfouri was responsible for collecting, analyzing, interpreting data, and drafting the manuscript. **Ana Carolina Fernandes**, **Greyce Luci Bernardo and Lúcio Costa Proença** contributed to planning the research, data analysis, and manuscript writing. **Vanessa Mello Rodrigues** and **Paula Lazzarin Uggioni** contributed to data interpretation and manuscript revision. **Rossana Pacheco da Costa Proença** was responsible for research planning and coordination, as well as for supervising and revising the manuscript. All authors approved the final version of this manuscript.

SUSTAINABLE SOLID WASTE MANAGEMENT IN RESTAURANTS: THE CASE OF THE ECOZINHA INSTITUTE, BRAZIL

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SUSTAINABLE SOLID WASTE MANAGEMENT IN RESTAURANTS: THE CASE OF THE ECOZINHA INSTITUTE, BRAZIL

A B S T R A C T

This study aimed to propose a systematic model for the sustainable management of solid waste in restaurants, based on the experience of the Ecozinha Institute (Brazil). The Solid Waste Management System for Restaurants (SGRS-R) was developed through a case study conducted in a Brazilian restaurant. Data on meal preparation processes were collected through direct observation and recorded on forms designed specifically for this purpose according to parameters and guidelines described in the literature. Corrective actions already in place were monitored, and the need for new actions was identified. SGRS-R consists of seven steps, two of which are aimed at defining corrective actions and recommendations for solid waste management and reduction. The other five steps are supported by evaluation forms for (1) gravimetric control of solid waste, (2) description of physical infrastructure and solid waste equipment, (3) survey of solid waste collection, recycling, and disposal companies, (4) description of the flow of solid waste, and (5) monitoring of meal preparation steps. It was observed that SGRS-R implementation promoted changes in meal preparation processes in line with the principles of waste avoidance, reduction, reuse, and recycling. Waste management plans implemented by the Ecozinha Institute were able to reduce the amount of solid waste sent to sanitary landfills by up to 90%. It is important to emphasize that SGRS-R can be adapted and applied to any type of restaurant, given that solid waste management criteria are defined for each meal preparation step. SGRS-R can be used to restructure the management of solid waste in restaurants through strategies that include from menu planning to temporary storage of solid waste, thereby minimizing the environmental impacts associated with food service.

Keywords: Sustainable development. Sustainability. Food service. Food and nutrition. Waste management.

1. INTRODUCTION

The United Nations' 2030 Agenda for Sustainable Development was endorsed by several countries as a commitment to promote sustainable practices. The Agenda proposes 17 Sustainable Development Goals. The second goal relates to the promotion of sustainable food systems as a strategy to ensure healthy environmental management, thereby securing natural resources for future generations (United Nations, 2015). A sustainable food system is characterized by the adoption of the best possible alternatives that promote respect to the environment throughout the life cycle of food, including farming, transportation, processing in industries and restaurants, arrival to consumers, and final disposal of solid waste (Brazil, 2018).

The Brazilian National Solid Waste Policy (NSWP) established definitions for solid waste and its management. Wastes are classified according to their origin (waste from commercial establishments and service providers, household waste, industrial waste, and healthcare waste, among others) and hazardousness (hazardous or nonhazardous) (Brazil, 2010). According to the NSWP, waste management comprises "any set of actions carried out, directly or indirectly, in the stages of collection, transport, transfer, treatment, and environmentally sound disposal of solid waste." Solid waste management should prioritize, in the following order, the nongeneration, reduction, reuse, recycling, and treatment of waste, and, as the last option, the disposal of refuse.

Restaurant wastes—classified by the NSWP as waste from commercial establishments and service providers (Brazil, 2010)—is mainly composed of organic waste (food scraps),

recyclable materials (paper, metal, plastics, glass), and refuse (materials not amenable to reuse and, therefore, sent to landfills).

The European Commission, in a technical report on the environmental impact of products and services, highlighted that the food and beverage sector is responsible for 20 to 30% of the environmental impact of products and services in Europe (Notarnicola et al., 2017). Inadequate management and disposal of such wastes may result in negative socioenvironmental impacts, such as intensification of floods, soil and air pollution, and vector proliferation in urban centers, streets, and disposal sites (Jacobi and Besen, 2011). The Academy of Nutrition and Dietetics of the United States of America (formerly the American Dietetic Association) published the informative brochure "Waste Reduction and Recycling Opportunities for Restaurants," aimed at owners and workers of food service establishments. The document warns of the environmental damage caused by solid waste and the importance of waste management (American Dietetic Association, 2007).

The meal production process includes steps such as menu planning, selection of suppliers, food purchase, receipt, storage, pre-preparation, preparation, distribution, and solid waste disposal (Hering et al., 2006). Solid waste can be either recyclable inorganic (e.g., metal, glass, plastics, Tetra Pak packaging), organic (e.g., paper/cardboard, meat, vegetables, leftovers), or refuse (e.g., paper film or aluminum foil with food residues, latex gloves, stainless steel sponges, cloths, nonrecyclable packaging). Such a diversity complicates management, as each type of waste requires specific treatment (Jacobi and Besen, 2011; Pospischek et al., 2014; Alves and Ueno, 2015; Araújo and Carvalho, 2015; Tatàno et al., 2017).

No study has yet proposed tools for the management of different types of solid waste generated during all stages of restaurant meal production. Previous studies conducted in Brazil (Santos et al., 2012; Coentrão and Coentrão, 2017; Colares et al., 2018) were the only to elaborate or validate checklists, protocols, and process roadmaps aimed at sustainability. These

studies evaluated whether solid waste management (organic or inorganic) was being carried out in restaurants; however, they did not indicate the production stages at which management was performed, nor did they provide directives for management.

We highlight that, in Brazil, the Ecozinha Institute started a solid waste management initiative for restaurants, covering all types of waste generated during meal preparation. The initiative was applied to 90 associated restaurants (Ecozinha Institute, 2019). This study aimed to systematize, on the basis of the solid waste management experience of the Ecozinha Institute, a proposal for the sustainable management of solid waste generated in restaurants.

1.1 ECOZINHA INSTITUTE

The present case study is focused on the Ecozinha Institute, located in Brasília, Federal District, Brazil. The Ecozinha Institute operates in several food service sectors, such as bars, restaurants, cafeterias, bakeries, hotels, and the like, and is associated with several of these establishments (Ecozinha Institute, 2019). The Institute was created after sanction of the Federal District Law no. 5,610/2016, which determined that commercial establishments whose daily generation of undifferentiated waste exceeds 120 L are considered large quantity generators and, therefore, may no longer use public waste collection services (Brasília, 2016).

The Ecozinha Institute developed a solid waste management plan to help its associated members to produce less than the daily limit of 120 L. With this, associated restaurants were able to be classified as small quantity generators and minimize the environmental impacts arising from their activities. Restaurants affiliated with the Ecozinha Institute received a solid waste management plan, which aims to reduce and organize solid waste (as illustrated in Fig. 1) generated during meal preparation (Ecozinha Institute, 2019).

Fig. 1. Sorting of solid waste according to the management process of the Ecozinha Institute.

The Ecozinha Institute solid waste management plan differentiates between solid waste types and proposes adequate management practices for each type. This goes against the still prevalent pattern in Brazil of sending all types of waste to landfills. According to the proposed plan, after internal sorting of solid wastes (Fig. 1), the following waste disposal routes should be adopted: (1) organic waste (Panels A and B) is sent to composting facilities, (2) recyclable material such as metal cans, plastic, and cardboard (Panels C, D, and E) is sent to recycling cooperatives, (3) glass (Panel F) is sent to a specialized recycling company, and (4) refuse (Panel G) is sent to landfills through the public collection service (Ecozinha Institute, 2019).

Participating restaurants perform quantification and gravimetric composition analyses of all waste generated. These analyses demonstrated that, by implementing the waste management plan of the Ecozinha Institute, restaurants can reduce the amount of waste sent to sanitary landfills by up to 90%. Waste management procedures have been effective in ensuring that refuse amounts to less than 120 L per day, allowing restaurants to fit into the “small waste generators” category according to local regulation. This classification enables restaurants to

benefit from public waste collection services, which are cheaper than private services that need to be hired by businesses that generate more than 120 L per day of refuse (Instituto Ecozinha, 2019).

According to the Ecozinha Institute, the most critical stage in the implementation of the waste management system is identifying suitable companies, cooperatives, or industries to adequately process all the different waste fractions sorted throughout meal preparation (Instituto Ecozinha, 2019).

2. MATERIAL AND METHODS

This investigation consisted of qualitative and descriptive research designed as a case study. The theoretical framework was based on the Nutritional and Sensory Quality Assessment System (AQNS) and the principles of Hazard Analysis and Critical Control Points (HACCP) (Hering et al., 2006). The study was conducted in three steps, as described in Fig. 2.

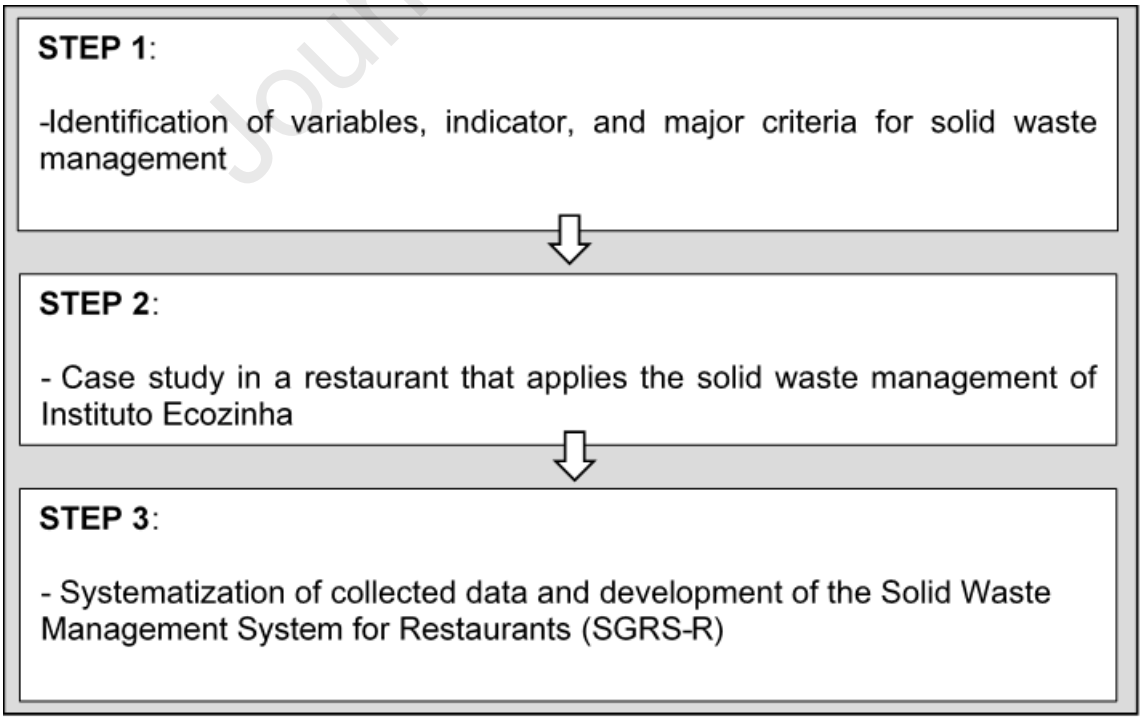

Fig. 2. Steps followed in the study.

The first step was to define the variables, indicators, and main criteria for solid waste management at different phases of meal preparation. The second step was the case study. The last step, presented in the Results and Discussion section, aimed to use the data collected in the case study to create a systematic model for solid waste management in restaurants.

2.1. IDENTIFICATION OF VARIABLES, INDICATORS, AND MAIN CRITERIA FOR SOLID WASTE MANAGEMENT

A systematic search of the literature was performed to identify the major criteria used for the management of solid waste in restaurants. The Scientific Electronic Library Online (SciELO), Scopus, Web of Science, and LILACS databases were searched for articles published between 2000 and 2019 by entering the keywords “solid waste” and “food” and “meal production” and “restaurant” and “management” and “sustainability”, in English and Portuguese. Government documents and guidelines published by national and international environmental institutions were also analyzed.

Meal preparation steps, their definitions, and potential indicators of solid waste management were defined based on current literature (Harmon and Gerald, 2007; Burlingame and Dernini, 2012; Singh et al., 2014; Alves and Ueno, 2015; Grau, 2015; Tatàno et al., 2017; Colares et al., 2018; Martinelli and Cavalli, 2019) and are presented in Table 1.

Table 1

Operational steps associated with solid waste generation during meal preparation, as identified from a review of the literature.

Step	Description	Solid waste management indicators
Menu planning	This step comprises the assessment of all components involved in menu planning before food purchase and preparation	Menus planned to include fresh, organic, agroecological, seasonal, and/or locally grown foods Cooking methods Use of technical data sheets Assessment of menu acceptability by diners
Food purchase	Food products and ingredients are selected and purchased	Purchase of fresh, organic, agroecological, seasonal, and/or locally grown foods Foods are requested to be delivered in returnable or reusable boxes
Receipt	Received products are inspected for quality, and prices and quantities are checked against the invoice. From this step onward, all products are under the restaurant's responsibility.	Before signing the invoice, the receiver verifies that the delivered products match those requested at the purchase stage Use of returnable or reusable food boxes Solid waste generated in this step is characterized, sorted, and disposed[a] Area for temporary storage of solid waste[b]
Food storage	Set of activities and procedures to ensure adequate conservation of ingredients and finished products	Analyze storage types (dry, chilled, and frozen food products) Storage containers made of suitable materials (reusable or recyclable)
Pre-preparation	Includes operations such as cleaning, selection, washing, peeling, and chopping. Foods can be treated or modified by sanitizing, portioning, grinding, and/or mixing with other ingredients	Analyze the types of foods used in this step (frozen, minimally processed, processed, and ready-to-eat) Analyze the types of pre-preparation operations (cleaning, selection, and sanitization of fruits, vegetables, and eggs; evisceration and portioning of poultry, meat, fish, and seafood)

Preparation	Fundamental operations to combine, separate, or modify foods using mechanical and thermal energy. Often includes cooking.	Analyze the types of foods used in this step (frozen, minimally processed, processed, and ready-to-eat) Analyze cooking methods (deep frying, shallow frying, searing, baking, among others) Reuse of leftovers[c]
Service	Meals are portioned and/or served	Use of reusable utensils Size of serving utensils and tableware is adequate for each meal
Temporary storage of solid waste	Each type of waste is packaged, treated, and stored until collection	Check the area and equipment (identification tags and containers) used for sorting and packaging solid waste Specific packaging procedures for each type of solid waste Each type of solid waste is collected by a qualified waste collection company

[a,b] These indicators also apply to downstream operational steps (storage, pre-preparation, preparation, service, and temporary storage of solid waste).

[c] Foods and preparations not served to customers/patients/users, properly preserved, and that can be safely reused (Brazilian Federal Council of Nutritionists, 2018).

2.2. CASE STUDY ON SOLID WASTE MANAGEMENT

The restaurant selected for the case study is affiliated with the Ecozinha Institute and follows the Institute's guidelines on solid waste management at all stages of meal preparation. The restaurant is open to the public every day of the week from midday to midnight. Both lunch and dinner are ordered *à la carte*. The restaurant serves an average of 190 meals per day and has a staff of 33 people divided into two work shifts. The case study was conducted from 9:00 to 18:00 h during five days (Monday to Friday) in the third week of November 2019. Forms were used to collect data on physical infrastructure, equipment, flow of solid waste, and meal preparation procedures. We also collected information on regional companies offering solid waste collection, recycling, and disposal services that would be able to meet the demands of the analyzed restaurant.

Data were collected during the meal production process. The restaurant manager was present at all times to resolve any doubts. All stages of meal preparation were described in detail and photographed. The methods of data collection included direct observation, digital photography, and document analysis (Table 2).

Table 2

Instruments used for data collection.

Instrument	Objectives and description
Specific protocols developed for each step of the meal production process, including the indicators listed in Table 1	Direct observation of operational steps and critical points for solid waste generation
Samsung A9 smartphone (model 2019) equipped with a 12-megapixel digital camera	Obtain a detailed record of the meal preparation process. Foods, ingredients, and their packaging were photographed at different stages of production. The photographs were used in data analysis and supported the development of the

	Solid Waste Management System for Restaurants (SGRS-R)
Document analysis of Good Environmental Practices, menus, control spreadsheets, and operational procedures for meal preparation	Understand the administrative processes related to meal preparation and the control of environmental practices during the production process

The following procedures were adopted for observation of restaurants and meal production processes, focusing on the critical points of solid waste generation:

Visual analysis of infrastructure and equipment used for solid waste management in restaurants; assessment of the presence and correct use of waste sorting bins and signs.

Observation of the meal production flow, from menu planning to final waste disposal; identification of the types of solid waste generated during meal production.

Monitoring of each step of the meal production process and operational sectors (storage areas, kitchens, bars, service room, and washing area) with attention to processes that generate solid waste; identification of meal preparation steps and operational sectors that generate waste. Formulation of corrective measures for inclusion in the SGRS-R.

Data related to the meal production process were compared with those found in the literature (Harmon and Gerald, 2007; Brazil, 2010; Burlingame and Dernini, 2012; SINGH et al., 2014; Alves and Ueno, 2015; Grau, 2015; Colares et al., 2018; Martinelli and Cavalli, 2019) for development of the SGRS-R.

3. RESULTS AND DISCUSSION

In this case study, we analyzed meal production processes and identified the types of solid waste generated in restaurants, as well as critical points of the production process (Table 3), using solid waste management indicators described in the literature.

Table 3

190 Operational steps, types of solid waste, and critical points identified in solid waste generation
191 at the case study restaurant.

Operational steps	Type of solid waste	Critical points
Menu planning	Paper, cardboard, plastic (office supplies)	The seasonality of ingredients is not considered during menu planning Cooking methods are not taken into account during menu planning
Food purchase	Paper, cardboard, plastic (office supplies)	Information about seasonality, fresh foods, organic foods, reusable or returnable delivery boxes, and nonuse of secondary packaging is not requested at the time of purchase
Receipt	Paper, cardboard, plastic	Dry, frozen, and chilled foods are not required to be transported and delivered in returnable or reusable boxes Received products are not inspected for presence of secondary packaging Solid waste generated in the step is not characterized, sorted, or disposed No temporary storage area for solid waste
Food storage	Paper, cardboard, plastic	Fish, poultry, and meat are vacuum-packed individually and stored in secondary packaging
Pre-preparation	Organic waste, paper, cardboard, refuse, plastic, metal, and glass	Use of frozen, minimally processed, and ready-to-eat foods Use of plastic bags for individual portioning of foods such as pasta, salads, fish, meat, and poultry
Service	Organic waste, paper	Paper napkins are used to clean the edges of dishes and trays Sells beverages bottled in containers that are not reusable or recyclable Solid waste is not classified or sorted before disposal in internal or external trash bins
Temporary storage of solid waste	Organic waste, inorganic waste, refuse, and glass	Difficulty in finding companies that treat and dispose of all types of solid waste generated during meal preparation

192

193 The solid wastes generated during meal production (Table 3) consisted mainly of
194 organic solid waste, inorganic solid waste (plastic and metal), glass, and refuse, in agreement
195 with the reports of Singh et al. (2014), Pirani and Arafat (2014), Alves and Ueno (2015), and
196 Tatàno et al. (2017) on restaurant waste. According to Tatàno et al. (2017), a sustainable,
197 integrated solid waste management system should consider all types of waste generated by
198 restaurant activities. It is argued that, as in other production processes, an increase in solid
199 waste generation in meal preparation is directly associated with failure to correctly perform
200 waste management operations or a lack of environmental policies, which may lead to the
201 emergence of critical points for waste generation (Harmon and Gerald, 2007; Burlingame and
202 Dernini, 2012; Pirani and Arafat, 2014; Grau, 2015; Tatàno et al., 2017; Colares et al., 2018;
203 Martinelli and Cavalli, 2019).

204 According to Gruia et al. (2021) and Baul et al. (2021), the most effective method to
205 reduce the environmental impact of restaurants is the implementation of an integrated waste
206 management system for all stages of meal preparation. In addition to minimizing the
207 environmental impact of restaurants, the waste management systems proposed in the referred
208 studies were shown to reduce operational costs.

209 Medeiros Gonçalves and Albuquerque (2019) identified critical points regarding the
210 generation of the most diverse types of solid waste during meal production, requiring corrective
211 measures to reduce waste generation.

212 Table 4 describes corrective actions for the critical points identified in this study.

Table 4

Corrective actions aimed at minimizing the amount of solid waste generated in each step of meal preparation.

Operational step	Corrective action
Menu planning	Plan menus including fresh, organic, agroecological, seasonal, and/or locally grown foods Take into account the amount of waste generated by different cooking methods Develop and use technical data sheets[a] Test the acceptance of new dishes by analyzing sales data and customers' leftovers
Food purchase	Contact suppliers directly to order fresh and seasonal foods Request that suppliers deliver products without secondary packaging Request that food products be transported and delivered in reusable or returnable boxes If these criteria are not met, request that nonconforming products be exchanged or that the nonconformity be resolved in the next delivery
Receipt	At receipt, evaluate the received products for nonconformities with purchase specifications. In the case of nonconformities, return the product to the supplier Check if products are delivered in reusable or returnable boxes Inspect products for secondary packaging Organize an area for temporary storage of solid waste Sort and temporarily store inorganic solid waste and glass, which later should be discarded in external or internal trash bins
Food storage	Pack dry, chilled, or frozen products in reusable plastic or stainless-steel containers with lids, if necessary Do not store foods in secondary packaging Arrange an area for temporary storage of solid waste[b] Sort and temporarily store organic waste, inorganic waste, and glass, which later should be discarded in external or internal trash bins[c]
Pre-preparation	After pre-preparation, store chilled or frozen food portions in lidded reusable containers, not in plastic bags

Preparation	Provide training on the use of technical data sheets during food preparation Store chilled and frozen foods in lidded reusable containers
Service	Serve meals in reusable tableware Prefer to sell beverages that come in reusable or recyclable packaging
Temporary storage of solid waste	Ensure the correct classification, separation, and disposal of organic waste, inorganic waste, refuse, and glass in internal trash bins; If waste is found in the wrong bin, place it in the correct container Ensure the correct classification, separation, and disposal of inorganic waste and glass in external trash bins; If waste is found in the wrong bin, place it in the correct container Request that waste collection and treatment companies (composting yards, collectors' associations, and glass recycling industries) collect waste when trash bins are full

[a] Technical data sheets are operational support tools that indicate the estimated cost, preparation steps, and nutrition facts of food preparations (Akutsu et al., 2005)

[b,c] These indicators also apply to downstream operational steps (storage, pre-preparation, preparation, service, and temporary storage of solid waste).

The corrective actions presented in Table 4 were formulated specifically for each step of the meal production process following the guidelines of Harmon and Gerald (2007), Singh et al. (2014), Grau (2015), and NSWP (Brazil, 2010), which are based on the avoid, reduce, reuse, recycle, and dispose concept of waste management. The proposed actions are aimed at reducing the volume of waste sent to landfills as a strategy to minimize the environmental impacts of meal preparation.

After analysis of waste management in the case restaurant, the SGRS-R was developed for all stages of the meal production process. Fig. 3 depicts the seven steps of SGRS-R. SGRS-R comprises specific protocols for each step, with instructions for meal production data collection and analysis and a glossary of the terms used in protocols.

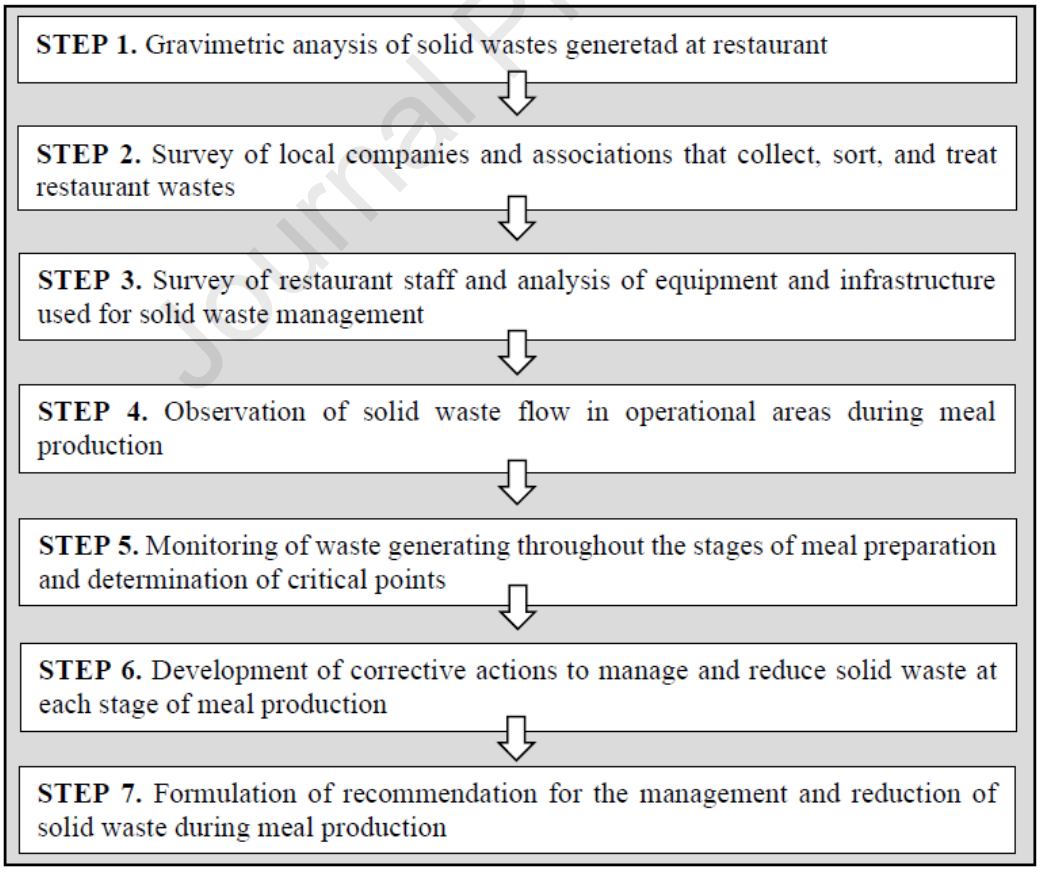

Fig. 3. Steps of the Solid Waste Management System for Restaurants.

Step 1 of the SGRS-R aims to quantify solid wastes generated during meal production, especially with regard to refuse, the only fraction of waste that should be sent to landfills. Waste quantification must be carried out in two moments: in the first step and after implementation of the seventh (last) step. With this, it is possible to measure the efficiency of SGRS-R actions.

Step 2 is for gathering information on local (municipal or state) companies and associations that collect, separate, and treat solid waste. The protocol must be applied individually for each type of waste.

In step 3, it is necessary to obtain information on restaurant staff, equipment, and infrastructure associated with waste management. This procedure is aimed at identifying the feasibility of facilities and staff availability for SGRS-R implementation.

Step 4 is aimed at observing the flow of solid waste inside and outside the restaurant, from generation to temporary storage. The form must be filled out during meal preparation. By completing the form, the analyst can observe all operational sites that generate, receive, or store solid wastes and assess whether the sites contain waste sorting bins and signs and personnel qualified to separate, package, and temporarily store waste.

In step 5 of SGRS-R, the analyst must determine whether criteria for solid waste management and reduction are being applied at each step of meal preparation, from menu planning to temporary waste storage. This step comprises eight forms that must be applied individually for each step of the meal production process. The solid waste management criteria used in the forms were developed based on the critical points observed during the case study and developed specifically for each step of the production process. With analysis of data generated in this step, it is possible to define the critical points of waste generation during meal preparation at the analyzed restaurant.

Step 6 aims to define corrective actions to avoid solid waste generation throughout the production process after application and analysis of step 5 protocols. The protocols of step 5

are the last of the SGRS-R and, therefore, must incorporate corrective actions for waste management practices that were not met in step 5.

The seventh and final step aims to develop recommendations for the management and reduction of restaurant waste according to information gathered during SGRS-R implementation. These recommendations are based on the reality of each food service establishment.

After SGRS-R has been implemented, it is recommended to periodically repeat the protocols of steps 1–4 to assess whether waste management practices, equipment, areas, and service companies are meeting the needs of the restaurant. Steps 5–7 can be applied less frequently after SGRS-R implementation, for assessment of whether solid waste management is being carried out adequately.

Below is a list of the main recommendations for SGRS-R implementation.

a) Perform gravimetric analysis of solid waste in step 1.
b) Survey the existing companies and or associations for solid waste collection in the city or state in which the restaurant is located and evaluate whether these companies/associations can collect, separate, treat, and dispose of restaurant waste. In the absence of such companies, it is recommended to form partnerships with public services or companies from other municipalities and states.
c) Assess the types of solid waste generated during meal preparation and install specific bins for each type of waste (organic, inorganic, refuse, and glass) inside or outside operational areas.
d) Use waste sorting signs and symbols to indicate the type of waste to be discarded in each bin.
e) In food preparation areas, install bins for organic, inorganic, and refuse waste that have a maximum capacity of 5 L. This measure is taken to prevent waste accumulation.

f) Outside food preparation areas (such as in corridors), install bins for organic, inorganic, glass, and refuse waste that have a maximum capacity of 60 L.

g) Assess whether there is space outside the restaurant for 800 L dumpsters for inorganic and glass wastes.

h) Define temporary storage areas inside the restaurant for solid wastes that are sorted as soon as they are generated.

i) When inorganic, glass, and refuse waste bins located in operational areas reach their maximum capacity, transfer wastes to outside containers.

j) Define internal fixed areas for solid organic and refuse wastes to be stored until collection.

k) Train employees to sort, clean/wash food packaging (if necessary), and store solid waste in operational areas as well as to transfer wastes to fixed temporary storage areas in the restaurant.

l) In addition to the operational team, the restaurant requires a technician capable of implementing and managing SGRS-R.

Fig. 4 shows an example of a form completed in step 5 for the monitoring of solid waste generation and identification of critical points.

Solid Waste Management System for Restaurants Form for the observation and monitoring of restaurant meal preparation and waste generation: **Pre-preparation Stage**			
1. Site: Restaurant in Brasília		**2. Date:** 19/10/2019	
3. Name of the responsible technician: Researcher			
4. Criteria for solid waste management	**5. Description**	**6. Conformity or Nonconformity**	**7. Corrective actions**
After pre-preparation, store chilled or frozen food portions in lidded reusable containers, not in plastic bags	Store chilled or frozen food portions in lidded reusable containers, not in plastic bags so as to minimize the generation of inorganic and refuse solid wastes	Criteria not met	Store chilled or frozen food portions in lidded reusable containers, not in plastic bags
Characterize, sort, and dispose of wastes generated in this step.	Sorting and disposing of solid wastes in appropriate sorting bins (organic, inorganic, and glass) located inside or outside the restaurant so that downstream operations steps are not affected	Criteria met - Solid waste is sorted into inorganic, organic, refuse, and glass wastes and then disposed of in separate bins	-
Have a specific area for temporary storage of solid wastes generated in this step.	Temporary waste storage areas are used to support operational areas. They are used to store solid wastes that have been sorted for subsequent transfer to appropriate sorting bins (organic, inorganic, and glass)	Criteria met - There is a dedicated space for temporarily storing solid wastes generated in operational areas - These wastes are transferred to internal or external bins	-

Fig. 4. Example of a completed form for monitoring waste generation in the pre-preparation step. Source: the authors.

In the example, three solid waste management criteria (item 4) for the pre-preparation

235 step and their descriptions (item 5) are listed. If criteria are not met (item 6), corrective actions
236 (item 7) must be applied.

237 The form used in step 6, exhibited in Fig. 5, lists the management criteria not met in
238 step 5. The form encompasses all stages of meal production, critical points, and corrective
239 actions. By filling out the form, the analyst will gain an overview of the system, allowing
240 adoption of adequate decisions toward sustainable solid waste management at all stages of the
241 meal production process.

242

Solid Waste Management System for Restaurants Form for the identification of critical points and corrective actions for restaurant waste management at all stages of meal preparation		
1. Site: Restaurant in Brasília	**2. Date:** 19/10/2019	
3. Name of the responsible technician: Researcher		
4. Step	**5. Critical points (nonconformities identified in step 4)**	**6. Corrective action**
Menu planning	-	-
Food purchase	-	-
Receipt	-	-
Storage	-	-
Pre-preparation	Plastic bags are used for storing portioned foods, such as pastas, salads, fish, meat, and poultry meat	Store chilled or frozen food portions in lidded reusable containers, not in plastic bags
Preparation	-	-
Service	-	-
Temporary storage of solid waste	-	-

243

244 **Fig. 5.** Example of a completed form for identification of critical points and description of
245 corrective actions. Source: the authors (2020).

The critical points of waste generation, addressed in steps 5 and 6 of SGRS-R, may vary according to the reality of each restaurant. However, solid waste management criteria and corrective actions are the same, regardless of the type or size of the establishment. We highlight that no other study has investigated the management of solid wastes at all stages of restaurant meal preparation, which precluded comparison of results.

The initiative to create the Ecozinha Institute and develop a solid waste management plan arose in response to the sanction of the Federal District Law no. 5,610/2016. The law defined that establishments that produce more than 120 L of waste per day must manage waste without using the public collection service. The Ecozinha Institute sought to articulate restaurants to gain enough scale in order to establish private partnerships for the collection, treatment, and adequate disposal of all types of waste (organic, inorganic, and glass) produced by its members. Such partnerships led to the creation of a new recycling market for organic, inorganic, and glass wastes in the region. Other outcomes included the strengthening of associations of inorganic waste collectors and composting facilities. These examples demonstrate how a public action facilitated the development of communities involved in the collection and treatment of solid wastes and stimulated circular economy through the return of wastes to private production chains.

4. CONCLUSIONS

The case study allowed the development of SGRS-R, a collection of steps, procedures, and forms applicable to all stages of the meal production process and that follow the premises of the NSWP and the United Nations' Sustainable Development Goals.

The proposed system can promote changes in the planning of meal preparation, aiming to avoid, reduce, reuse, and recycle solid waste generated in restaurants. The tool can contribute to the restructuring of solid waste management at all stages of meal preparation, from menu

planning to temporary waste storage, reducing environmental impacts arising from this activity.

Our results highlight the importance of municipal and state policies, guidelines, and actions aimed at sustainability that motivate and empower individuals, legal entities, and institutions to minimize the impacts of their activities on the environment. In the present case study, a local waste management regulation stimulated the development of new practices, services, and private businesses related to waste processing, thereby increasing waste recycling and strengthening the circular economy. Implementation of SGRS-R in Brasília, Brazil, enabled, for instance, the development of a glass recycling service and a set of decentralized organic waste composting facilities that did not previously exist.

SGRS-R is innovative and was based on scientific literature and observations of an existing successful case of sustainable solid waste management in a restaurant. This systemized tool can be applied to different types of restaurants, as the meal preparation steps considered here are carried out in all food service establishments.

CRediT authorship contribution statement

Tanes Kfouri was responsible for collecting, analyzing, interpreting data, and drafting the manuscript. **Ana Carolina Fernandes**, **Greyce Luci Bernardo and Lúcio Costa Proença** contributed to planning the research, data analysis, and manuscript writing. **Vanessa Mello Rodrigues** and **Paula Lazzarin Uggioni** contributed to data interpretation and manuscript revision. **Rossana Pacheco da Costa Proença** was responsible for research planning and coordination, as well as for supervising and revising the manuscript. All authors approved the final version of this manuscript.

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REFERENCES

Akutsu, R.C., Botelho, R.A., Camargo, E.B., Sávio, K.E.O., Araújo, W.C., 2005. The Technical cards as quality instrument for good manufacturing process. Revista de Nutrição [online], 18, 277-279. https://doi.org/10.1590/S1415-52732005000200012

Alves, M.G., Ueno, M., 2015. Identification of sources of solid waste generation in a food and nutrition unit. Rev. Ambient. Água. 4, 874-888. https://doi.org/10.4136/ambi-agua.1640

American Dietetic Association, 2007. Position of the American Dietetic Association: food and nutrition professionals can implement practices to conserve natural resources and support ecological sustainability. J Am Diet Assoc., 6, 1033-43. https://doi.org/10.1016/j.jada.2007.04.018

Araújo, E.M.L., Carvalho, A.C.M.S., 2015. Sustainability and waste generation in a food and nutrition unit in Goiania-GO, Brazil. Demetra. 4, 775-796. https://doi.org/10.12957/demetra.2015.17035

Baul T.K., Sarker A., Nath T.K. 2021. Restaurants' waste in Chittagong city, Bangladesh: Current management, awareness on environmental hazard and perception towards potential uses. Journal of Cleaner Production, 292. https://doi.org/10.1016/j.jclepro.2021.126073

Brasil, 2010. Lei nº 12.305, de 02 de agosto de 2010. (In Portuguese). http://www.planalto.gov.br/ccivil_03/_Ato2007010/2010/Lei/L12305.htm. (accessed February 2018)

Brasil, 2018. Ministério do Meio do Meio Ambiente. Produção e consumo sustentável. (In Portuguese). http://www.mma.gov.br/responsabilidade-socioambiental/producao-e-consumo-sustentavel/conceitos/producao-sustentavel.html. (accessed November 2019)

Brasília, 2016. Lei nº 5.610, de 16 de fevereiro de 2016**.** (In Portuguese). http://www.sinj.df.gov.br/sinj/Norma/0ff7a122ae454ffb9e01db0589e029e6/Lei_5610_18_02_2016.html. (accessed March 2020)

Burlingame, B.A. Dernini, S., 2012. Sustainable diets and biodiversity: directions and solutions for policy, research and action. http://www.fao.org/3/a-i3004e.pdf (accessed 10 November 2018).

Coentrão, M. E., Coentrão, M.R., 2017. Roadmap for sustainability in food production. Hig. Aliment., 31, 140-144. https://docs.bvsalud.org/biblioref/2017/05/833501/266-267-site-140-144.pdf

Colares, L.G.T., Figueiredo, V.O., Ferreira, A.A., Oliveira, A.G.M., 2018. Good environmental practices check list for food services: elaboration, content validation and inter-rater reliability. Braz. J. Food Technol, 21, e2017066. http://dx.doi.org/10.1590/1981-6723.06617

Federal Council of Nutritionists. Resolution No. 600, February 25 de 2018. (In Portuguese). https://www.cfn.org.br/wp-content/uploads/resolucoes/Res_600_2018.htm (accessed 20 February 2021).

Grau, 2015. *Green Restaurant Certification 4.0 Standards*. http://www.dinegreen.com/restaurants/standards.asp (accessed 20 August 2019).

Gruia R, Florescu G.I., Gaceu L., Oprea O.B., Ţane N. 2021. Reducing Environmental Risk by Applying a Polyvalent Model of Waste Management in the Restaurant Industry. *Sustainability*. 13(11),5852. https://doi.org/10.3390/su13115852

345 Harmon, A.H., Gerald, B.L., 2007. Position of the American Dietetic Association: food and
346 nutrition professionals can implement practices to conserve natural resources and
347 support ecological sustainability. J Am Diet Assoc., 6, 1033-43.
348 https://doi.org/10.1016/j.jada.2007.04.018
349 Hering, B., Proença, R.P.C., Sousa, A.A., Veiros, M.B., 2006. Evaluation of nutritional and
350 sensorial quality in meal production – NSQE system. Journal of Foodservice, 17: 173-
351 181. https://doi.org/10.1111/j.1745-4506.2006.00033.x
352 Instituto Ecozinha. 2019. (In Portuguese). https://www.institutoecozinha.org.br/sobre
353 (accessed 28 February 2019).
354 Jacobi, P. R., Besen, G. R., 2011. Solid Waste Management in São Paulo: The challenges of
355 sustainability. Estud. av., v. 25, 135-158. https://doi.org/10.1590/S0103-
356 40142011000100010
357 Martinelli, S. S., Cavalli, S. B., 2019. Healthy and sustainable diet: a narrative review of the
358 challenges and perspectives. Ciênc. saúde coletiva, 24, 4251-4262.
359 https://doi.org/10.1590/1413-812320182411.30572017
360 Medeiros Gonçalves, M., de Lima Albuquerque J. 2019. Solid Waste Management at the
361 University Restaurant of the Federal Rural University of Pernambuco: Diagnosis and
362 Analysis from the Perspective of the Environmental Agenda for Public Administration.
363 Brazilian Journal of Management / Revista de Administração da UFSM. 12:1260–77.
364 https://doi: 10.5902/ 19834659 38740
365 Notarnicola, B., Tassielli, G., Renzulli, P.A., Castellani,V., Sala, S., 2017. Environmental
366 impacts of food consumption in Europe. J.Clean.Prod., 140, 753-765.
367 https://doi.org/10.1016/j.jclepro.2016.06.080
368

United Nations Organization, 2015**.** The Sustainable Development Agenda. https://www.un.org/sustainabledevelopment/development-agenda (accessed 15 February 2019).

Pirani, S.I., Arafat, H.A., 2014. Solid waste management in the hospitality industry: A review. J Environ Manage.,146, 320-336. https://doi.org/10.1016/j.jenvman.2014.07.038

Pospischek, V.S., Spinelli, M.G.N., Matias, A.C.G., 2014. Evaluation of environmental sustainability actions in commercial restaurants in the city of São Paulo, Brazil. Demetra, 9, 595-611. http://dx.doi.org/10.12957/demetra.2014.8822

Santos, L. L., Akutsu, R.C.C.A., Botelho, R.B.A., Zandonadi, R.P., 2012. Food service compliance with ISO 14001 and ISO 22000. *Rev. Nutr*. [online], 25, 373-380. https://doi.org/10.1590/S1415-52732012000300007

Singh, S.K., Vishakha, K., Shivani, S., Nisha, L., 2014. Waste Management in Restaurants: A Review. IJEERT, 2, 14-24. http://www.ijeert.org/pdf/v2-i2/3.pdf

Tatàno,F., Caramiello., Paolini,T., Tripolone, L., 2017. Generation and collection of restaurant waste: Characterization and evaluation at a case study in Italy. Waste Manage., 61, 423-442. https://doi.org/10.1016/j.wasman.2017.01.020

Highlights

- A systematic model was developed for solid waste management in restaurants.
- Protocols were designed to avoid, reduce, reuse, and recycle waste.
- The proposed management system minimizes the environmental impacts of solid waste.

Implications for gastronomy

The system presented in the article can promote changes in the way of planning the production process of meals, aiming not to generate, reduce, reuse, recycle solid waste generated during activities related to gastronomy. Its application to different types of restaurants is possible since all stages of the meal production process listed in the protocols developed in the study are carried out in these establishments.

Declaration of interests

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: