

Restaurant food waste management strategy in Asia using the Restaurant Food Waste Map (RFWM) approach

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Abstract. Background: Food waste is a global issue due to its serious environmental, economic, and social impacts. Objective: This research aimed to collect information regarding restaurant food waste management using the Restaurant Food Waste Map (RFWM) approach. Method: This research is a narrative review. Results: The main contributors to food waste at each phase are managers, chefs, kitchen staff, waiters, and customers. Most types of food waste produced are avoidable. Factors that affect food waste include management of food supplies, lifestyles, and customer behavior. Conclusion: Management strategies that can be implemented include improving food supply management, using smaller plates, and various interventions to increase customer awareness of food waste.

1 Introduction

Food waste is a growing global issue. According to the Food and Agriculture Organization (FAO) in 2017, approximately one-third of all food produced, or around 1.3 billion metric tons, is wasted as food waste. In Asia, about 665 million metric tons of food waste are generated annually, and this figure continues to rise each year. Meanwhile, according to FAO (2021), an estimated 7.628 billion people worldwide are at risk of hunger, with approximately 9.1% or 24.5 million of them being from Asia. Rapid population growth, industrialization, urbanization, and globalization in Asia have led to changes in dietary patterns and increased purchasing power, increasing food waste [1].

The issue of food waste is important due to its environmental, economic, social, and nutritional impacts [2]. Discarded food results in the waste of resources used in its production, such as electricity, fuel, and labor, leading to economic losses. Accumulated food waste in landfills generates methane gas, which contributes to global warming, harming the environment. Food waste also exacerbates global social challenges related to increasing food demand due to population growth [3]. This challenge can be partially addressed by reducing the food waste generated across the global food supply chain [4]. When edible food is discarded, people who need food are deprived of access to sufficient, safe, and nutritious

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sources[2]. This can worsen food insecurity and hinder access to food for individuals experiencing hunger or who are unable to meet their dietary needs.

Food waste can come from leftover food in restaurants, supermarkets, traditional markets, and households[7]. Leftovers from restaurants significantly contribute to the amount of food waste at 95% compared to kitchen waste and serving waste[8]. This issue is exacerbated by the fact that food waste management in Asia has not received sufficient emphasis, investment, or urgency[9]. Additionally, public knowledge and awareness regarding food waste in Asia are still lacking[10]. Knowledge and awareness are crucial for reducing food waste. Both the public and businesses (restaurant managers) must possess knowledge and awareness about food waste, as this affects restaurant management standards in handling food waste[11].

Although the issue of food waste is receiving increasing global attention, specific research on food waste management strategies in Asian restaurants remains limited. Research on food waste management strategies in Asian restaurants is necessary to identify challenges, habits, and appropriate practices for managing restaurant food waste in Asia. The limited data and information available on restaurant food waste in Asia also hinder the development of effective management strategies. Research can focus on collecting more comprehensive data and information regarding main contributors, influencing factors, and food waste management strategies in restaurants across various Asian countries to find solutions to this problem. Evaluating the impact of implemented food waste management strategies in Asian restaurants will help identify best practices for managing food waste. Additionally, this research can serve as a foundation for future studies.

Previous research using a systematic literature review divided restaurant operations into three phases to identify food waste mitigation activities known as the Restaurant Food Waste Map (RFWM) [12]. These phases facilitate the identification of factors and characteristics related to restaurant food waste. However, this study only discussed restaurant food waste on a global scale, without specifying the location of the research. The study also did not specify the types of food waste generated. Specific locations and types of food waste would help restaurants manage food waste better by addressing the specific issues they face. The study focused on the business perspective in managing food waste, thus requiring the addition of the consumer perspective, particularly at the consumer consumption stage, to provide a more comprehensive insight. Therefore, a study was conducted to explore the strategies that Asian restaurants can implement in managing food waste.

2 Materials and methods

The design used in this study was qualitative research with the systematic literature review method. The data collection method began by identifying the research questions. The primary research question in this study is: How is the management strategy of food waste in restaurants in Asia at each phase? The secondary research questions are: 1) What are the main contributors influencing the occurrence of food waste at each phase of restaurants in Asia? 2) What types of food waste are generated at each phase of restaurants in Asia? 3) What factors influence the occurrence of food waste at each phase of restaurants in Asia? 4) How are the food waste management strategies implemented at each phase of restaurants in Asia?

The next step was conducting a literature search using Preferred Reporting Items for Systematic Review and Meta-analysis (PRISMA) flow diagram. This diagram was used to outline the results of the search and selection process, from the number of identified literature in the search to the number of literature included in the study[13]. The literature search was systematically carried out using keywords as an internal quality assurance measure to avoid bias in the researcher literature selection. Keywords were derived based on the variables studied and their synonyms, abbreviations, alternative spellings, or terms related to those

variables [14]. Keywords were constructed using Boolean operators, with the "AND" operator to combine main variables and the "OR" operator for variable synonyms [15]. The keywords were then entered into the Google Scholar and PubMed database search engines. The search on Google Scholar was conducted using keywords: "restaurant food waste" AND "Asia" AND ("management" OR "mitigation" OR "strategies") and "restaurant food waste" AND ("manajemen" OR "mitigasi" OR "strategi"). The search on PubMed was conducted using the "Advanced Search" tool with the keywords: ((restaurant) AND (food waste)) AND (Asia)).

The identified literature was screened three times. The first screening was based on title, abstract, and inclusion and exclusion criteria that could be identified from the title and abstract. The inclusion criteria used in this study are: 1) Literature discussing management strategies implemented by restaurants to reduce amount of food waste generated 2) The publication year of the literature is 2022, 3) Journals indexed by Scopus (Q1, Q2, Q3), national journals indexed by Sinta (1, 2, 3, 4, and 5), and extended abstracts 4) Research conducted in Asia. Meanwhile, the exclusion criteria include incomplete literature, literature with only an abstract, duplicate journals, theses, dissertations, and duplicate articles.

Title and abstract screening were carried out based on the following guiding questions: 1) Does the literature focus on restaurant food waste? 2) Does the literature discuss the types of restaurant food waste generated? 3) Does the literature address the factors influencing restaurant food waste? 4) Does the literature discuss food waste management strategies to reduce restaurant food waste? (answering the primary question). Literature that meets the above questions was downloaded for full screening.

Full-text screening was conducted by reading the entire content of the literature. The selection process at this stage was carried out using the following guiding questions: 1) After reading the full literature, is the literature still relevant for further processes? 2) Does the literature provide a specific explanation of the main contributor types of food waste, factors influencing food waste, and food waste management strategies in restaurants? Literature that answered "yes" to the above questions proceeded to the third screening, which was based on inclusion and exclusion criteria, along with an evaluation of the eligibility of the literature based on the previous guiding questions. Literature that passes this stage is deemed suitable for data extraction.

Data extraction was performed based on the literature selected from the previous two processes. Data extraction involved reviewing, analyzing, and synthesizing the literature. Data extraction was carried out to obtain general information on bibliographic information, main contributor types of food waste, factors influencing food waste, and management strategies implemented by restaurants to reduce food waste.

3 Results and discussion

The literature search followed the PRISMA 2020 flow diagram template for systematic literature review. The initial stage of data collection was conducted through the identification process of articles. After identification, a screening process was performed to obtain articles that contained the required information and met the criteria. The first screening is done by removing duplicate articles, which were obtained from as many as 7 articles from 385 articles. Duplication means the same article but identified as more than one article. This can happen because the search is taken from two databases, so there is a possibility that the same article is identified in both databases.

The remaining 378 articles were screened again based on the suitability of the title and abstract of the research with the topic under study. The selected articles must discuss restaurant food waste. The type of restaurant discussed is not limited to certain restaurant

criteria but does not include catering or other food services. The next requirement is that the article must contain information about the type of food waste generated, factors that affect the amount of food waste, or management strategies to reduce the amount of restaurant food waste. At this stage, unsuitable research areas and inaccessible articles were also excluded.

The second screening resulted in the remaining 34 articles by removing 344 articles that did not fit the topic under study. The 34 articles were reassessed for suitability by reading the entire article. At this stage, the variables discussed and their relation to each other in the articles were highly scrutinized for their suitability to the information sought. In addition research areas that were not mentioned in the abstract and did not fit the inclusion criteria so that they passed the previous stage were also excluded. A total of 13 articles were excluded in the second stage of screening.

The remaining 21 articles were assessed for eligibility based on inclusion criteria, namely the suitability of the information needed and the journal index and exclusion criteria if the article was incomplete, in the form of a thesis or dissertation. After screening again, 2 articles were not indexed by Scopus or SINTA so they were excluded. In addition, there were 4 articles that after reviewing did not contain the information needed in the study, 1 article was part of a book, 1 article was a conference result, and 1 other article a thesis so these articles were excluded from the study. The final number of articles that will be extracted is 12 selected articles. A more detailed process can be seen in Figure 1.

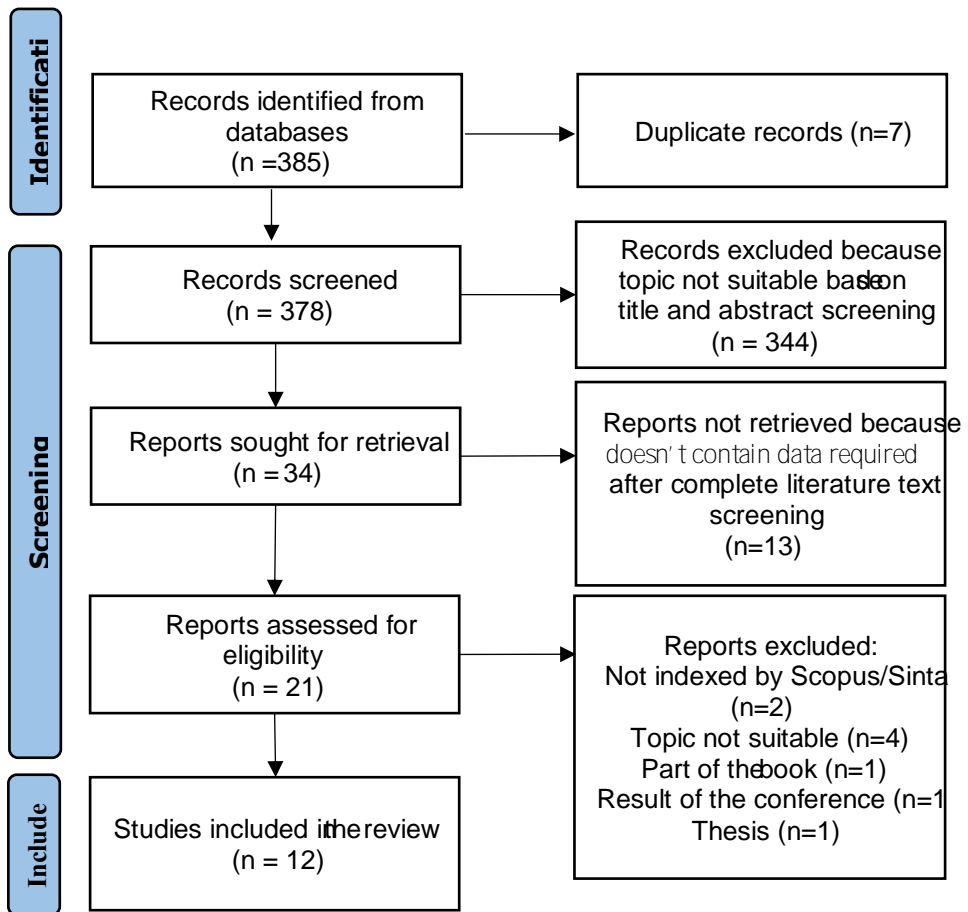


Fig. 1. PRISMA literature study process flowchart

Table 1. Final articles selected for data extraction

No.	Main Author. Year of Publication. Journal Name. Article Title	Scopus Indeks	Research Area	Design Study
1	Long et al. 2022. Appetite. Examining young Chinese consumers' engagement in restaurant food waste mitigation from the perspective of cultural values and information publicity.	Q1	China	Crosssectional study
2	Liang et al. 2021. Waste Management. Uncovering residents and restaurants' attitude and willingness toward effective food waste management: A case study Macau	Q1	Macau	Crosssectional study
3	Chang et al. 2022. International Journal of Gastronomy and Food Science. Examining effective means to reduce food waste behaviour in buffet restaurants	Q2	Taiwan	Experiment
4	Bharucha. 2018. British Food Journal. Tackling the challenges of reducing and managing food waste in Mumbai restaurants	Q1	India	Case study research
5	Manala dan Aure. 2019. Asia Pacific Social Science Review. Food waste behavior of young fast food consumers in the Philippines	Q3	Philippines	Crosssectional study
6	Zhang et al. 2021. Journal of Cleaner Production. Characteristics, environment impact, and reduction strategies of food waste generated by young adults: Case study on university canteens in Wuhan, China	Q1	China	Case study research
7	Zeineddine et al. 2021. Plos One. Post consumer food waste generation while dining out: A closeup view	Q1	Lebanon	Crosssectional study
8	Billore et al. 2021. British Food Journal. Consumer attitudes towards leftover food takeout interventions: a case study of the doggy bag in Japan	Q1	Japan	Experiment
9	Siaputra et al. 2019. Jurnal Manajemen Perhotelan. analisa implementasi food waste management di restoran 'X' Surabaya	Sinta 5	Indonesia	Case study research
10	Wang et al. 2017. Waste Management. The weight of unfinished plate: Survey based characterization of restaurant food waste in Chinese cities	Q1	China	Crosssectional study
11	Papargyropoulou et al. 2016. Waste Management. Conceptual framework for the study of food waste generation and prevention in the hospitality sector	Q1	Malaysia	Case study research, Grounded theory methodology, Ethnomethodology
12	Yu et al. 2021. Appetite. Consumer over-ordering behavior at restaurant: Understanding the important roles of interventions from waiter and ordering habits	Q1	China	Experiment

Based on the selected articles, information was obtained about the main contributors, types of food waste, affecting factors, and management strategies that complement each other. The information obtained is classified based on phases in the restaurant, namely kitchen food preparation, service phase, and consumer consumption. [12]. Kitchen food preparation is the preparation phase until the food production process in the kitchen or production area [12]. The preparation phase is important because it produces the most food waste [16]. The food service phase involves the process of serving food after it has been prepared in the kitchen and delivered to the consumer, including activities such as plating, serving, and delivering [12]. This stage is under the control of the waitstaff [12]. Consumer consumption food waste refers to food discarded by customers after the food has been sold or served [12].

The main contributors is someone who is responsible for the generation of food waste (restaurant managers, chefs, employees, and restaurant customers/consumers). Type of food waste is food waste that is differentiated based on the likelihood of food waste occurring, divided into avoidable and unavoidable food waste. Avoidable food waste is food that is discarded because it is no longer wanted or is past its best. Most avoidable food waste consists of food that is still edible although some of it cannot be eaten because it has deteriorated. Meanwhile, unavoidable food waste is the part of food that cannot be eaten under normal circumstances such as bones, eggshells, and pineapple skins [16]

Table 2. Result of data extraction based on Restaurant Food Waste Map (RFWM)

Phase	Main Contributors	Type of food waste	Affecting factors	Management strategies	References
Kitchen food preparation	Manager, chef, kitchen staff	Unavoidable (74%), avoidable (26%)	Food supply management, low food quality, kitchen facilities especially refrigerator, mistakes in cooking techniques, prediction of the number of customers is not accurate	Evaluate and improve menu planning, determine food quality standards, improving food storage systems (availability of refrigerators, SOP, routine inspections), conduct training for chefs and kitchen staffs using a pre booking system	Siaputra et al. 2019; Papargyropoulou et al. 2016; Bharucha 2018; Zeineddine et al. 2021; Liang et al. 2021.
Food services	Manager, waiters/waitresses	Unavoidable (6%), avoidable (94%)	Serving style, larger plates, rules regarding the maximum duration of serving food, misunderstanding between waiter and kitchen staff	Use a smaller plate (27 cm), regulate the policy of distributing leftovers, serve food immediately after it is prepared, improve effective communication and coordination among staff	Siaputra et al. 2019; Principato et al. 2021; Yi Chi Chang et al. 2022; Yu et al. 2021; Papargyropoulou et al. 2016; Zeineddine et al. 2021; Bharucha 2018; Zhang et al. 2021; Papargyropoulou et al. 2019.
Consumer consumption	Consumer	Unavoidable (8%), avoidable (92%)	Over-ordering/ excessive purchasing, internal culture values, dining purposes, excess portion	Intervention from waiters when consumers over-ordering, moral persuasion (posters) and financial incentives (discounts/fines), education and campaigns, serving smaller portions and providing doggy bags or takeaway service	Zeineddine et al. 2021; Long et al. 2022; Chang et al. 2022; Papargyropoulou et al. 2016; Liang et al. 2021; Zhang et al. 2021; ManalaO and Aure 2019; Wang et al. 2017; Yu et al. 2021; .Billore et al. 2021.

3.1 Kitchen food preparation

At this stage, around 17% of food is wasted as food waste [17]. Chefs, kitchen staff, and managers play a crucial role in reducing food waste during the kitchen food preparation phase. Managers are responsible for managing various systems, such as selecting suppliers and establishing supplier contracts to ensure that the food ingredients received are of good quality. Chefs and kitchen staff are responsible for the entire food preparation process, from receiving ingredients, storing them, and distributing them to production areas to the actual cooking process [16].

Most food waste generated during the preparation phase is unavoidable (74%), such as bones, shells, fruit peels, seeds, and more [17]. Trimming or cutting vegetable parts and other ingredients are also common sources of food waste [16]. A small portion of the food waste generated during the cooking process is avoidable, such as leftovers due to overcooking [18].

Food waste during the kitchen food preparation phase is influenced by several factors, including inefficient food inventory management, leading to overstocking and resulting in food waste [18]. This is often affected by menu planning that fails to consider frequently discarded ingredients or those with a short shelf life, causing them to become food waste [16]. Additionally, poor quality ingredients, such as products that are starting to spoil or are not fresh, can result in inedible or unsatisfactory dishes, which must be discarded [16]. Lack of proper kitchen facilities, especially adequate refrigeration, also cause ingredients to spoil quickly, resulting in food waste [19]. Cooking mistakes can also lead to food waste [17]. If chefs lack skill, food may be overcooked or burned, making it unsuitable for serving.

Another factor contributing to food waste is inaccurate predictions of customer numbers [17-18]. This affects the amount of food prepared. If too much food is cooked and not consumed, it ends up as food waste. Strict food safety regulations force restaurants to discard food that no longer meets safety standards, even if it is still consumable [19]. The disposal of food waste requires proper processing technology [20]. However, due to high operational costs, most restaurants do not have specialized treatment for food waste, leading to waste accumulation and direct environmental harm.

3.2 Food service

The style of food service significantly contributes to service food waste. Restaurant managers and waitstaff play a crucial role in influencing the amount of food waste at the service stage [21]. Restaurant managers are responsible for implementing effective management interventions and training staff to encourage customers to eat in more environmentally friendly ways. Waitstaff can also influence food waste by serving customers, from greeting them, taking orders for food and beverages, serving ordered items, and clearing tables after meals. They are also tasked with making a quality check of the food and drinks before serving them to customers [16]. Moreover, waitstaff can contribute to food waste through their intervention in customers' ordering behavior at restaurants [22]. Waitstaff can influence customers' ordering decisions by making suggestions or recommendations that may lead to over-ordering, contributing to food waste.

The majority (94%) of food waste in the service phase is avoidable [17]. This is because food waste typically consists of leftovers due to overpreparation of food, which is served within a limited time frame, and due to ordering errors. The most commonly wasted foods are rice, noodles, cakes, and desserts.

The biggest factor affecting food waste in the service phase is the serving style [7, 19, 21]. Serving style can influence the volume of food waste because different styles of service are associated with different consumer behaviors [21]. For instance, fine dining restaurants

are more likely to produce food waste due to over-ordering [19]. Fine dining customers generally do not worry much about their expenses, and food preparation in fine dining establishments is often more extensive, leading to more food waste [18]. Another example is the buffet style, which is more prone to generating food waste because customers tend to overfill their plates but are unable to finish their meals. This is also related to the size of the plates or serving utensils. Larger plates can create a visual illusion, leading to biased perceptions of how much food is served or consumed [18].

Policies regarding the maximum time food can be served also impact food waste, especially for restaurants with a buffet style. These policies stipulate that food should not be left on the buffet for more than four hours for food safety reasons [17]. Approximately 26.3% of managers find this policy challenging in reducing food waste. For serving styles other than buffets, the timing of service needs to be carefully managed, related to holding time and the temperature at which food is served [16]. Food should be served at the appropriate temperature to maintain quality, ensuring customers can finish their meals.

The quality of communication between managers, staff, and waitstaff also affects food waste. Miscommunication between kitchen staff and waitstaff led to food orders being replaced with new ones, and the discarded food was either eaten by staff or thrown away [16].

3.3 Consumer consumption

Customers are the main contributors at this phase as their behavior significantly influences the amount of food waste [19, 21, 25]. Customers leave food on their plates for various reasons, making it difficult to repurpose the leftovers, except for human food purposes. At the consumer consumption phase 92% of food waste is avoidable while the remaining 8% is unavoidable [17]. Avoidable food waste consists of leftover food, while unavoidable food waste includes inedible parts such as bones or shells. The most commonly wasted items include staple foods, vegetables, fruits, soups, and drinks [17, 20, 23].

Several factors influence the amount of food waste at the consumer consumption phase mostly related to consumer behavior, such as over-ordering/excessive purchasing, internal cultural values, dining purposes, and food consumption practices. Over-ordering is defined as ordering more food or a greater variety than can be consumed. Research by Marcella Aure (2019) found that 20% of Filipino university student respondents left food because they ordered too much. Another study in Lebanon indicated that over-ordering is influenced by cultural practices, such as offering large quantities of food to honor guests.

A study in China highlighted the significant impact of cultural values such as "face saving" and "group conformity" on personal norms and food waste behaviors [25]. Face saving refers to actions individuals take to maintain their social image, while group conformity is the tendency to behave similarly to one's reference group.

Dining purposes significantly affect the amount of food waste. Simple dining results in less waste compared to social dining [20]. Wang et al. (2017) also found that social gatherings generate more food waste than personal dining experiences. Serving sizes that are too large lead to customers leaving food on their plates. Marcella and Aure (2019) found that 20% of respondents reported that excessively large portions caused them to leave food.

3.4 Restaurant food waste management strategy

Managing food waste strategies in the kitchen food preparation phase in restaurants is key to reducing food waste and maintaining operational efficiency. First, a key strategy is proper menu planning. Designing several menus with similar ingredients can simplify procurement

processes and reduce food waste [16]. Menus should also be regularly evaluated and updated, removing or improving less popular items [18]. Second, setting food quality standards is essential. Accepting and storing low-quality ingredients can lead to food waste and financial losses for the restaurant [16]. Experienced staff should be assigned to inspect incoming food supplies to ensure no substandard ingredients are accepted [16]. Third, improving food storage systems is crucial, starting with appropriate storage facilities, clear Standard Operating Procedures (SOP) for storage, and regular inspections. Proper storage facilities are vital for food quality. One essential facility for restaurants is a refrigerator. Perishable items are often prepared early, stored in the refrigerator, and used when orders are received [18]. Clear and detailed SOP reduce the likelihood of staff errors that could lead to food waste. For example, trimming vegetables before storage helps prevent spoilage and contamination of other ingredients [18]. The First In First Out (FIFO) system should be used for perishable items to maximize their shelf life [16, 18]. Regular inspections should be conducted daily for perishable items like dairy products and weekly for other ingredients like grains and sauces [18]. Fourth, training chefs and all kitchen staff is essential. Trained chefs and staff who understand each menu item can help avoid misunderstandings about the menu, reducing food waste [18]. Additionally, trained chefs and staff are expected to be creative in managing food waste. For example, orange and lemon peels can be used to make marmalade, and leftover peanut shells can be turned into powder for garnishing or adding flavor to dishes [18]. Fifth, implementing a pre-booking system can significantly help in predicting customer numbers accurately, preventing excess food preparation and reducing food waste [19]. Sixth, the government could provide recycling programs for processing restaurant food waste [20]. For instance, Organic Waste Compost could be provided to recycle food waste into biogas and energy for lighting [18].

There are several strategies to reduce food waste at the food service stage in restaurants. First, use smaller plates, around 27 cm in diameter, especially for restaurants with a buffet serving style [18, 21, 23]. Smaller plates allow customers to take reasonable portions, reducing the risk of excess food that ends up as waste. Second, implementing food waste distribution policies. Some policies allow food waste to be consumed by staff but not taken home, donate excess desserts and sweets to orphanages and temples, or collaborate with Food Banks to distribute food waste [18]. Additionally, leftover food can be served in the next meal, such as breakfast pastries that were consumed can be served again at lunch. This can only be done for foods that have a longer shelf life, such as desserts and pastries, for food safety reasons. Some restaurants also implement a "public fridge" system to distribute leftover food. People can take the leftover food from the fridge for free. However, the restaurant must ensure the food stored in the fridge is still safe to consume and will not cause food poisoning. Another management strategy to reduce food waste is serving food immediately after it is prepared and improving communication and coordination among staff [18, 24]. Serving food immediately helps maintain its quality so that customers can finish it. Effective communication and coordination between staff minimizes errors, allowing food to be utilized to its fullest extent.

Both restaurants and consumers play essential roles in reducing food waste during the consumer consumption phase. Waitstaff can intervene when customers order too much. Over-ordering is influenced not only by personal factors but also by external and situational ones. Yu et al. (2021) emphasized the importance of waitstaff interventions to prevent over-ordering. YiChi Chang et al. (2022) demonstrated the effectiveness of combining moral persuasion (e.g., posters and signs) with financial incentives such as discounts or penalties to reduce food waste in buffet restaurants. Discounts were found to be more effective than penalties in reducing food waste.

The next management strategies targeted educational initiatives. For example, universities can offer courses or competitions focused on food waste reduction, or place

posters around campuses [23]. Education motivates individuals to become more aware of food waste issues [20]. In addition, restaurants can offer smaller portions to prevent customers from leaving food behind. In China, 56% of respondents indicated that offering smaller portions could reduce food waste [26], while 31.3% of respondents in Lebanon identified varying portion sizes as the most effective way to reduce food waste [19]. Additionally, providing doggy bags or takeaway services for uneaten food can further reduce food waste [27].

4 Conclusion

The Restaurant Food Waste Map divides the restaurant's operation into three phases that are suspected to be generating significant food waste. In each phase, main contributors can be identified: in the kitchen food preparation phase, the main contributors are the manager, chef, and kitchen staff; in the food service phase, the manager and waitstaff; and in the consumer consumption phase, the customers. Most of the food waste produced is avoidable, except during kitchen food preparation, which generates more unavoidable food waste, such as inedible food scraps. The factors influencing food waste are varied. In the kitchen food preparation phase, waste is affected by inventory management, food quality, kitchen facilities, cooking techniques, and customer prediction. In the food service phase, the main factors causing food waste include serving style, oversized utensils, food service regulations, and staff communication. Customer behavior plays a significant role in food waste causes, including cultural factors. Strategies for managing and reducing restaurant food waste include improving inventory management, using smaller plates or utensils, and implementing various interventions to raise customer awareness about food waste.

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