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A Systematic Review of Marketing Interventions in Reducing Consumer Plate Waste

Abstract

Purpose – This study provides a systematic literature review to explore the factors contributing to effective plate waste reduction intervention in catering outlets. This paper aims to understand which factors effectively facilitate consumers to reduce food waste when eating out of home, particularly from the perspective of how marketing plays a role in influencing consumers' sustainable behaviour to reduce plate waste.

Design/methodology/approach – This systematic literature review, which follows PRISMA guidelines, identified 27 peer-reviewed studies that examined plate waste reduction programs published in peer-reviewed scholarly literature over the past decade.

Findings – This study presents a systematic literature review to synthesize extant knowledge in peer-reviewed journals of barriers, motivators, utilization, and effectiveness of marketing in plate waste reduction, and current theories used in plate waste reduction programs over the past decade. Literature on plate waste reduction is fragmented and findings are inconclusive.

Practical implications - This review contributes to understanding effective plate waste reduction interventions that have previously been applied in universities, hotels, and commercial settings. Such interventions could enhance sustainable out-of-home food consumption practices, thereby contributing to the attainment of SDG 12.3.

Originality – This paper extends our understanding of plate waste reduction. Although all 27 included studies heavily relied on informational elements, adjusting product and place is found to be more influential than pricing strategies in reducing consumer plate waste.

Keywords: Plate waste**,** food waste, sustainable consumption, systematic literature review, catering services, sustainable marketing

Paper type: Research Paper

1. Introduction

Food waste is a complex global issue (PBS News, 2024). Food waste is often considered edible food loss at various stages of the food chain, including harvest, production, processing, distribution, and consumption (Ivert *et al.*, 2015). Food loss involves food waste at the start of the food chain, while food waste refers to food loss at the end of the chain (Parfitt *et al.*, 2010). According to the United Nations Food and Agriculture Organization (FAO, 2024), over 30% of edible global food is not consumed annually within the food supply chain, accounting for 1.6 billion tons of food wasted or lost. From an ethical perspective, almost 800 million people suffer from hunger, and nearly 700 million people suffer from malnutrition and food insecurity (The United Nations, 2024), whereas the number of obese individuals who are below 18 nearly tripled between 1975 and 2016 due to overconsumption of food (WHO, 2020). Hence, reducing food loss and the amount of food in production, consumption, and supply chains at both the retail and consumer levels are needed to achieve the Sustainable Development Goal (SDG) 12.3 food reduction target (The United Nations, 2023).

Previous studies on food loss in developing countries have primarily examined the infrastructure and behavioural and managerial decisions in the agriculture or manufacturing sector. In contrast, several studies on food waste, conducted mostly in developed countries, have analyzed the commercial sector (e.g., retail, catering, and food service sectors) and households with demographics, infrastructure, and behaviour (Bhattacharya *et al.*, 2021). Prior studies on food waste generation show that substantial food waste is created at the consumption stage (both out-of-home and at-home dining) rather than the production and distribution stages in developed countries (Cozzio *et al.*, 2021; Lee *et al.*, 2024; Martin-Rios *et al.*, 2018). In particular, the food service sector accounts for approximately 25% of food waste consumers generate (ReFED, 2018). By achieving SDG 12.3, service operators can increase profits, saving

an estimated US$18 million of net economic value (ReFED, 2016) while minimizing environmental impacts (Alcorn *et al.*, 2021). Further, reducing food waste reduces landfill pressure (ReFED, 2016).

Researchers conducted systematic literature reviews from several perspectives to advance the body of knowledge in food waste reduction. However, there is a lack of focus on the role of marketing in fostering consumers' sustainable behaviour about food waste reduction in the food and beverage industry. According to existing systematic review articles, consumer-level food waste reduction studies that specifically focused on interventions conducted in commercial catering outlets are limited. First, prior systematic literature reviews on food waste involve a wide range of topics other than consumer-level food waste (e.g., food waste management) (Huang *et al.*, 2021), food waste prevention methods (Moraes *et al.*, 2021), and the effectiveness of the food waste hierarchy (Redlingshöfer *et al.*, 2020). Second, for systematic literature reviews focusing on consumer-level food waste, the review articles examine evidence on reducing household food waste (Schanes *et al.*, 2018; Sewak *et al.*, 2021). Third, limited research has been conducted on out-of-home settings, with a majority of studies examining food waste reduction at university or hotel all-you-can-eat buffet restaurants (Seo and Yung, 2022). Review articles examined the evidence in reducing consumer out-of-home food waste (or food left on plates) in hospitality and food services (Dhir *et al.*, 2020; Kasavan *et al.*, 2022; Vizzoto *et al.*, 2021) and food waste in educational institutions (Kaur *et al.*, 2021) only examined all-you-can-eat catering outlets. Fourth, a recent systematic review on plate waste reduction in food services by Guimarães *et al.* (2024) showed that most of the previous studies experimenting with consumer plate waste reduction were either not in real commercial settings (e.g., university canteen), not serving fixed-portion meals (e.g., buffet), or not in the form of field experiments (e.g., cross-sectional survey or interview). However, many food

service establishments in the real world offer fixed-portion meals, and consumers often leave uneaten edible food items on their plates (i.e., plate waste) for reasons that differ from those observed in all-you-can-eat restaurants. Currently, practical strategies to reduce consumer plate waste have not been systematically reviewed (Lee *et al.*, 2024). The success of food waste reduction programs relies on consumer behaviour change, and it is crucial to consider the influence of food service providers in developing such programs (Legendre *et al*., 2024). Plate waste is generated at the point of sale, where consumers are exposed to the marketing mix implemented by food service providers to stimulate purchase and consumption. Therefore, understanding the effectiveness of previous studies and identifying future research directions in utilising or modifying the marketing mix in catering outlets to motivate consumer plate waste reduction will enable marketing researchers and practitioners to resolve sustainability issues through marketing.

Responding to the call of the special issue "integrating sustainability into the marketing of food services and food and beverage retail merchandising" and the scarce review examining sustainable consumption at the point of sale (Paul and Bhukya, 2021). This paper, using a systematic literature review, intends to fill the research gap above by addressing two primary research questions:

RQ1: What empirical behavioural factors of plate waste reduction have been experimentally examined in non-buffet-style catering outlets?

RQ2: How has the catering industry effectively facilitated diners to reduce food waste through marketing?

Hence, this paper seeks to offer researchers and practitioners valuable insights into developing transformative sustainability marketing strategies that go beyond auxiliary and reformative approaches to advocate for transforming existing institutions and norms, encouraging critical reflection to promote greater sustainability (Kemper and Ballantine, 2019).

2. Materials and Methods

This systematic literature review followed the rigorous Scientific Procedures and Rationales for Systematic Literature Reviews (SPAR-4-SLR) protocol (Paul *et al*., 2021) and the PRISMA guidelines (Page *et al*., 2021).

2.1 Assembling: Identification and Acquisition of Studies

The initial step of this systematic literature review was to define the domain and research questions. This review focused on studies that aimed to motivate diners to reduce the amount of food leftover on plates. This review aims to answer the above-mentioned research questions. The source type was primarily English-language peer-reviewed quality academic journals in three major electronic databases: Scopus, Web of Science, and EBSCO. No restriction was set on the publication period during the initial search to ensure that all relevant studies were extracted. The following search terms and Boolean code were used: ((Foodwast* OR "Food wast*" OR "Food Los*" OR "Food Dispos*" OR Leftover OR Platewaste* OR "Plate waste*" OR "Wasted food" OR "Wast* of Food" OR "Loss* of Food" OR "Disposal of food") AND (“Marketing” OR Intervention OR Campaign OR Program* OR Strateg*) AND (reduc* OR minimi* OR decreas*)). The search was conducted initially in April 2023, and a subsequent search was done in January 2025. A total of 3,989 articles (Scopus = 1,392, WOS = 1,724, EBSCO = 873) were retrieved, and 1789 duplicated results were removed.

2.2 Arranging: Organization and Purification

Two reviewers independently coded the 2,200 unduplicated records. A codebook was set up to code and record each article, adopting the population, interventions, comparators, outcomes, and study design (PICOS) in accordance with the PRISMA guidelines (Liberati *et al*., 2009). The reviewers coded for the following:

P – population: whether the studies targeted consumers who dine out

I – intervention: plate waste reduction programs implemented in non-buffet-style outlets

C – comparison: as compared with programs with less marketing mix

O – outcome: reducing consumers' food leftover on plates?

Unduplicated records were screened and purified in full compliance with the inclusion and exclusion criteria derived from the code book. The two reviewers independently reviewed whether the title and abstract of each article met the inclusion and exclusion criteria. When the two reviewers had any discrepancies, the full article was analyzed to reach a final decision. A total of 2,102 records were excluded since these studies were empirical papers with no field intervention or on-site experiment conducted. Then, 98 records were retrieved for full-text review. Figure 1 shows the flowchart of the literature search process.

< Insert Figure 1 >

In the full-text reviews, the following exclusion criteria were used to determine which studies were ineligible for this systematic review: (i) studies that were not interventions, programs, or campaigns intended to reduce plate waste; (ii) studies including target groups who are not consumers (diners); (iii) studies in the context of household-level food waste (i.e., consumer

food waste not related to dining-out occasions); and (iv) studies in which consumption-level food waste was not measured as an intervention outcome (e.g., food waste in the supply chain or kitchen waste); or (v) studies intended to reduce food waste other than plate leftover (e.g., promote the use of doggy bags or the donation of food leftovers). Articles that met any one of the exclusion criteria were excluded with no further inspection. A total of 49 records were excluded for not measuring consumer plate waste reduction as a program outcome. A total of 20 studies were excluded since they evaluated consumer food waste at the household level or in all-you-can-eat buffet catering settings. Two studies were excluded due to non-consumer targets. No studies were excluded due to the promotion of consumer behaviours besides plate waste reduction in catering outlets. After the two reviewers examined the full texts of the 98 records to confirm their eligibility, 27 articles were finally included in this systematic review for the next "assessing: evaluation and reporting" stage, illustrated in Section 3.

3. Results

3.1 Study Characteristics

All 27 studies examined plate waste reduction programs implemented in non-buffet-style catering outlets. The screening process unveiled a considerable number of previous studies on plate waste or consumer food waste, yet most of which were cross-sectional empirical investigations. The results highlight a notable scarcity of field studies assessing interventions' effectiveness on real consumer plate waste behaviour. Table 1 summarizes the characteristics of the 27 studies included in this systematic review. Most studies were conducted in the Western contexts, with 10 in Europe (Belgium, Germany, Italy, Netherlands, Portugal, Slovenia, Spain, Sweden, and Switzerland), 9 in the USA, 6 in Asia (China, Hong Kong, Taiwan, and Thailand), one in Iran, and one in the UK and India. Nearly all studies conducted interventions over a few weeks and assessed the effectiveness of the programs by comparing

the results with pre-program baseline data on food waste. Only six studies were conducted in commercial catering outlets, while the remaining 21 were conducted in university canteens.

Of the 27 included studies, six studies examined plate waste interventions lasting between four and seven days (Alattar and Morsem, 2021; Kuo and Shih, 2016; Liu *et al*., 2022; Rajbhandari-Thapa *et al.*, 2018; Richardson *et al.*, 2021; Vermote *et al.*, 2018). Ten studies conducted plate waste interventions for one to three weeks (Ahmed *et al*., 2018; Cozzio *et al*., 2021; Dolnicar *et al*., 2020; Jagau and Vyrastekovam, 2017; Manomaivibool *et al*., 2016; Pinto *et al*., 2018; Richardson *et al*., 2021; Vidal-Mones *et al*., 2022; Visschers *et al*., 2020; Whitehair *et al*., 2013) while nine studies deployed plate waste interventions for four weeks or more (Alcorn *et al*., 2021; Berkowitz *et al*., 2016; Chang, 2022; Ellison *et al*., 2019; Jiang *et al*., 2024; Lee *et al*., 2024; Lorenz-Walther *et al*., 2019; Malefors *et al*., 2022; Yazdankhah *et al*., 2020). Two studies did not specify the intervention period. Of the 27 studies, 19 used a pre-test and post-test quasi-experiment, four applied a quasi-experiment, one adopted a field experiment, one used randomized controlled trials, one conducted one quasi-experiment (crossover trial), and one employed a lab experiment.

< Insert Table 1 >

Figure 2 indicates the annual publications on plate waste reduction in catering settings. There were limited studies on plate waste reduction programs prior to 2013, after which the plate waste studies gradually increased and peaked at five articles in 2021 and six in 2022. This finding could be explained by the UN SDGs establishing 17 goals that created public awareness and research interest in SDG 12 sustainable consumption and production, particularly the SDG 12.3 food reduction target. Due to the lockdown during COVID-19, studies conducted in

catering establishments were almost unfeasible, resulting in zero articles published in 2023 and three in 2024. Figure 3 shows that plate waste studies were published in various journals, including food, nutrition, health, waste management, and tourism. Among the 27 articles extracted and evaluated, only two recent studies were published in marketing journals (Jiang *et al.*, 2024; Lee *et al.*, 2024).

< Insert Figure 2 >

< Insert Figure 3 >

3.2 Barriers and Motivators for Reducing Plate Waste in the Eating System

Figure 4 shows barriers and motivators for reducing plate waste in the eating system. The barriers and motivators for reducing consumer plate waste in catering settings (non-buffet-style) were mainly based on three main categories: the macro level of the eating system (cultural rules and norms), the meso level of the system (facilities and settings, and dining options with serving size, style, and dinnerware), and the micro level of the eating system, including individual choice and personal capabilities, according to the influence of stakeholders on the supply and demand sides of food services.

< Insert Figure 4 >

These findings of the 27 extracted articles are summarized in Table 2, which highlights the identified barriers, and Table 3, which outlines motivators for consumer plate waste reduction. However, the researchers experimentally tested not all of the barriers and motivators mentioned in the articles. Both tables also denote whether the barriers and motivators were incorporated

into the research programs applied to reduce plate waste. In these two tables, the column "empirically highlighted" refers to plate waste reduction factors involving one or more hypotheses made by the author/s based on citations to prior studies. The column "practically examined" records plate waste reduction intervention/experiment implemented in catering settings, testing whether the intervention/experiment was somehow effective.

3.3 Major Barriers to Consumers to Reduce Plate Waste

Table 2 summarizes barriers to plate waste reduction identified in this systematic review. Among the 27 studies, 15 have reviewed barriers to plate waste reduction in previous empirical studies, while six investigated barriers to plate waste reduction in practice on site. The major barriers to plate waste reduction are broadly divided into three levels of the eating system: macro, meso, and micro. At the macro level, two studies examined the impact of cultural rules and norms on plate waste reduction at the macro level of the eating system. Davison *et al.* (2022) demonstrated the influence of cultural differences on individuals' perception of and behaviour toward food waste, while Dolnicar *et al.* (2020) showed cultural background plays a role in influencing how children are taught about plate waste. This highlights the need for businesses and marketers to develop culturally tailored interventions for reducing plate waste effectively.

< Insert Table 2 >

At the meso level, restaurant settings, in terms of dining options, serving sizes, and styles, profoundly influence plate waste reduction. Large and fixed portion sizes of food were the primary barrier to reducing plate waste (Alcorn *et al.*, 2021; Chang, 2022; Jagau and Vyrastekova, 2017; Jiang *et al.*, 2024; Visschers *et al.*, 2020). This has been empirically

supported by Davison *et al.* (2022) and Lee *et al.* (2024). Unit size reduction experiments and randomized controlled trials (RCTs) were conducted by Werkman *et al.* (2022) to address this issue. Serving style with non-desirable food/side items offered by default contributes to increased plate waste (Alcorn *et al.*, 2021; Chang, 2022; Lee *et al.*, 2024), while the serving sequence, including the timing and order of food delivery, plays a role in influencing plate waste (Kuo and Shih, 2016). In addition, overly large menus were another barrier to plate waste reduction (Liu *et al*., 2022).

At the micro level, the key barriers to plate waste reduction are individual choice and personal capabilities. Individuals' attitudes toward food quality are influenced by freshness, low-quality food, and poor taste. These were empirically examined through quasi-experimental field studies conducted by Davison *et al.* (2022) and Dolnicar *et al.* (2020). Unsurprisingly, customers often prioritize food quality. When food quality expectations are not met, it can inadvertently lead to increased plate waste. Thus, enhancing food quality perceptions can contribute to commercial success and reduce plate waste. Another aspect of individual choice is plate waste perceptions, which were empirically assessed by Ellison *et al.* (2019) using a pre-test and post-test study design. Dolnicar *et al.* (2020) pointed out that a psychological perception, fear of missing out, may cause people to order more food than necessary, particularly in travel and tourism contexts. In contrast, Davison *et al.* (2022) showed that perceived inconvenience can inhibit individuals from taking pro-environmental actions, including plate waste reduction. These perception-related barriers can be addressed through customer educational initiatives and social marketing campaign approaches.

The final key barrier to plate waste reduction is personal capabilities within the eating system's micro level, encompassing individual habits and knowledge and information exchange. Certain

individual habits, such as following a low-carbohydrate diet, eating insects, and having insufficient time to finish meals, can contribute to plate waste (Davison *et al.*, 2022; Kuo and Shih, 2016; Zhang *et al*., 2024). Moreover, patrons' laziness or reluctance to retrieve food from buffet stations often leads them to take more food than needed at once and increasing plate waste (Dolnicar *et al.* 2020). Furthermore, Lee *et al.* (2024) examined the role of embarrassment in requesting plate waste reduction options, such as smaller portions of commonly wasted items like carbohydrates or vegetables. Furthermore, a lack of knowledge on proper eating and insufficient information exchange on plate waste reduction strategies can contribute to an increased level of plate waste (Davison *et al.*, 2022; Dolnicar *et al.*, 2020). These habits and knowledge deficiencies may be addressed through targeted marketing strategies that offer practical tips on food consumption and promote mindful eating practices from an environmental or cost-saving perspective.

3.4 Motivators for Plate Waste Reduction

Table 3 summarizes motivators for reducing plate waste identified in the 27 studies (see Figure 4). The eating system in this review included the macro level of the eating system. Environmental concerns and social pressures are key motives within cultural rules and norms that induce plate waste behaviours. Various behavioural models suggest that environmental attitudes and social influences strongly motivate pro-environmental behaviours in plate waste studies (Pinto *et al.*, 2018; Visschers *et al.*, 2020). This implies that businesses and marketers should consider environmental concerns and prevailing social norms as their informational strategies for encouraging plate waste reduction.

< Insert Table 3 >

Within the meso level of the eating system can be broadly classified into two mainstreams: management side and customer side. The management side includes (i) restaurant dining facilities and settings, (ii) restaurant management (frontline staff training, waste measurement, and menu design/planning), (iii) awareness/education campaigns. The customer side involves (i) financial incentives and penalties from restaurants and (ii) dining options (portion size, serving style adjustment, and dinnerware adjustment).

On the management side, restaurant dining facilities and settings, such as limiting the number of food stations in buffet settings and avoiding live cooking at the buffet can effectively reduce plate waste (Cozzio *et al.*, 2021). Restaurant management practices at catering businesses play a vital role in reducing plate waste. Internal frontline staff training can enhance employees' understanding of customers' dietary needs and help them recommend portion sizes that better align with customer needs and desires (Pinto *et al.*, 2018; Jiang *et al.*, 2024). In addition, implementing plate waste trackers to quantify and monitor food waste can effectively provide a measure and control system that contributes to more sustainable food consumption practices (Malefors *et al.*, 2022) and was empirically examined by recent studies (Jiang *et al.*, 2024; Zhang *et al.*, 2024). Menu design that enhances customers' knowledge about food items and offerings and provides kids' meals for family guests can support campaigns aimed at reducing plate waste (Cozzio *et al.*, 2021; Ellison *et al.*, 2019). These strategies empower customers to make informed choices and offer alternatives to customers that minimize the likelihood of overordering. As evidenced by the studies reviewed in this paper, well-designed awareness campaigns have proven effective in motivating individuals to reduce plate waste. These studies demonstrated the effectiveness of various campaigns, such as functional appeals, eating instructions, food waste demonstrations, and informational and educational campaigns (Alattar

and Morse, 2021; Cozzio *et al.*, 2021; Jiang *et al.*, 2024; Richardson *et al.*, 2021; Vidal-Mones *et al.*, 2022; Yazdankhah *et al.*, 2020; Zhang *et al.*, 2024). Promotional messages in serving or dining areas have demonstrated their potential to nudge and engage customers in reducing plate waste (Ahmed *et al.*, 2018; Chang, 2022; Cozzio *et al.*, 2021).

On the customer side, utilizing inducements to promote and discourage undesirable behaviours can motivate individuals to reduce plate waste. Incentives such as stamps, discounts, and coupons and disincentives such as penalties for food leftovers have been identified as effective motivators for encouraging individuals to adopt environmentally friendly behaviours and discourage wasteful consumption (Ahmed *et al.*, 2018; Chang, 2022; Dolnicar *et al.*, 2020; Jiang *et al.*, 2024; Malefors *et al.*, 2022; Zhang *et al.*, 2024). Furthermore, offering options related to portion size and side dishes and the provision of tasting spoons offer more flexible choices to customers that align with their consumption needs (Alcorn *et al.*, 2021; Malefors *et al.*, 2022). The style in which food is served, including the appropriate temperature and serving style (buffet vs. table service), can also motivate customers to consume what they need (Davison *et al.*, 2022; Ellison *et al.*, 2019; Yazdankhah *et al.*, 2020). Altering plate shape, reducing plate size, and eliminating trays can also effectively motivate individuals to take less food in a buffet setting, preventing unnecessary plate waste (Ahmed *et al.*, 2018; Jiang *et al.*, 2024; Richardson *et al.*, 2021; Rajbhandari-Thapa *et al.*, 2018; Zhang *et al.*, 2024).

At the micro level of the eating system, individual choices are influenced by attributes of offerings and eating motivations. Ellison *et al.* (2019) and Visscher *et al.* (2020) investigated how offering attributes including price change and pay-by-weight options impact food consumption. Furthermore, Cozzio *et al.* (2021) and Richardson *et al.* (2021) empirically

examined how eating motivations, including altruistic appeal and perceived food satisfaction, affect food choices.

The 27 studies reviewed motivators for plate waste reduction based on previous studies, whereas 20 studies analyzed motivators for plate waste reduction in practice on site. These 20 studies used three main study designs: a pre-test and post-test study design, experiments, and quasi-experiment studies. However, quasi-experimental field studies, quasi-experimental baseline interventions, field experiments, crossover trials, and randomized controlled trials (RCTs) were less commonly used (Chang, 2022; Dolnicar *et al.*, 2020; Jiang *et al.*, 2024; Lorenz-Walther *et al.*, 2019; Richardson *et al.*, 2021).

3.5 Utilization and Effectiveness of Marketing in Plate Waste Reduction

All included studies implemented interventions for plate waste reduction that aimed to reduce plate waste among consumers and diners. Table 4 summarizes the interventions reported in the 27 studies and reports whether the programs used a marketing mix in the program design. The effectiveness of the programs was assessed based on the results reported in the included studies. The plate waste measurement method varied between studies. The most common measurement methods consisted of weighing collected edible plate waste. Only two studies observed plate waste portions (Jagau and Vyrastekova, 2017; Lorenz-Walther *et al.*, 2019); one study performed self-reported estimation based on the fraction of plate waste relative to the plate (Visscher *et al.*, 2020), and one study took photos of edible plate waste (Richardson *et al.*, 2021). The intended behavioral outcomes were often measured in terms of plate waste reduction. Most of these studies showed a significant decrease in plate waste, except for the study conducted by Jagau and Vyrastekova (2017), which intended to reduce plate waste through a communication campaign using guilt or shame appeal.

< Insert Table 4 >

According to Table 4, no prior studies have attempted to use all the 4Ps (product, price, place, and promotion) of marketing to influence consumers' plate waste behavior. However, the results of the included studies indicated that applying one, two, or three marketing mixes in catering outlets effectively reduces consumer plate waste.

For product, 11 studies provided individual consumers with different tangible products. Offering options to diners regarding portion size (Ahmed *et al.*, 2018; Alcorn *et al.*, 2021; Berkowitz *et al.*, 2016; Lorenz-Walther *et al.*, 2019; Pinto *et al.*, 2018; Vermote *et al.*, 2018 Visschers *et al.*, 2020; Werkman *et al.*, 2022; Yazdankhah *et al.*, 2020), menu (Liu *et al.,* 2022), and garnish choice (Lee *et al.*, 2024) are effective in reducing waste, particularly for high waste items such as carbohydrates (e.g., rice and French fries). A reduction in portion sizes did not affect customer dining experiences, satisfaction, or willingness to pay if the quality of the food was perceived to be equivalent (Ge *et al.*, 2018).

For price, only six studies provided individual consumers with price as financial incentives to reduce plate waste. Several studies found that solely offering a price cut (i.e., discounts) to consumers who opt for a reduced portion does not help motivate voluntary behaviour (Berkowitz *et al.*, 2016; Chang, 2022; Jiang *et al.*, 2024; Lee *et al.*, 2024; Visschers *et al.*, 2020; Zhang *et al.*, 2024). Monetary penalties for plate waste are somehow ineffective in reducing plate waste (Chang, 2022; Jiang *et al.*, 2024; Kuo and Shih, 2016). However, nonfinancial incentives such as stamps for winning gifts and certificates motivate behavioural changes to achieve zero plate waste outcomes via pleasure and reward (Dolnicar *et al.*, 2020).

For place, ten studies offered individual consumers different environmental settings in their dining experience. Changing the serving style to self-serve (Chang, 2022; Werkman *et al.*, 2022), tasting spoons before food collection (Malefors *et al.*, 2022), serving high-waste items on request (Alcorn *et al.*, 2021; Pinto *et al.*, 2018; Yazdankhah *et al.*, 2020), changing the plate form and size (Ahmed *et al.*, 2018; Manomaivibool *et al.*, 2016; Richardson *et al.*, 2021) and eliminating trays in serving areas (Rajbhandari-Thapa *et al.*, 2018) are all effective approaches in reducing food left on the plate.

For promotion, 21 studies focused on influencing consumer plate waste behaviour using different promotional strategies, including informational campaigns, educational campaigns, and simple nudges. Informational campaigns using cards, signage, posters, flyers, stickers, leaflets, and tableware (Cozzio et al., 2021; Davison *et al.*, 2022; Dolnicar *et al.*, 2020; Kuo and Shih, 2016; Jiang *et al.*, 2024; Lee *et al.*, 2024; Lorenz-Walther *et al.*, 2019; Manomaivibool *et al.*, 2016; Visschers *et al.*, 2020; Zhang *et al.*, 2024) were effective. Educational campaigns were found to be effective (Ahmed et al., 2018; Alattar and Morse, 2021; Pinto *et al.*, 2018; Vidal-Mones *et al.*, 2022; Whitehair *et al.,* 2013; Yazdankhah *et al.*, 2020). Another promotional strategy featuring simple nudges on-site achieved environmental goals (Alcorn *et al.*, 2021), environmental appeals (moral persuasion) (Chang, 2022), and nudges to reduce plate waste (Ellison *et al.*, 2020; Malefors *et al.*, 2022) effectively reduced plate waste. Jagau and Vyrastekova (2017) found that a communication program consisting solely of guilt and appeal posters at food disposal locations does not significantly alter plate waste behaviour.

3.6 Current Theories in Plate Waste Reduction Program

This study adopted the theory utilization framework to assess levels of theory application as initially suggested by Glanz and Bishop (2010) and more recently used by Pang *et al.* (2017). Nearly 37% (n=10) of sampled studies adopted theory to examine plate waste reduction programs in various settings (Chang, 2022; Cozzio *et al.*, 2021; Donicar *et al.*, 2020; Jagau and Vyrastekova, 2017; Jiang *et al.*, 2024; Kuo and Shih, 2016; Liu *et al.*, 2022, Lorenz-Walther *et al.*, 2019; Visschers *et al.*, 2020; Whitehair *et al.*, 2013) (See Table 4). Ten studies reported applying theory, but application rates of theory were low. This review showed that the most common theory adopted in plate waste studies was the elaboration likelihood model (ELM) of persuasion (Chang, 2022; Cozzio *et al.*, 2021; Whitehair *et al.*, 2013) and the theory of planned behaviour (TPB) (Lorenz-Walther *et al.*, 2019; Visschers *et al.*, 2020) that both are streamed from the psychology field. Different theories from different disciplines can be used to explain attitudes and predict behaviour. Thus, the application of theory could be further examined in the plate waste reduction intervention studies.

The theory coding framework has been used in prior systematic literature review studies (Glanz and Bishop, 2010; Mathew *et al.*, 2023; Pang *et al.*, 2017). The levels are classified into four different levels: (i) level 4 is building theory; (ii) level 3 is testing theory; (iii) level 2 is applying theory; and (iv) level 1 is informed by theory. No study in this review reached level 4 (building theory) when an existing theory is adjusted or a novel theory is generated by measuring, testing, and examining the theoretical constructs (Glanz and Bishop, 2010).

Three studies in this review reached level 3 (testing theory), in which a study implements, measures, and investigates over 50% of the theoretical constructs (Glanz and Bishop, 2010; Pang *et al.*, 2017). These studies mainly applied dual process theory and the theory of planned behaviour (TPB), which are both influential theories in psychology. Both theories provide

insights into understanding human behaviour through cognitive processes and behavioural prediction. Liu *et al.* (2022) used dual process theory to generate hypotheses to test the effect of a broad menu (big portions of food) and a narrow menu (small portions of food) on plate waste behaviour by using an experimental design. Lorenz-Walther *et al.* (2019) used the classical theory of planned behaviour (TPB) to develop a structural model with behaviour intention, attitudes, subjective norms, and perceived behavioural control along with personal, social, and environmental factors to examine plate leftovers in a canteen. The constructs in this model were measured and tested in two interventions, including informational campaigns and portion size reduction (Lorenz-Walther *et al.*, 2019). Visschers *et al.* (2020) conducted a questionnaire derived from the theory of planned behaviour (TPB) with plate waste reduction behaviour, intention to minimize, and personal norms for pre-test and pro-test via informational campaigns and small serving sizes to examine plate waste reduction behaviour.

Four studies in this review are considered level 2 (applying theory), which means that a study implements and tests multiple components of theory (Glanz and Bishop, 2010; Pang *et al.*, 2017). These studies applied the same theory, the elaboration likelihood model (ELM) of persuasion streamed from social psychology. This theory provides a framework to understand how different factors influence individuals to process persuasive messages and affect their attitudes and behaviour. Chang (2022) used this theory to test moral persuasion with financial incentives in a field experiment to motivate consumers to minimize plate waste. This study shows that moral persuasion through educational signage has a positive effect on plate waste reduction (Chang, 2022). Cozzio *et al.* (2021) adopted this theory to generate one hypothesis to examine the adoption of an altruistic appeal (i.e., sustainability logos, awards, and ecolabels) as a credible source rather than an egoistic appeal to mitigate plate waste by using a quasi-experimental design. This is a peripheral route with little cognitive elaboration, as consumers

may be persuaded by credible sources of information to convey sustainable messages (Cozzio *et al.*, 2021). Whitehair *et al.* (2013) used this theory to develop the peripheral route of persuasion (i.e., a prompt-type message intervention poster) and the central route of persuasion (i.e., a feedback-based message intervention poster) to minimize food waste behaviour change by using a pre and post quasi-experimental design. These two types of route persuasion examined the presence or absence of elaboration or thinking about reducing plate waste that can improve communication strategies for restaurant owners (Whitehair *et al.*, 2013). Jiang *et al.* (2024) used four theories: the persuasion effect, prospect theory, expected utility theory, and level of explanation theory. By using the persuasion effect, this study used authoritative sources of information to encourage individuals to review information to change their attitudes and behaviour. This study also used prospect theory focusing on loss aversion, in which individuals tended to emphasize losses rather than gains depending on the expected outcomes as participants faced different levels of financial interventions (i.e., penalties and rewards). Expected utility theory was the supplement theory to explain individuals tended to maximize their utility or self-interest. Surprisingly, the level of explanation theory was mentioned in this study, but this theory did not clearly explain in the literature review and discussion sections.

Finally, three studies in this review are considered the lowest level of theory application (level 1), where a study mentions a theory without applying it in the study (Glanz and Bishop, 2010; Pang *et al.*, 2017). Dolnicar *et al.* (2020) only stated that their findings align with the utility theory of human behaviour. Kuo and Shith (2016) mentioned social role theory in the literature review, but no evidence of the theory being applied or tested was clearly reported in their study. Jagau and Vyrastekova (2017) indicated prospect theory without clearly reporting the use of the theory in their study. These three theories are mainly from behavioural economics, psychology, and sociology to understand how individuals make their decisions and what

contextual factors influence individual behaviour. However, three studies did not empirically apply or test the theory to examine plate waste reduction.

4. Discussion

This review aimed to identify the behavioural factors, including barriers and motivators, influencing individuals' plate waste behaviours and examined intervention strategies for reducing plate waste (See Figure 4). Table 2 shows barriers and Table 3 highlights motivators for plate waste reduction in the 27 studies. In this review, barriers to reducing plate waste at the micro level are mainly based on individual factors, including attitude toward food quality, perception of plate waste, individual habits, and knowledge and information exchange. Conversely, motivators for reducing plate waste at the meso level are broadly driven by two organizational factors: the management side and the customer side. For organizational factors, the management side includes (i) dining facilities and settings, (ii) management frontline (staff training, waste measurement, and menu design/planning), and (iii) awareness campaigns, while the customer side involves (ii) dining options and services (portion size, serving style adjustment, and dinnerware adjustment), (iii) financial incentives and penalties from restaurants. However, economic, social, and institutional factors were under research in the context of plate waste. By systematically examining a wide range of relevant studies, this review contributes a summary of evidence-based practices that can be applied in the catering industry to reduce food waste, thereby contributing to an understanding of how SDG 12.3 can be achieved.

4.1 Building Programs to Use Marketing Mix to Influence Sustainable Consumption Behaviour

The studies reviewed in this paper explored the use of marketing to motivate individuals to engage in plate waste reduction. One of the common marketing mixes that has been empirically

tested is "promotion". Communicating the economic, social, and environmental impact of plate waste reduction through informational and educational campaigns in the dining areas is necessary to raise diners' awareness of the issues. Various messages and techniques have been employed and tested, including guilt and shame appeals (Jagau and Vyrastekova, 2017), functional and experiential appeals (Cozzio *et al.*, 2021), information and statistics about plate waste (Ahmed *et al.*, 2018; Ellison *et al.*, 2019), simple nudge on site (Alcorn *et al.*, 2021; Chang, 2022; Malefors *et al.*, 2022), on-site discussion tables (Alattar and Morse, 2021), educational campaign (Vidal-Mones *et al.*, 2022; Whitehair *et al.*, 2022) and informational campaigns (Davison *et al.*, 2022; Dolnicar *et al.*, 2020; Jiang *et al.*, 2024; Kuo and Shih, 2016; Lorenz-Walther et al., 2019; Zhang *et al.*, 2024), and they have proven to be effective, particularly when working alongside another marketing mix.

Optional pricing intended to induce diners to opt for a smaller portion of high-waste items at a price reduction is not necessarily helpful. Another intervention emphasizes the use of inducements. Positive and negative financial incentives, such as discounts for no plate waste and penalties for food leftovers, have proven to be effective strategies for plate waste reduction (Chang, 2022; Jiang *et al.*, 2024; Kuo and Shih, 2016). Furthermore, nonfinancial incentives such as stamps for winning gifts and certificates motivate behavioural changes and enhance the dining experience through pleasure and reward (Dolnicar *et al.*, 2020).

Adjusting the product and place are common but useful tactics significantly reducing plate waste. These interventions often involve adjusting the serving size, serving style, and other aspects of dining facilities and settings. Common interventions in portion size include the provision of portion choices, side dishes, and reduced portions (Ahmed *et al.*, 2018; Alcorn *et al.*, 2021; Lorenz-Walther *et al.*, 2019). These interventions effectively prevent customers from

taking more food than they need. To support the provision of flexible choices, it is essential that staff members are trained to inquire about customer preferences and requirements (Yazdankhah *et al.*, 2020). Alteration of plate shape and size and elimination of trays are useful measures that reduce unnecessary food consumption (Rajbhandari-Thapa *et al.*, 2018; Richardson *et al.*, 2021).

Since there are a limited number of studies in this review, it remains too early to draw definitive conclusions. Behavioural change approaches in plate waste reduction should extend beyond the intervention approaches identified in this review. Specifically, multi-faceted intervention approaches, which include different objectives, various components, and high levels of stakeholder engagement, are recommended (Mathew *et al.*, 2023). Such work is recommended to preserve autonomy to enhance levels of intrinsic motivation which are needed for long-term behavioral change (Geiger *et al.*, 2021). While adjusting existing practices to create sustainable changes in commercial settings is sometimes challenging, adjusting one or two marketing mix have already been found to be effective in changing consumers' plate waste behaviour. Since the practices are hardwired into the marketing mix, long-term behavioural change can be fostered in a more profound manner than the usual short-term education or communication campaign.

4.2 Increasing Theory Application in Plate Waste Reduction Studies

This study shows that 56% (n=15) of studies do not clearly report theory application (See Table 4). Approximately one-third of studies, 37% (n=10) mentioned, applied, and tested theories. No study has built a theory (Glanz and Bishop, 2010). The findings differ from other systematic literature reviews showing more theory-building (Mathew *et al.*, 2023). Theory application is essential to designing, applying, and assessing plate waste interventions (Willmott *et al.*, 2019).

This review indicates low levels of theory application, which remains comparable to prior systematic literature review studies (Pang *et al.*, 2017; Mathew *et al.*, 2023; Willmott *et al.*, 2019), which is concerning given that theory use has been linked to larger effect sizes (Kim *et al.*, 2019). The elaboration likelihood model of persuasion (ELM) (Chang, 2022; Cozzio *et al.*, 2021; Whitehair *et al.*, 2013) and the theory of planned behaviour (TPB) (Lorenz-Walther *et al.*, 2019; Visschers *et al.*, 2020) were the most commonly adopted theories from the psychology field in plate waste reduction interventions. The application of ELM and TPB has been found to enhance behaviour change. However, these two theories are limited to the consumer perspective at the micro level. The problem of plate waste involves different levels of shared responsibility with broader stakeholder groups in the eating system (Mesiranta *et al.*, 2022).

Future studies could advance theory application in plate waste reduction studies. First, this review has identified low rates of theory application in plate waste reduction interventions. Future research could adopt and integrate theory into plate waste intervention design, application, and evaluation, given that theory has been linked to greater rates of behaviour change. Second, this review suggests that future studies could consider the application of theories in social and institutional factors, such as the socio-ecological model (Bronfenbrenner, 1979), COM-B (Michie *et al.*, 2011), social network theory (Krause *et al.*, 2007), stakeholder theory (Mitchell *et al.*, 1997), and institutional theory (Suchman, 1995). Third, this study suggests that future studies could clearly define the target behaviour and consider using more than one theory to explain and examine actual behaviour change after interventions.

4.3 Advancing Future Research on Plate Waste in Commercial Settings

Most studies were conducted in buffet-style non-commercial university canteens. First, most commercial establishments in the food service sector serve fixed-portion meals rather than offering buffets (Filimonau and Delysia, 2019). Second, commercial restaurants face more pressure regarding profit and customer satisfaction when introducing smaller portions. For example, some restauranteurs purposely serve large portions despite knowing the potential increases in operating costs to deal with plate waste (Betz *et al.*, 2015). Restaurants intentionally provide a different variety of food in an excessively large menu to satisfy customers preferences which is a main cause of plate waste in restaurants (Block *et al.*, 2016). To extend the empirical evidence base, further research is needed to examine intervention strategies in non-buffet, commercial contexts.

Most studies were conducted in the US and European countries, while only six studies were conducted in a non-Western context, i.e., China and Iran, (Chang, 2022; Jiang *et al*., 2024; Lee *et al*., 2024; Kuo and Shih, 2016; Yazdankhah *et al.*, 2020; Zhang *et al*., 2024). To date, limited studies have been conducted in Asian countries, which is concerning given that China is often considered one of the significant contributors to Asia's plate waste crisis (FAO, 2024). Moreover, only one study compared plate waste reduction between two countries, namely the UK and India (Davison *et al.*, 2022). This suggests a knowledge gap in understanding whether plate waste reduction behaviours can be reliably applied across countries. More comparative studies are recommended. Future research should expand to cover other cultural contexts, such as Asia, South America, and Africa. Doing so will help advance the understanding of unique social and other environmental forces in formulating globally applicable plate waste reduction strategies.

Future research may also benefit from methodological considerations. First, previous experimental studies ranged from days to weeks. Identifying the long-term effectiveness of interventions may help advance the understanding of optimal approaches to reducing plate waste. Second, experimental design rigour can be improved to further enhance reliability and validity of study findings. Quasi-experiments were frequently employed. Whenever feasible, randomization can help reduce bias and provide a more rigorous examination of causal relationships. Finally, the most common measurement used in previous studies consisted of weighing edible plate waste, while a few studies employed observations (e.g., photos) and self-reported estimation. While weighing plate waste provides accurate data on behavioural changes, additional measures can offer insights into the underlying drivers and mechanisms.

5. Conclusion

This paper responds to the call for future research to investigate sustainable consumption from a consumer aspect (Paul and Bhukya, 2021). This systematic literature review synthesizes current knowledge in peer-reviewed journals of barriers, motivators, utilization and effectiveness of marketing in plate waste reduction, and current theories used in plate waste reduction programs in catering outlets reported in scholarly journals over the past decade. The 25 studies identified various factors at macro, meso, and micro levels. Barriers preventing plate waste reduction and motivating factors that can further facilitate plate waste reduction were summarized. Additionally, the utilization and effectiveness of the marketing mix and the application of current theories were identified in this review. This paper extends our understanding of plate waste reduction. This review identified plate waste reduction approaches that caterers can apply to achieve SDG 12.3.

5.1 Practical Implications

There are some implications for policymakers, managers in catering outlets, and researchers to play essential roles in achieving SDG 12.3. First, this systematic literature review identified different factors contributing to plate waste that policymakers could take the lead in supporting sustainable lifestyles and responsible production practices in the catering industry that provide grants, subsidies, or tax reductions to establish benchmarking restaurants to implement plate waste reduction initiatives as the cultural norms. The government can work with sustainable food associations to formulate standardized dietary guidelines for restaurants to inform diners of the suggested quantity of food for each meal to avoid over-consumption. Local authorities develop a special task force to offer training programs, short courses, and certifications for catering staff on plate waste knowledge, sharing best practices, and successful case studies. Besides, regulators not only can establish a fund to provide financial support to industries, universities, and research centers to develop innovative technologies on plate waste interventions but also can collaborate with sustainable catering associations and social service organizations to organize a series of responsible consumption via public education and informational campaigns to increase awareness of plate waste reduction and encourage community engagement.

Second, this paper could offer practical implications for managers in evaluating their plate waste approaches as sustainable branding strategies in catering outlets. The restaurant owners and their staff members could show their plate waste commitment to enhance consumer loyalty for existing diners and attract potential environmentally conscious diners. Managers could consider adopting innovative technologies aligned with 4P marketing strategies, such as gamification, social media challenges, and AI influencers, to create enjoyment and incentives for consumers to participate in plate waste reduction and influence consumer plate waste behaviour.

Third, this paper is a stimulus for current researchers and emerging scholars in plate waste reduction. No prior studies have attempted to examine and evaluate the effectiveness of all the 4Ps of marketing aimed at consumers' plate waste behaviour in catering outlets. The findings show that no more than three marketing mixes are adopted, which can temporarily reduce consumer plate waste in catering outlets. However, insufficient empirical research on these ineffective and inconsistent marketing mixes could advocate long-term individual behaviour changes and nudge consumer eating habits in plate waste reduction. Thus, researchers can foster interdisciplinary collaboration between food science, strategic marketing, and behavioural psychology to generate effective marketing interventions for reducing plate waste in catering settings.

5.2 Research Limitations

There are several limitations of this study. First, this paper was limited to reviewing articles between 2013 and 2024. The mindset and perception of consumers in commercial settings regarding plate waste reduction might change over time. More research could extend the observation period and identify patterns and trends to develop appropriate marketing intervention strategies. Second, not all the articles were selected for review in this study because the marketing intervention programs and campaigns were intended to reduce food waste rather than plate leftovers. These studies were primarily examined in commercial settings rather than at the household level and the buffet catering settings. A further systematic literature review can include these inclusion criteria. Third, this paper did not include the grey literature in relation to food loss law and policy (Hackstadt, 2021). Future studies can involve informal reports and public policy documents in the grey literature to design effective marketing interventions for consumers in commercial settings.

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Figure 1. Flowchart of the literature search process

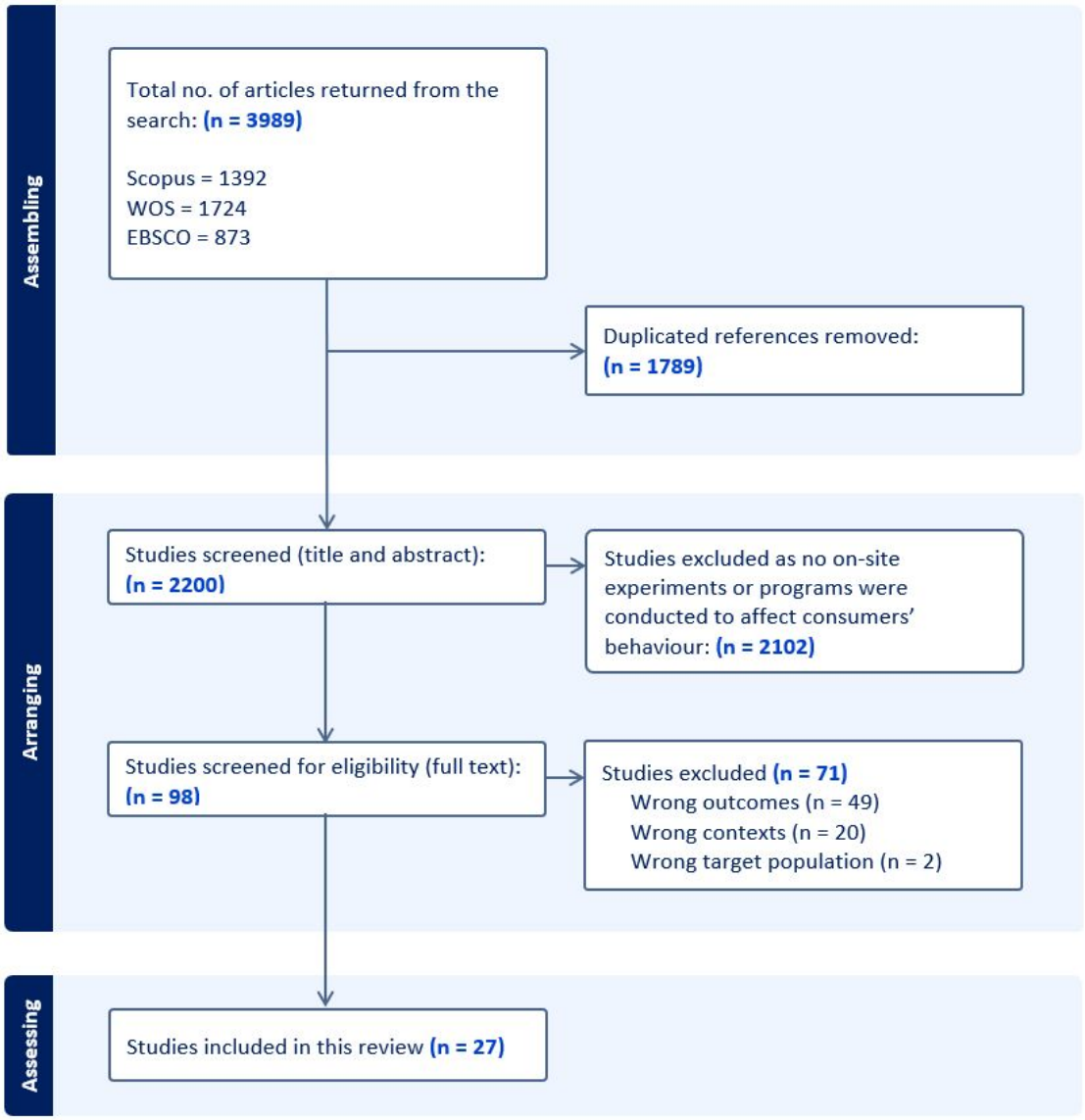

Figure 2: Plate waste studies in commercial settings

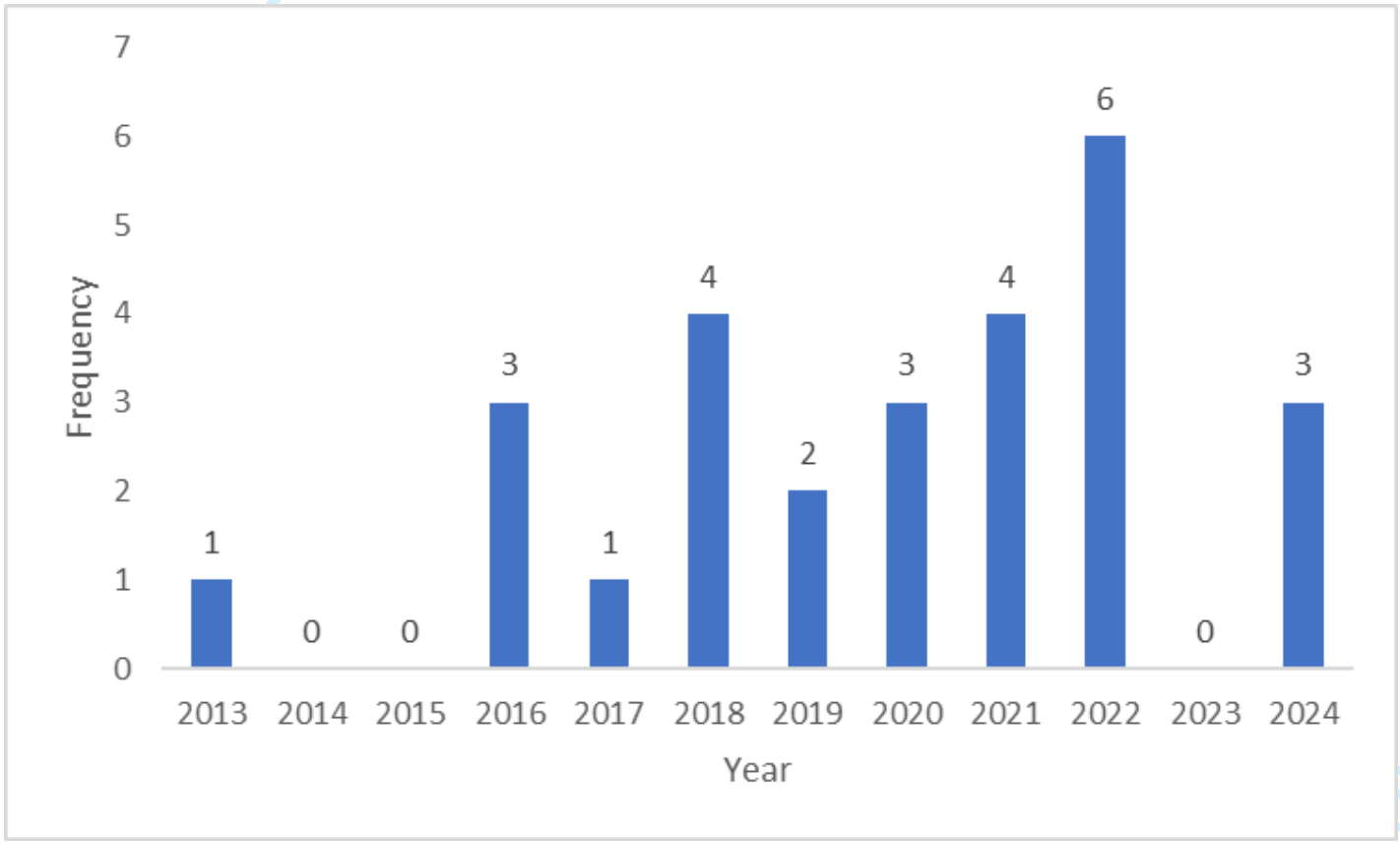

Figure 3 Publications on plate waste by journal

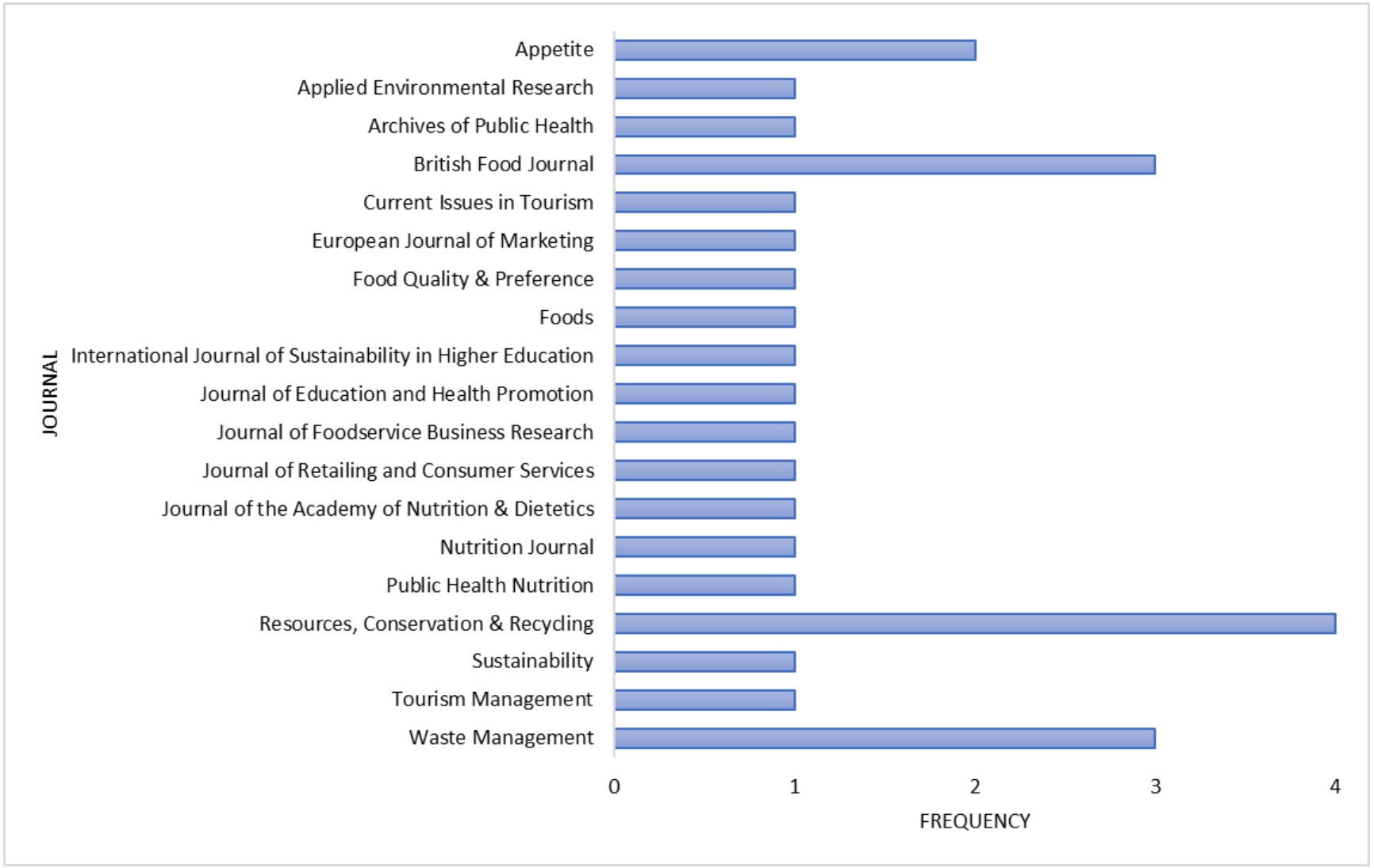

Figure 4 Barriers and motivators for plate waste reduction in the eating system.

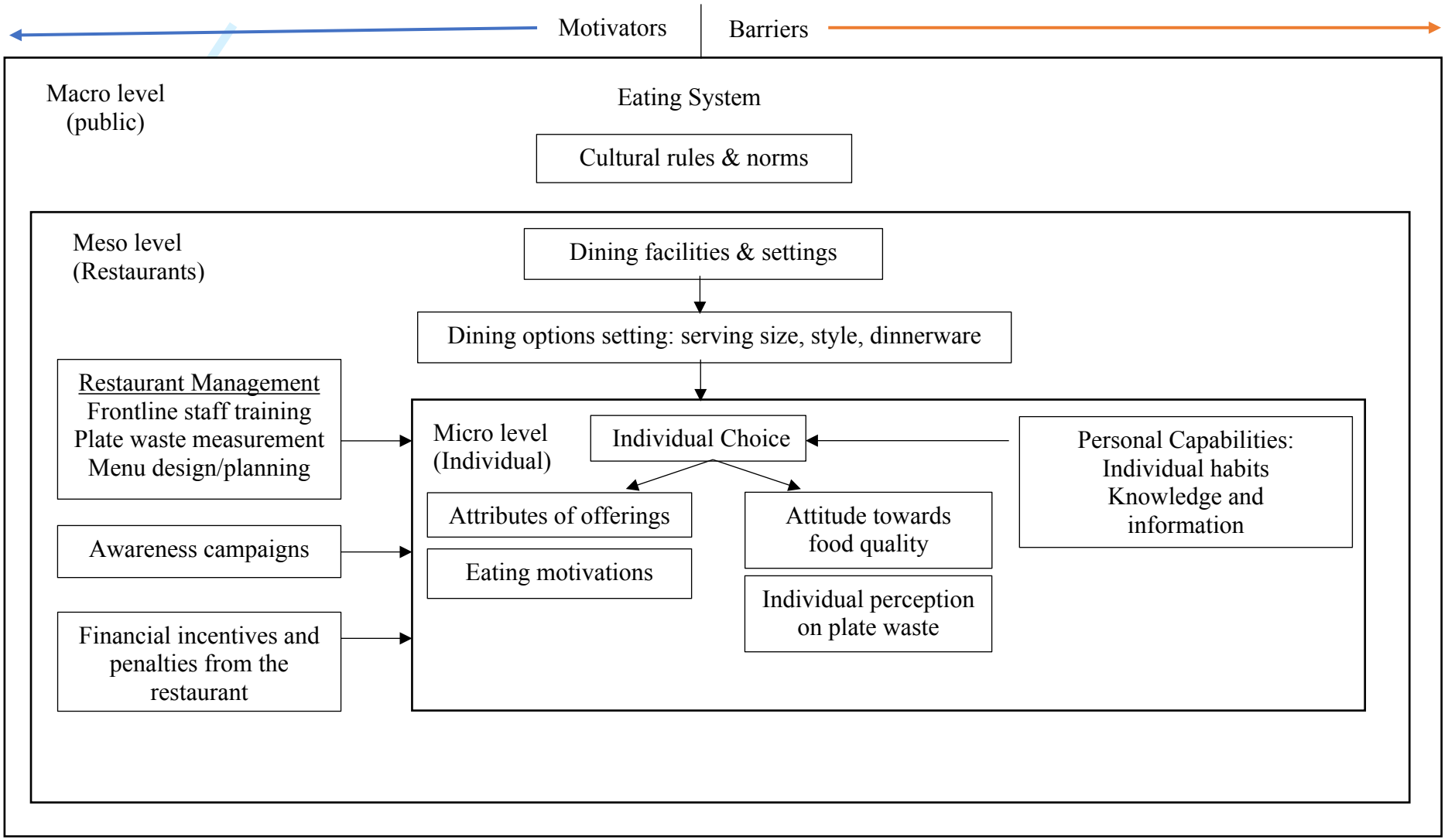

Table 1. Characteristics of the included studies

	Author(s)	Setting (Sample size)	Country	Study Period	Study Design
1.	Ahmed et al. (2018)	University Dining Hall (4500/day)	USA	1.5 week	Pre & post, Quasi-experiment
2.	Alattar and Morse (2021)	University cafeteria (300-400/day)	USA	1 week x 4 semesters	Pre & post, Quasi-experiment
3.	Alcorn et al. (2021)	University restaurant (unspecified)	USA	6 weeks	Pre & post, Quasi-experiment
4.	Berkowitz et al. (2016)	(1) Worksite lunch cafeteria (150-200 /day) (2) commercial restaurant (daily average 50)	USA	Worksite cafeteria: 7 weeks Commercial restaurant: 4 weeks	Pre & post, Quasi-experiment
5.	Chang (2022)	Commercial restaurant (Study 1: 360; Study 2: 270)	China (Taiwan)	6 weeks per study	Quasi-experiment
6.	Cozzio et al. (2021)	Hotel restaurant (Functional treatment: 8057 Experiential treatment: 11396)	Italy	Functional treatment: 3 weeks Experiential treatment: 3 weeks	Quasi-experiment
7.	Davison et al. (2022)	University student canteen UK: 260; India: 375	UK & India	1 month	Pre & post, Quasi-experiment
8.	Dolnicar et al. (2020)	Hotel restaurant (Control: 538; Expt. 1a: 162; Expt. 1b: 268; Expt. 2a: 667; Expt. 2b: 551)	Slovenia	10 days	Quasi-experiment
9.	Ellison et al. (2019)	University dining hall (2125/day)	USA	5 weeks	Pre & post, Quasi-experiment
10.	Jagau and Vyrastekova (2017)	University restaurant (1437)	Netherlands	9 days	Pre & post, Quasi-experiment
11.	Jiang et al. (2024)	Commercial restaurant (2524)	China	4.27 months	Randomized controlled trials
12.	Kuo and Shih (2016)	University semi-buffet restaurant (Education: 196; Coercion: 194)	China (Taiwan)	1 week	Pre & post, Quasi-experiment
13.	Lee et al. (2024)	Commercial restaurant (unspecified)	China (Hong Kong)	4 weeks	Pre & post, Quasi-experiment
14.	Liu et al. (2022)	College pizza order (130)	USA	3 sessions	Field experiment

15.	Lorenz-Walther et al. (2019)	University canteen (377)	Germany	Reduced portion size: 4 weeks Reduced portion + posters: 1 week	Pre & post, Quasi-experiment
16.	Manomaivibool et al. (2016)	School canteen (314)	Thailand	2 weeks	Pre & post, Quasi-experiment
17.	Malefors et al. (2022)	School canteens (unspecified)	Sweden	7 weeks	Pre & post, Quasi-experiment
18.	Pinto et al. (2018)	University canteen (4278)	Portugal	16 days	Pre & post, Quasi-experiment
19.	Rajbhandari-Thapa et al. (2018)	University dining hall (1589)	USA	5 days	Pre & post, Quasi-experiment
20.	Richardson et al. (2021)	University dining hall (Site 1: 652; Site 2: 2186)	USA	1 week	Quasi-experiment (Crossover trial)
21.	Vermote et al. (2018)	University restaurant (2175)	Belgium	4 days	Pre & post, Quasi-experiment
22.	Vidal-Mones et al. (2022)	School canteens (Case 1: 183; Case 2: 343; Case 3: 500; Case 4: 742)	Spain	10 days	Pre & post, Quasi-experiment
23.	Visschers et al. (2020)	University canteen (Intervention A: 1905 Intervention B: 2164)	Switzerland	3 weeks	Pre & post, Quasi-experiment
24.	Werkman et al. (2022)	University restaurant (Study 1: 206; Study 4A: 120; Study 4B: 112)	Unspecified (Europe)	Unspecified	Lab Experiment
25.	Whitehair et al. (2013)	University dining facility (296)	USA	2 weeks per intervention	Pre & post, Quasi-experiment
26.	Yazdankhah et al. (2020)	University restaurant (233)	Iran	1 month	Pre & post, Quasi-experiment
27.	Zhang et al. (2024)	University canteen (Study 1: 33; Study 2: 86)	China	Unspecified	Quasi-experiment

Table 2: Barriers to plate waste reduction (empirically highlighted vs practically examined)

Analysis Levels	Category of eating systems	Barriers	Empirically highlighted	Practically examined
Macro	**Culture rules and norms**	Custom & Courtesy	Davison et al. (2022)	✖
		Familial diners	Dolnicar et al. (2020)	✖
Meso	**Restaurant Settings** Dining options of serving size and style	Portion size: Large portion	Alcorn et al. (2021), Chang (2022), Davison et al. (2022), Jagau and Vyrastekova (2017), Jiang et al. (2024), Visschers et al. (2020)	Davison et al. (2022)
		Portion size: Fixed portion size	Pinto et al. (2018), Lee et al. (2024)	Lee et al. (2024)
		Portion size: Unit size reduction	Werkman et al. (2022)	Werkman et al. (2022)
		Portion size: Large plate size	Chang (2022), Richardson et al. (2021)	✖
		Serving style: Non-desirable food/side items offered by default	Alcorn et al. (2021), Chang (2022), Lee et al. (2024)	Lee et al. (2024)
		Serving style: Serving sequence	Kuo and Shih (2016)	✖
		Overly large menu	Liu et al. (2022)	Liu et al. (2022)
Micro	**Individual Choice** Attitude toward food quality	Cheap ingredients	Dolnicar et al. (2020)	✖
		Freshness	Dolnicar et al. (2020)	Dolnicar et al. (2020)
		Low-quality food	Dolnicar et al. (2020)	Dolnicar et al. (2020)
		Not tasty	Alcorn et al. (2021), Davison et al. (2022), Dolnicar et al. (2020), Jagau and Vyrastekova (2017), Visschers et al. (2020)	Davison et al. (2022), Dolnicar et al. (2020)
	Individual Choice Perception of plate waste	Fear of missing out	Dolnicar et al. (2020)	✖
		Perceived insignificant impact of individual's action	Ellison et al. (2019)	Ellison et al. (2019)
		Perceived inconvenience	Davison et al. (2022)	✖
	Personal capabilities Individual habits	New dietary trend	Kuo and Shih (2016), Zhang et al (2024)	✖
		Not enough time to finish	Davison et al. (2022)	Davison et al. (2022)
		Laziness	Dolnicar et al. (2020)	✖
		Embarrasses to request waste reduction options	Lee et al. (2024)	Lee et al. (2024)
	Personal capabilities Knowledge and information exchange	Hard-to-eat food	Dolnicar et al. (2020)	✖
		Lack of knowledge on plate waste reduction	Davison et al. (2022)	✖
		Unknowledgeable about eating unfamiliar food	Dolnicar et al. (2020)	✖

Table 3: Motivators for reducing plate waste (empirically highlighted vs practically examined)

Analysis Levels	Category of Eating System		Motivator	Empirically highlighted	Practically examined
Macro	**Culture rules and norms**		Environmental concern	Visschers et al. (2020)	✖
			Social/peer pressure	Alattar and Morse (2021), Pinto et al. (2018), Vidal-Mones et al. (2022)	Pinto et al. (2018)
Meso	**Management Side**	**Restaurant Setting** Dining facilities	Live-cooking stations	Cozzio et al. (2021)	✖
		Restaurant Management Frontline staff training	Frontline staff training (e.g. ask consumers' desirable portion size or recommendation)	Pinto et al. (2018)	Jiang et al. (2024)
		Restaurant Management Waste measurement	Plate waste tracker (Quantifying food waste)	Malefors et al. (2022)	Malefors et al. (2022), Jiang et al. (2024), Zhang et al. (2024)
		Restaurant Management Menu design/planning	Kid's menu	Cozzio et al. (2021)	✖
			Sample/photo display in the menu	Ellison et al. (2019)	✖
		Awareness/education campaigns	Functional appeal	Cozzio et al. (2021)	Cozzio et al. (2021)
			Eating instruction	Vidal-Mones et al. (2022), Jiang et al. (2024)	Jiang et al. (2024)
			Visualizing food waste	Alattar and Morse (2021)	Alattar and Morse (2021)
			Information/Education/ Campaign	Alcorn et al. (2021), Cozzio et al. (2021), Davison et al. (2022), Dolnicar et al. (2020), Ellison et al. (2019), Jiang et al. (2024), Kuo and Shih (2016), Lorenz-Walther et al. (2019), Manomaivibool et al. (2016), Malefors et al. (2022),	Jagau and Vyrastekova (2017), Jiang et al. (2024), Manomaivibool et al. (2016), Malefors et al. (2022), Pinto et al. (2018), Vidal-Mones et al. (2022), Visschers et al. (2020),

				Pinto et al. (2018), Richardson et al. (2021), Vidal-Mones et al. (2022), Visschers et al. (2020), Whitehair et al. (2013), Yazdankhah et al. (2020), Zhang et al. (2024)	Whitehair et al. (2013), Yazdankhah et al. (2020), Zhang et al. (2024)
			Messaging in serving & dining areas	Ahmed et al. (2018), Alattar and Morse (2021), Chang (2022), Davison et al. (2022), Dolnicar et al. (2020), Ellison et al. (2019), Jagau and Vyrastekova (2017), Lorenz-Walther et al. (2019), Malefors et al. (2022), Pinto et al. (2018), Vidal-Mones et al. (2022),Visschers et al. (2020), Whitehair et al. (2013), Yazdankhah et al. (2020)	Ahmed et al. (2018), Chang (2022), Cozzio et al. (2021), Jagau and Vyrastekova (2017), Malefors et al. (2022), Pinto et al. (2018), Vidal-Mones et al. (2022), Visschers et al. (2020), Whitehair et al. (2013), Yazdankhah et al. (2020)
	Customer Side	**Financial incentives and penalties from the restaurant**	Stamp collection for clear plates	Malefors et al. (2022)	✘
			Incentives (Consumer side) (e.g. discount/coupons)	Chang (2022), Dolnicar et al. (2020), Ellison et al. (2019), Jiang et al. (2024), Malefors et al. (2022), Pinto et al. (2018), Visschers et al. (2020), Zhang et al., (2024)	Ahmed et al. (2018), Dolnicar et al. (2020), Jiang et al. (2024)
			Incentives (Supplier side)	Jagau and Vyrastekova (2017)	✘
			Penalty	Dolnicar et al. (2020), Kuo and Shih (2016), Zhang et al. (2024)	Chang (2022), Jiang et a. (2024)
		Dinning Option Setting Dinning options of portion size	Limiting food choice	Ellison et al. (2019)	Davison et al. (2022)
			Ask consumer about their desirable portion	Lee et al. (2024), Yazdankhah et al. (2020)	Lee et al. (2024), Yazdankhah et al. (2020)
			Pre-portioning	Pinto et al. (2018)	✘
			Reduced portion/serving size	Ahmed et al. (2018), Alcorn et al. (2021), Chang (2022), Cozzio et al. (2021), Dolnicar et al. (2020), Jiang et al. (2024), Lorenz-	Ahmed et al. (2018), Berkowitz et al. (2016), Lorenz-Walther et al. (2019), Vermote et al. (2018), Visschers et al. (2020)

				Walther et al. (2019), Pinto et al. (2018), Richardson et al. (2021), Vermote et al. (2018), Visschers et al. (2020), Werkman et al. (2022), Zhang et al. (2024)	
		Dinning Option Setting Dining options or serving style adjustment	Additional serving on request	Alcorn et al. (2021)	✖
			Adjusting automatic service of garnishes (side dishes)	Alcorn et al. (2021), Lee et al. (2024)	Lee et al. (2024)
			Self-served	Chang (2022)	Chang (2022), Werkman et al. (2022)
			Serving Style	Davison et al. (2022), Ellison et al. (2019), Yazdankhah et al. (2020)	✖
			Tasting spoons	Malefors et al. (2022)	Malefors et al. (2022)
			Maintain food temperature before serving	Yazdankhah et al. (2020)	Yazdankhah et al. (2020)
		Dinning Option Setting Reducing the amount of dinnerware	Alter plate shape & size	Jiang et al. (2024), Richardson et al. (2021), Zhang et al (2024)	Richardson et al. (2021), Zhang et al (2024)
			Reduced plate size	Ahmed et al. (2018), Alattar and Morse (2021), Chang (2022), Cozzio et al. (2021), Davison et al. (2022), Dolnicar et al. (2020), Richardson et al. (2021), Visschers et al. (2020)	Richardson et al. (2021)
			Eliminate trays	Ahmed et al. (2018), Alattar and Morse (2021), Davison et al. (2022), Dolnicar et al. (2020), Ellison et al. (2019), Rajbhandari-Thapa et al. (2018), Richardson et al. (2021), Vidal-Mones et al. (2022), Visschers et al. (2020)	Rajbhandari-Thapa et al. (2018)
Micro	**Individual Choice** Attributes of offerings		Price change	Visschers et al. (2020)	Berkowitz et al. (2016), Visschers et al. (2020), Zhang et al (2024)
			Pay by weight (Quantity)	Ellison et al. (2019), Visschers et al., (2020)	✖
	Individual Choice		Altruistic appeal	N/A	Cozzio et al. (2021)

	Eating motivations	Perceived food satisfaction	N/A	Richardson et al. (2021)

Table 4: Summary of the use of marketing in plate waste reduction programs

	Author(s)	Product	Price	Place	Promotion	Theory	Effectiveness (plate waste reduction %)
1.	Ahmed et al. (2018)	Reduced high waste items' portion size	X	Reduced plate size	Display statistics of plate waste generated by consumers	X	-17%
2.	Alattar and Morse (2021)	X	X	X	Information or statistics of food waste impact; Physically displaying the plate waste generated by consumers	X	Average -27%
3.	Alcorn et al. (2021)	Reduced high waste items' portion size	X	Food originally served by default became served on request	Simple nudge on site to inform consumers that the restaurant is trying to achieve certain environmental goals (collectivism)	X	-14.3 pounds of food waste per week
4.	Berkowitz et al. (2016)	Reduced high waste items' portion size	Size options with price reduction	X	X	X	-34.73% to -41.56%
5.	Chang (2022)	X	Plate waste penalty; Zero-plate-waste discount	Serving style: self-served vs being served	Simple nudge on-site with environmental appeal (moral persuasion)	Elaboration likelihood model	Penalty: -5% to +16% Discount: -76% to -10% Persuasion: -30% to -14%
6.	Cozzio et al. (2021)	X	X	X	Functional appeal nudge on nutritional information; Informational Campaigns to inform consumers that the restaurant is trying to achieve	Elaboration likelihood model	Functional appeal: -72.3% Experiential appeal: -87.2%

					certain environmental goal (collectivism)		
7.	Davison et al. (2022)	X	X	X	Informational campaigns with cards, signage, and posters	X	UK: -11.4% India: -50.2%
8.	Dolnicar et al. (2020)	X	X	X	Informational campaigns with flyer; Zero-plate-waste stamp collection booklet to win gifts and certificate	Utility theory of human behaviour	-31.11% to -37.78%
9.	Ellison et al. (2019)	X	X	X	Informing consumers of the current practice of treating food waste by the restaurant; Simple prompt nudging consumers to reduce plate waste	X	-3.92%
10.	Jagau and Vyrastekova (2017)	X	X	X	Displaying guilt and shame appeal posters to consumers at food disposal locations; Nudging consumers to reflect on their appetite (i.e. how hungry they were)	Prospect Theory	No significant impact
11.	Jiang et al. (2024)	X	Plate waste penalties and rewards	X	Information intervention (informational, guilt, coupled), financial intervention (rewards and penalties), and integrated interventions (informational and financial)	Persuasion Effect, Prospect Theory, Expected Utility Theory, and Level of Explanation Theory	-23% to -43%
12.	Kuo and Shih (2016)	X	Plate waste penalty	X	Informational campaigns (signage)	Social role theory	Education & communication: -1.27% Coercion: -53.55%

13.	Lee et al. (2024)	Options for reduced portion size & garnish choices	X	X	Informational campaigns (signage); Waiters' reminder of portion size options	X	Weekdays: -41.9% Weekends: -61.5%
14.	Liu et al. (2022)	Broad vs narrow menu	X	X	X	Dual process theory	Narrow vs broad menu: -57%
15.	Lorenz-Walther et al. (2019)	Reduced high waste items' portion size	X	X	Informational campaigns (posters)	Theory of planned behaviour	-32.4%
16.	Manomaivibool et al. (2016)	X	X	Meals served in bowl vs plate	On-site awareness campaign - stickers with food ordering tips & food waste impacts	X	3.7% of returned bowls were empty compared to 17.3% of returned plates.
17.	Malefors et al. (2022)	X	X	Serving style adjustment (tasting spoons)	Simple prompt nudging consumers to reduce plate waste; Informational exhibits (Plate waste tracker)	X	Awareness campaign: -35% Tasting spoon: -22%
18.	Pinto et al. (2018)	Reduced high waste items' portion size (on request)	X	Food originally served by default became served on request	Educational message on-site; Peers randomly approach diners to share how to reduce plate waste	X	-15.46% (Per capita plate waste)
19.	Rajbhandari-Thapa et al. (2018)	X	X	Eliminate trays	X	X	Difference-in-difference estimate: $\beta \approx -0.15$
20.	Richardson et al. (2021)	X	X	Alter plate shape with reduced size	X	X	-33.63%
21.	Vermote et al. (2018)	Reduced high waste items' portion size	X	X	X	X	-66.4%
22.	Vidal-Mones et al. (2022)	X	X	X	Instructions or demonstration on how to eat unfamiliar food; Educational campaign	X	-9.19% to -61.10%
23.	Visschers et al. (2020)	<u>Intervention B:</u> Reduced high waste items' portion size	<u>Intervention B:</u> Price reduction for reducing portion	X	<u>Intervention A:</u> Informational campaign (posters & leaflet)	Theory of planned behaviour	Intervention A: +0.05% Intervention B: -21.45%

		(on request with price reduction)					
24.	Werkman et al. (2022)	Reduction of high waste items' portion size	X	Serving style adjustment (self-served instead of being served)	X	X	-71.7% to -92.5%
25.	Whitehair et al. (2013)	X	X	X	Educational campaign (poster)	Elaboration likelihood model of Persuasion	-15.42%
26.	Yazdankhah et al. (2020)	Reduced high waste items' portion size	X	Food originally served by default became served on request; Keeping food warm till it is served	Educational & information campaign (pamphlets & leaflets)	X	bread wasted: -49.6% Food wasted: -35%
27.	Zhang et al (2024)	X	Price evaluation	X	Information on tableware design	X	Not Sepcified