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*Review*

# Strategies to Curb Food Waste on University Campuses: A Scoping Review

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## ABSTRACT

Food waste is a major contributor to climate change, responsible for about one-third of all human-induced greenhouse gas emissions. Despite widespread sustainability efforts, institutions of higher education are not immune from generating substantial waste. Universities also present unique opportunities to both study and intervene in consumer food waste in a controlled environment. In this scoping review, we screened 1294 articles, finding just 27 studies that directly measured food waste changes associated with strategies implemented in university dining facilities. Results indicate five primary behavioral and educational intervention methodologies employed. *Environmental interventions*, particularly tray removal, were among the most effective strategies, resulting in food waste reductions of 20% to 32% by weight. *Passive education* efforts, such as displaying informational posters, had mixed results, while *financial incentives* resulted in food waste reductions but may unintentionally encourage overconsumption. Combination interventions resulted in greater impact than individual interventions, though implementation challenges remain. Inconsistent waste measurement methods across studies, including whether to include both liquid and unavoidable food waste, complicate cross-study comparisons. Short intervention durations also limit insight into long-term effectiveness. While student support for sustainability initiatives is widespread, standardized auditing methods and longer-term research are needed to develop realistic and sustainable interventions that effectively reduce consumer food waste in university settings.

**KEYWORDS:** food waste; reduction; intervention; university; effectiveness; literature review



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## ABBREVIATIONS

GHG, greenhouse gas emissions; FW, food waste; AYCTE, all-you-care-to-eat

## INTRODUCTION

The global food system is under immense pressure. As the world's population continues to grow, total food demand is expected to increase by 60% between 2019 and 2050 [1]. The future of such food production under a changing climate is tenuous, threatened by more extreme weather events [2], rising global temperatures [3], and pest outbreaks. Increased "insect pest pressure" will likely continue due to warming temperatures expanding the geographic range of crop pest insects into higher altitudes and more northern latitudes [4]. Although there is currently enough food produced to feed everyone on the planet [5], an alarming 2.4 billion people faced moderate to severe food insecurity in 2023, a number that is only expected to rise as climate change reduces crop yields [6]. These challenges are compounded by excessive food waste (FW), which is a global problem. There are numerous, sometimes contradictory definitions of FW. The European Union, for example, defines it as edible and inedible parts of food from post-harvest to consumption that is disposed or recovered. This includes compost, anaerobic digestion, bio-energy production, incineration, and landfills [7]. Between 30% and 40% of all food produced—approximately 1.3 billion tons—is currently lost or wasted each year [8]. FW unnecessarily generates greenhouse gas emissions (GHG) while feeding no one. With increased efforts to prevent FW and promote adequate distribution of food, we could potentially feed up to 1.26 billion people per year, almost double the amount of undernourished people around the world [5].

The food system itself is a major contributor to climate change, responsible for up to 34% of GHG emissions [9] by producing 13.7 billion metric tons of carbon dioxide equivalents ($CO_2$eq) annually though agriculture, land-use change, and transportation. Food production is responsible for approximately 32% of soil acidification and around 78% of eutrophication, threatening biodiversity and ecosystems [10]. Unsustainable industrial farming practices further exacerbate environmental degradation, causing deforestation, biodiversity loss, and soil erosion. Without intervention, these trends will continue and could cause degradation of over 90% of the world's land and a 10% reduction in global crop yields by 2050 [11]. Additionally, global food loss and waste results in significant environmental harm and economic costs, worth an estimated $936 billion in losses each year [12]. When factoring in broader health and environmental impacts—such as undernourishment, poverty, and non-communicable diseases associated with food consumption—the total cost of food loss and waste jumps to $15 trillion [6,13]. Food loss is typically understood to occur early in the supply chain, during cultivation,

storage, processing, and transportation, and is driven by factors such as crop damage from infestations or weather, inadequate infrastructure, financial restrictions, and technical or technological limitations. In contrast, the World Food Program describes FW as happening towards the end of the supply chain, at the retail and consumer level, and is often caused by inefficient food management, aesthetic standards, and consumer behaviors [14].

The United States (U.S.) is the world leader in FW, with approximately 40% of the edible and nutritive food produced across the country ending up in landfills and generating both GHG emissions and solid waste streams. This wasted food contains enough calories to feed 150 million people annually—more than triple the number of food-insecure Americans, currently estimated at 44 million [15]. FW is a primary component of U.S. landfills, comprising about 24% of municipal solid waste [16]. As food decomposes anaerobically in landfills, it generates methane—a potent GHG with 86 times the global warming potential of carbon dioxide over a 20-year period—of which about 61% is released into the atmosphere, further contributing to climate change [17].

FW is prevalent everywhere people eat, but in higher-income countries, most waste is generated at the consumer level. Consequently, typical reduction efforts target household waste, restaurant waste, industrial waste, or institutional waste [18]. This includes waste from retailers, schools, universities, and businesses. Among these, universities stand out as high-impact settings for FW interventions due to their size, dining structure, and the opportunity to influence behaviors among learners. With over 19.2 million undergraduate students enrolled in the U.S. as of Fall 2024, and approximately 3.6 million tons of food wasted at universities annually—the average student generates around 110 pounds of edible FW each year; thus, there is potential for large-scale impact from FW interventions at Universities [19–21].

Universities are ideal contexts for FW interventions. They are densely populated with young people who are potential drivers of social and environmental change as future leaders, and on-campus dining halls are tightly controlled and monitored environments where interventions and concurrent data collection may be feasible. Moreover, the conventional university model, with contained dining areas serving a consistent clientele, is comparable to other large institutions and businesses, where employees dine on-site. FW interventions tested at institutions of higher education have the potential to be implemented beyond academic settings. Given that the primary drivers of FW at universities are unsustainable practices, such as over-purchasing, ineffective food planning management, inadequate food storage, and wasteful behaviors of university diners [22], there are numerous points for intervention and opportunities for improvement.

Many universities utilize an all-you-care-to-eat (AYCTE) model in their dining facilities. Compared to a pay-by-item model, this design is

correlated with higher FW in both “back of house” (pre-consumer waste) and “front of house” (consumer waste)[23]. The AYCTE model involves a fixed entry rate, so students can take and waste as much food as they want without paying more. The fixed-rate price strategy eliminates a monetary disincentive to waste food; why pay for what you don’t eat? Monetary incentives are one of the most identified motivators for consumers to limit waste [24]. AYCTE buffet-style dining service operations generate the most FW, primarily because of their high rates of food production, oversized portions, and consumer behavior [23]. The model also expands menu options, leading to more food preparations—the scraps generated from additional meal prep and more ingredients used—that ultimately go to waste in the “back of house” [25].

Factors that drive FW vary across settings and by consumer preferences. Reducing pre- and post-consumer FW, for example, may require distinct interventions. Pre-consumer waste at universities, also referred to as “kitchen waste,” can be categorized by operational and contextual factors. Operational causes of excess FW include overproduction of menu items, inadequate meal planning, and legal restrictions on re-using unserved food [26]. Contextual drivers include large menu options, portion sizes, and quality and appearance of food [27]. Strategies to reduce pre-consumer FW are often environmental interventions that modify the infrastructure, such as through reducing portion sizes [28], removing trays [29], changing the shape and style of plates [30], adjusting menu options [31], and implementing composting [32]. Post-consumer waste is primarily driven by behavioral and demographic factors. However, contextual factors, such as the quality and taste of food, and students having enough time to eat, also contribute to consumer FW [27,33]. Consumer demographics have been correlated with differing amounts of FW. Research indicates that women and younger students generate more FW compared to men and older students [34]. For women, this disparity is attributed to less food intake paired with fixed large portion sizes, dietary preferences, and sociocultural pressures related to appearances [35–37]. Younger students may waste more food due to limited familiarity with cafeteria offerings and meal planning strategies [21,38].

Limited research has explored the efficacy of FW intervention models targeting consumers in dining facilities, such as those eating on university campuses. However, outcomes from such interventions could be useful in addressing consumer FW in a variety of settings, while also helping campus sustainability initiatives better plan for and reduce FW. To explore this issue, we conducted a scoping review on academic literature investigating FW reduction strategies implemented in university dining facilities. This review synthesizes findings from original research at institutions of higher education worldwide to identify, categorize, and evaluate the effectiveness of intervention strategies on pre- and post-consumer FW. We map the current landscape of on-campus FW reduction

efforts, highlight trends and gaps in the literature, and provide insight into opportunities for future research.

## MATERIALS AND METHODS

### Search Strategy

This scoping review involved a comprehensive literature search spanning six databases: PubMed, EMBASE.com, Academic Search Premier, PsycINFO, ScoINDEX, and Web of Science. We identified four relevant articles during preliminary investigations, which were used to fine-tune our search strategy and validate the accuracy of our search terms. These articles served as benchmarks to confirm the relevance of the results obtained through our searches. Our literature search was conducted in December 2023. Each database was searched using three key categories:

1. Food waste, including terms such as “food loss,” “food scraps,” “kitchen waste,” “compost,” “wasted food,” and “plate waste.”
2. University-related terms, such as “university,” “college,” “higher education,” “academic institution, “collegiate,” “cafeteria,” and “dining.”
3. Reduction strategies, encompassing terms like “recycling,” “reducing,” “management,” “intervention,” “promotion,” “program,” “prevention,” and “mitigation.”

This method ensured a thorough exploration of the literature relevant to our study. Language was limited to English, and the publication date was restricted from 2000–2023. Results from each database were uploaded to Covidence, an online platform for managing systematic reviews. The complete search strategy for each database is available in the Supplementary Material File S1: Complete Search Strategy.

### Study Selection Intervention

For data extraction, three authors of this paper served as independent reviewers (Dyrbye-Wright, Stull, Grabow) and assessed articles for inclusion via Covidence and over multiple rounds of screening. Disagreements were resolved through consensus.

Inclusion criteria for articles involved studies focused on higher education settings, such as colleges, universities, and community colleges. Eligible studies tested strategies to reduce FW, quantified or qualified the effectiveness of the intervention, or targeted consumer behaviors, attitudes and practices through informative campaigns or physical changes (e.g., smaller plates, tray-less dining, limited menu options). Studies related to non-university environments, such as businesses, other large institutions, and educational institutions below the undergraduate level, were excluded. Studies not specifically aimed at reducing FW and non-intervention studies were excluded. Additionally, observational studies, narrative reviews, legal papers, and non-original research were not included (Figure 1).

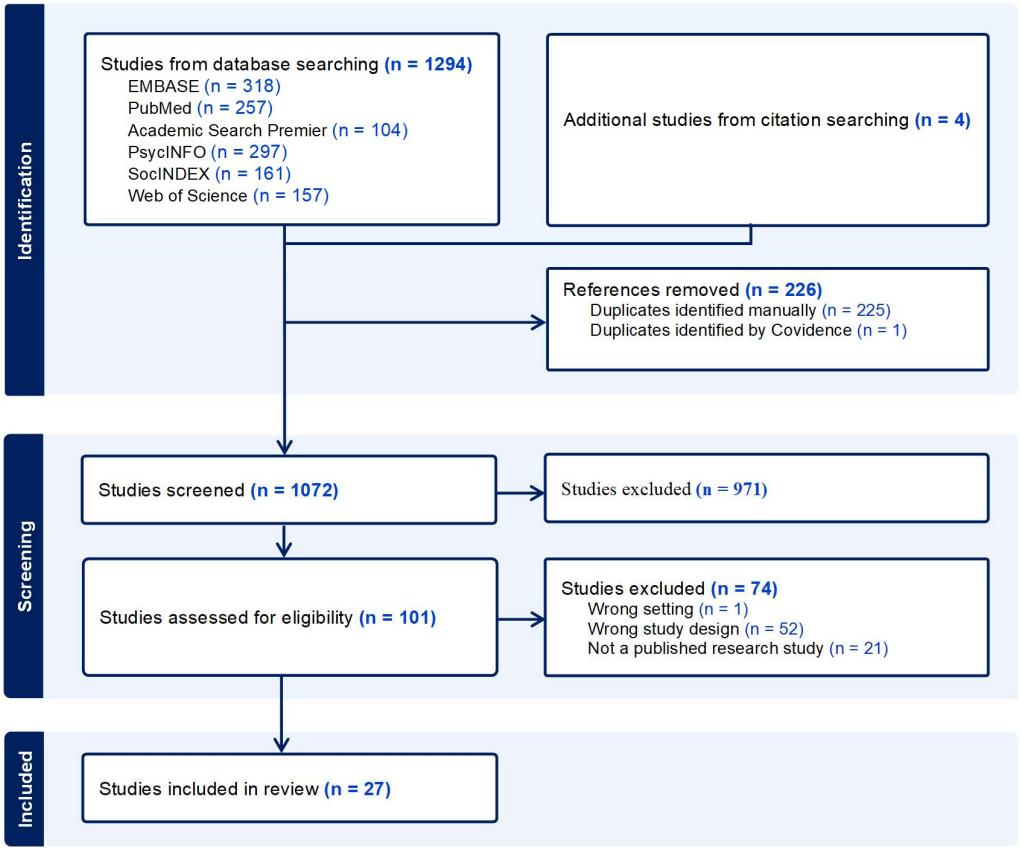



**Figure 1.** PRISMA Flow Diagram of the literature review method for the study.

### Data Profiling

After selecting articles for inclusion in the review, a research profile was created based on content analysis for descriptive statistics including publication year, geographic scope, intervention type, and FW audit method. We systematically extracted and organized key characteristics from included articles to develop a comprehensive overview of the literature landscape. Using a standardized data extraction form, we documented bibliometric information (authors, year, journal, country of study), methodological approaches (study design, data collection methods, sample characteristics), and thematic content (primary objectives, key findings, theoretical frameworks). Disagreements in data extraction were resolved through discussion until consensus was reached. The completed matrix was then analyzed to identify clusters of evidence, methodological trends, and research gaps that informed our analyses in subsequent stages of the review.

## RESULTS

### Final Studies Included in Scoping Review

A total of 27 papers met all the inclusion criteria for this review (Table 1). The majority of the studies (~60%) were conducted at institutions of higher education located in the U.S. The remainder of the studies were from western and northern Europe and across Asia. Based on the search strategy and inclusion criteria for this scoping review, there was a noticeable absence of representation from Eastern Europe, South America, Africa, and Oceania. A total of 18 academic publishers were represented; however, the journal of *Sustainability* published the greatest number of relevant articles in this sample with four papers.

The FW reduction interventions were then categorized into five discrete groups developed by the research team and based on methodology and underlying factors they aim to address: *environmental*, *incentive-based*, *passive education program*, *engaged education program*, and *combined*. Environmental interventions addressed operational and contextual factors contributing to FW, such as altering physical surroundings through reducing portion sizes, removing trays, changing the shape or style of plates, and adjusting menu options. These interventions primarily target waste deriving from large menu options, portion sizes, and logistical inefficiencies in food preparation. Other scholars may refer to these interventions as "nudge" interventions that include "any aspect of the choice architecture that alters people's behavior predictably without forbidding any options or significantly changing their economic incentives" [39]. We use the term environmental to be descriptive as to physical changes in the dining area. Incentive-based interventions leveraged financial motivators, such as rewards for reducing plate waste, to influence consumer behavior. By appealing to self-interest, these interventions aimed to shift consumer decision-making during food selection and consumption. Education-based interventions were divided into passive (e.g., posters, handouts), which raised awareness and encouraged behavioral change, and engaged (e.g., classes, interactive exercises, facilitated discussions), which promoted active learning and deeper participation with FW reduction practices. Combined interventions included studies that implemented and measured more than one intervention type, recognizing that a multifaceted approach may be more effective in targeting the complex and multi-layered drivers of FW. Many studies paired interventions with perception-based surveys to collect self-reported motivations behind FW, perceived effectiveness of intervention, and overall opinions on campus sustainability efforts.

**Table 1.** Research investigating strategies for reducing food waste (FW) at universities.

| Author(s) & Date | Reported Location | Intervention Type | Study Population (Participation) | Outcomes and Measures | Additional Findings |
|---|---|---|---|---|---|
| Ahmed (2018) [22] | Montana State University, United States | Combined; Environmental intervention (portion and utensil size reduction), passive education (posters) | 4500 diners/day | 17% total FW reduction by weight; $p < 0.121$. | Survey ($N = 249$) found that students considered the poster campaign effective in raising awareness on FW and their interest increased with potential meal plan savings. |
| Lorenz-Walther et al. (2019) [40] | Unspecified University, Germany | Combined; Environmental intervention (portion size reduction), passive education (posters) | 556 diners at a high-volume canteen (~3000 lunches/day) | In three dishes with reduced portions, FW decreased slightly but significantly. | Survey participants ($N = 880$) who recalled the posters reported increased efforts to lower personal FW. |
| Visschers et al. (2020) [41] | Unspecified large University, Switzerland | Combined; Passive education (posters), environmental intervention (portion size reduction) | 1321 diners completing a questionnaire | 20% per plate FW reduction by weight; $p = 0.020$. | Although information increased awareness, it did not lead to behavior change or reduced FW. |
| Alcorn et al. (2021) [42] | Midwest University, United States | Combined; Environmental intervention (portion size reduction), engaged education (employee training sessions), passive education (table tents) | High-volume canteen (~6750 meals/month) | 11.8% total FW reduction by weight; $p = 0.048$. | Effective FW reduction required engagement of both customers and staff. |

**Table 1.** *Cont.*

| Author(s) & Date | Reported Location | Intervention Type | Study Population (Participation) | Outcomes and Measures | Additional Findings |
|---|---|---|---|---|---|
| Tufaner (2021) [43] | Adiyaman University, Turkey | Combined; Passive education (posters), engaged education (verbal lectures), environmental intervention (anaerobic digestor) | 30 students randomly sampled over 20 days | 30% total FW reduction by weight; No *p*-value provided. | Anaerobic digestor gave high gains from waste to energy while also reducing the GHG footprint of FW. |
| Davison et al. (2022) [44] | University in Yorkshire, United Kingdom & university in Maharashtra, India | Combined; UK: passive education (posters), India: passive education (posters), environmental interventions (table service, portion control, smaller menu, improved food-demand estimates) | UK canteen (~260 diners); India canteen (~375 diners) | 13.2% total FW reduction by weight in UK and 50% per person FW reduction by weight in India. | UK students were more concerned with economic and environmental issues associated with FW. Students in India focused on social issues of food security and guilt. Students eating off-campus led the university to prepare excess food. |
| Katare et al. (2019) [45] | Large Midwest University, United States | Incentive-based intervention ($2/day for clean plate) | 90 diners (51 as controls) | 22% increased probability of a clean plate. | Financial incentives, though effective, unintendedly encouraged diners to consume more. |
| Sarjahani et al. (2009) [46] | Virginia Polytechnic Institute and State University, United States | Environmental intervention (tray removal) | Tray week (14,512 diners); trayless intervention week (14,308 diners) | Tray week FW had 248.3 lbs. per meal, trayless week had 202.8 lbs. per meal (45.5 fewer lbs.); $p = 0.001$. | Trayless week significantly lowered waste, with educational efforts being essential in raising awareness. |
| Freedman et al. (2010) [47] | The San José State University, United States | Environmental intervention (reduced portion sizes) | 703+/−140 diners | Significant reduction from reducing French fries from 88 g to 44 g; $p < 0.050$. | Many diners reported no noticeable change in portion size. |
| Kim et al. (2012) [48] | American University, United States | Environmental intervention (tray removal) | 360 diners | 32% total FW reduction by weight; $p = 0.003$. | Tray removal reduced FW, and the number of dishes used per meal. |

**Table 1.** *Cont.*

| Author(s) & Date | Reported Location | Intervention Type | Study Population (Participation) | Outcomes and Measures | Additional Findings |
|---|---|---|---|---|---|
| Thiagarahaj et al. (2013) [29] | Unspecified B10 University, United States | Environmental intervention (tray removal) | Tray week (4901 diners); trayless week (4279 diners) | Almost 20% decrease in solid waste per patron; $p = 0.001$. | Going trayless reduced solid plate waste; however, dishware breakage and cleaning tables increased. |

| Author(s) & Date | Reported Location | Intervention Type | Study Population (Participation) | Outcomes and Measures | Additional Findings |
|---|---|---|---|---|---|
| Vermote et al. (2018) [49] | Vrije Universiteit Brussel, Belgium | Environmental intervention (portion size reduction of one food item) | On-campus restaurant (1200–1300 meals/day), plate waste measured 2056 diners (baseline), 2175 diners (intervention) | Reducing portions of French fries by 20% led to 66.4% total FW reduction by weight; no p-value provided. | While most diners noticed the reduced portion size and found it sufficient, only 9.32% of survey respondents favored permanent implementation. |
| Kurzer et al. (2020) [31] | University of California, Davis, United States | Environmental intervention (menu change) | 86 diners | Flipped dessert had a significantly lower % of waste than alternatives; $p = 0.016$. | Fruit may decrease FW from specific desserts. |
| Richardson et al. (2021) [30] | Unspecified large Midwest University, United States | Environmental intervention (changing plate size and shape) | 1285 observations from 2 dining halls | 4% FW reduction per person by weight; $p < 0.001$. | Oval platters reduced FW but increased the likelihood of getting seconds. Diners eating with peers had slightly higher FW. |
| Zhang et al. (2022) [50] | Unspecified Midwest University, United States | Environmental intervention (tray removal) | 329 diners from a dining facility averaging 1150 diners per dinner | The number of diners with no plate waste increased from 32.8% to 40.4% during trayless intervention; $p > 0.05$. The number of diners with FW < 100 g stayed similar; $p > 0.05$. | Trayless dining improved food selection and consumption, but average total FW remained unchanged. Removing trays was not the most effective FW reduction method, and participants reported inconvenience. Education and promoting social responsibilities may be more effective. |
| Cavazos et al. (2023) [51] | Rural southwestern public University, United States | Environmental intervention (altering location of composting bin) | Total student population of 13,176 | Diverted 13.4 lbs. of food across 7775 diners from landfills. (Note: no statistical analysis was conducted on these outcomes). | The visibility of compost bins was essential since cafeteria designs either encourage or discourage sustainable behavior. |

**Table 1.** *Cont.*

| Author(s) & Date | Reported Location | Intervention Type | Study Population (Participation) | Outcomes and Measures | Additional Findings |
|---|---|---|---|---|---|
| Liu et al. (2023) [28] | University in the Haidian District, Beijing, China | Environmental intervention (reduced portion sizes and implemented an "automatic food supply") | 1142 "valid observations" across 11 canteens | 32.4% total FW reduction by weight; p-value not provided. | Questionnaire ($N = 326$) revealed that FW was primarily vegetables and rice, with 60% of diners identifying portion sizes as the key driver of FW. |
| Radnitz et al. (2023) [52] | Fairleigh Dickinson University, United States | Environmental intervention (menu changes) | 295 diners sampled from 1790 interested participants | No significant difference in FW between vegan and omnivore menu options. | Vegan menus did not increase FW, indicating canteens can transition to sustainable menus without increasing FW. |
| Whitehair et al. (2013) [53] | Unspecified Midwest University, United States | Passive education (posters) | ~412 diners/lunch across 6 weeks | 15% total FW reduction by weight; $p = 0.020$. | Simple postings increased awareness and effectively reduced FW. |

| Author(s) & Date | Reported Location | Intervention Type | Study Population (Participation) | Outcomes and Measures | Additional Findings |
|---|---|---|---|---|---|
| Jagau et al. (2016) [33] | Radboud University, Netherlands | Passive education (posters) | 2500 meals during observation period | The number of meals sold with smaller portions was significant ($p = 0.013$). No significant FW reduction ($p = 0.842$). | Survey ($N = 62$) identified portion sizes and unmet taste expectations as primary drivers of FW. |
| Manomaivibool et al. (2016) [54] | Mae Fah Luang University, Thailand | Passive education (information cards, stickers, banners) | 314 photos of post-consumer FW at a main canteen | The share of diners with no plate waste almost doubled to 20%; $p$-value not provided. | The intervention was found to be more effective in female students. |
| Pinto et al. (2018) [55] | University of Lisbon, Portugal | Passive education (posters) | 240 diners/day | 15% total FW reduction by weight; $p < 0.050$. | 44% of participants felt that universities should promote environmental awareness. |
| Ellison et al. (2019) [25] | University of Illinois Urbana-Champaign, United States | Passive education (posters) | Two dining halls (one comparison) serving 2125 and 580 diners for lunch/day | 3.9% total FW reduction by weight; p-value not provided. | Post-survey ($N = 301$) revealed that most students believed educational materials would effectively change their own and their peers' behavior. |

**Table 1.** *Cont.*

| Author(s) & Date | Reported Location | Intervention Type | Study Population (Participation) | Outcomes and Measures | Additional Findings |
|---|---|---|---|---|---|
| Yazdankhah et al. (2020) [56] | Shahid Beheshti University, Iran | Passive education (pamphlets and posters) | 419 students; 208 intervention, 211 control | Significant FW reduction per person from 116 g to 76 g; $p < 0.001$. | Educational intervention encouraged environmentally sustainable behaviors and attitudes. |
| Erälinna et al. (2021) [57] | Turku University, Finland | Passive education (posters) | Reached over 50% of the target population of 14,000 bachelor and master level students | 30% total FW reduction by weight; $p$-value not provided. | After intervention week, the leftovers returned to previous levels. |
| Sanders et al. (2011) [58] | Texas State University, United States | Engaged education (signs and student workers standing by source-separation bins) | Overall student enrollment of 32,000 | 3.36% overall FW reduction by weight; $p > 0.050$. | Composting led to higher diversion rates and cost savings. |
| Alattar et al. (2021) [21] | Unspecified University, United States | Engaged education (informative posters with "informational discussion tabling") | 300–400 diners for lunch/day | 28% FW per student reduction by weight; $p = 0.001$. | Survey ($N = 174$) found that intervention increased student awareness and efforts to reduce FW. |

The studies included in the review were published between 2009 and 2023, with a noticeable increase in publications in 2021, followed by a decline in 2022, and increase again in 2023. (It is possible that COVID-19 school closures and a move to online learning impacted research on this topic.) Participant recruitment for perception-based surveys was predominantly conducted via mall intercept surveys. The most frequently utilized data collection method across studies was physical waste audits (56%), followed by calculated audits (22%), survey on perceptions and a physical waste audit (15%), and both a physical and calculated waste audit (7%) (Figure 2). Environmental interventions emerged as the most common type of intervention tested, followed by passive education programs, combined interventions, engaged education programs, and least common, incentive-based interventions (Figure 3).

Apart from one study, where the intervention was implemented during the entire academic year, the majority (42%) of interventions tested were implemented for a week or less.

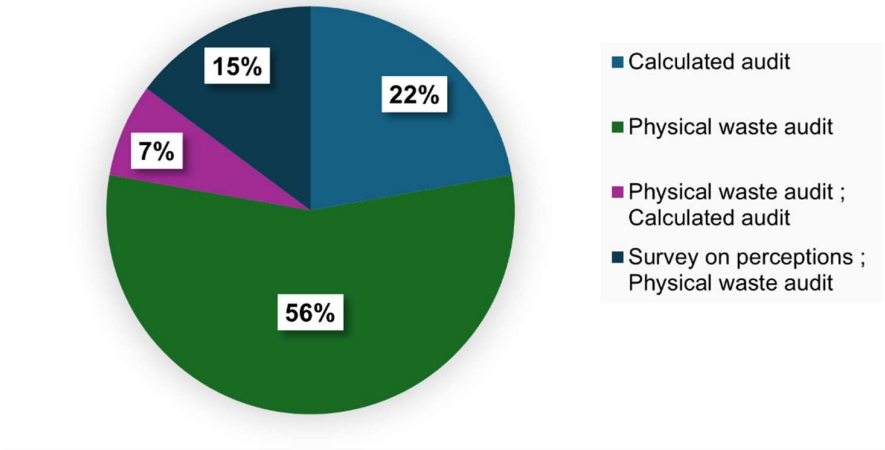



**Figure 2.** Pie chart displaying percentage of included articles by data collection method.

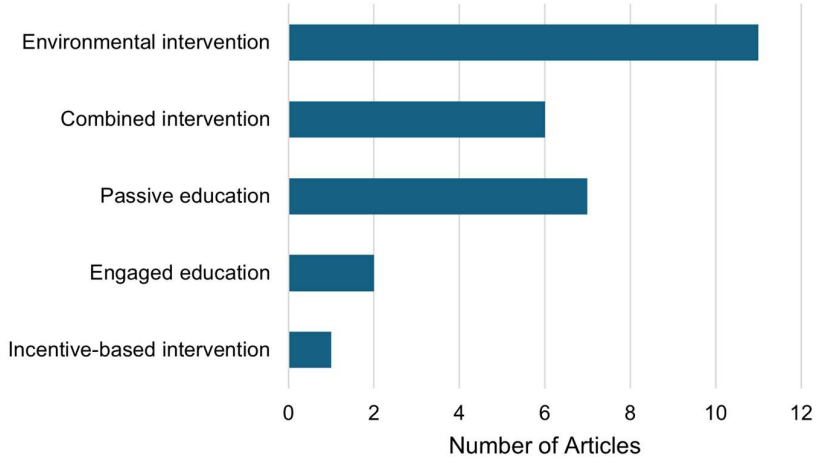



**Figure 3.** Bar graph illustrating the distribution of articles by intervention type.

### Results from Environmental Intervention Studies

A total of 11 studies in this review reported on environmental interventions, four evaluating the impact of going trayless, four on portion reductions or menu changes, one on changing the size and shape of plates, and one on altering the location of the composting bin. Removing trays from the cafeteria had an observed FW reduction varying from 20% to 32% (Table 1). At one institution, changing the shape and size of the plate resulted in a 4% reduction in FW [30]. In another study, decreasing the portion sizes reduced FW by 32.4% [28]. Two studies that reduced the portion size of only French fries found significant decreases in FW—as much as a 66.4% reduction in total plate waste after reducing the portion size of fries by only 20% (Table 1).

Moving to a trayless dining setting was one of the most studied singular environmental interventions (Table 1). However, surveys indicated that not all students and employees were on board with a permanent tray-free situation. Employees were concerned about costs and labor, including the increased amount of dishware breakage and necessity to wipe down tables in the absence of trays [29]. Students with a positive attitude on reducing FW supported going trayless, yet students with a positive attitude towards sustainability and the environment—and not necessarily on reducing FW—were not as likely to support the intervention [59].

According to surveys, the most identified driver of FW by students was large portion sizes [25,28,33]. However, student support for permanently reducing portion sizes yielded mixed results. In a study that only reduced the portion sizes for French fries, common objections to permanent implementations included the absence of price adjustments for the smaller portions and the perception that the reduced serving was too small [49]. Yet, in a different study that also reduced French fries, 70% of students did not notice the change in serving size [47].

### Results from Passive and Engaged Education Program Studies

A total of seven studies in this review reported on passive education interventions, mainly quantifying the effect of displaying posters and circulating educational materials on reducing FW. Informational posters placed in dining areas and pamphlets distributed to students resulted in an observed decrease in FW between 3.9% and 30% (Table 1). There was a consensus across studies that students believed educational campaigns to be effective in raising awareness on FW. Surveys revealed that informational campaigns increased motivational attitudes towards preventing plate waste (Table 1).

Only two studies reported on engaged education interventions. Both articles involved actively educating students on FW reduction or teaching students how to separate waste into the correct bins. Engaged education had outcome measures that varied between 3.36% to 28% reduction (Table 1). A survey revealed that the No Scrap Left Behind Program—an

intervention that included informational discussion tabling, signage, and quizzes on FW for small prizes—led students to be more conscious about their own FW generation and increase their efforts in practicing sustainable behavior [21].

### Results from Incentive-based Intervention Studies

Only one study examined the impact of incentive-based interventions to reduce FW. It offered a fixed financial incentive of $2 every day (equaling a 15% discount on their fixed priced lunch) for a clean lunch plate. The study reported a 22% increased probability of students having a clean plate during the intervention week [45]. The study noted that financial incentives may have unintendedly resulted in students consuming more food.

### Results from Combined Intervention Studies

Six studies in this review quantified the impact of combining multiple interventions to reduce FW. The most common combination was passive education programs with environmental interventions. Five studies paired displaying informational posters or table tents with portion size reduction efforts, which ranged in effectiveness in reducing FW from 17%–50% (Table 1). Two studies added an engaged element to the combination of interventions, such as an employee training session, with a resulted decrease of FW between 11.9% to 30% (Table 1). The one study with a 30% reduction in FW combined wall posters, pamphlets, and verbal lectures in the main dining area with FW collection to put in an anaerobic digestor [43].

## DISCUSSION

Although results varied, this scoping review sheds light on the most effective and heavily researched FW interventions on university campuses today. It also exposes critical gaps to guide future research, policy initiatives, and efforts to curb FW. Despite limited research, implementation of environmental interventions seemed to consistently yield the greatest reductions in FW, suggesting that changes made outside of the control of diners may be more effective than other strategies that require more “effort.” Passive education alone yielded mixed results, and while combining interventions could enhance impact, implementing multiple strategies simultaneously may strain staff and infrastructure. Nonetheless, addressing FW requires a multifaceted approach—simply printing a poster is not adequate. However, low-effort measures like removing trays in dining halls offer a win-win, benefiting both the environment and university finances.

Out of the 27 studies examined, environmental interventions were the most implemented in university settings. For example, removing trays altered how much food students could carry in one trip to their dining area,

discouraging them from filling up multiple plates and bowls and resulting in less FW. This is in line with behavior change research investigating pro-environmental behaviors. It seems that interventions may be most successful when the sustainable option, lower FW, is the default option, representative of a new "normal," or more convenient than the alternative [60]. Limiting food through trayless systems could easily become "normal" and thus be easier. However, more research is needed to better understand this potential. The combination of passive education with environmental interventions—though under researched—appeared to be the most effective means in reducing FW in this review (Table 1). However, given the variability in results, it is difficult to assert that combined interventions will be successful in all contexts.

Attempts to reduce post-consumer FW often involved efforts to increase awareness and knowledge of the impact or scope of FW primarily through passive or engaged education, and sometimes through incentive-based interventions. Passive education programs, such as displaying educational posters, differed from engaged education programs in terms of contact and interaction with consumers; engaged programs included more face-to-face interactions [58], courses [61], and "informational discussion tabling" [21] aimed at reducing FW. Incentives programs were typically financial, such as providing a monetary reward for a clean plate [45] or changing the cafeteria model to pay-by-item [62].

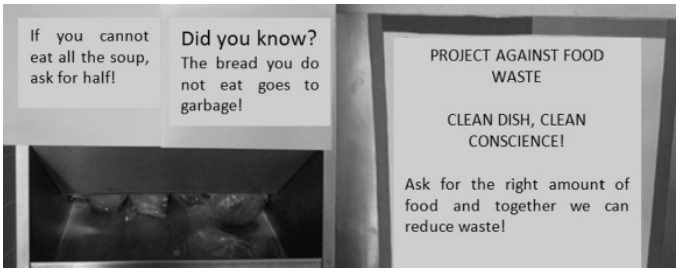
A systematic review of FW interventions reported that passive education programs—primarily centered on raising awareness through basic information—are the predominant approach in university settings [63]. Despite their widespread use, our findings indicate that these interventions yield mixed results. FW reductions among the studies reviewed varied considerably, ranging from 3.9% [25] to 30% [57], while one study reported no significant change following an information-only intervention [41]. Notably, the systematic review emphasized the role of student dietary preferences in intervention effectiveness, whereas our results suggest that environmental nudges may be more influential in shaping student behavior.

Likely, the variable quality and accessibility of educational materials used in passive education campaigns may alter their effectiveness. As with all communication techniques, visuals, like infographics, are useful for memory recall, as they decrease the amount of cognition needed in processing information [64]. Effectiveness, however, varies based on the organization and structure of the visual. Infographics that clearly communicate information to a targeted audience have consistency, key messages, a balance of words and images, a flow, and an accessible format [65–67]. Effective behavior change communication through visual materials requires the message to be concise and understandable with culturally relevant designs, minimal text, and a single call to action. For maximum impact, these materials should be integrated into a broader communication strategy that considers local context, strategic placement,

accessibility, and community input. A 2022 study found that less authoritative and controlling messages, such as “Reduce Food Waste” instead of “Stop Food Waste” were more effective in increasing consumer willingness to address FW [68]. This is likely due to psychological reactance—the tendency for individuals to intentionally resist messages perceived as coercive [69]. When people feel pressured, they may react by doing the opposite of what is being urged. Additionally, the study reported that simple messages emphasizing social welfare and environmental benefits were more persuasive than those highlighting economic costs [68]. This indicates that the framing of the message also plays a crucial role, with research showing that gain-framed messages, which focus on positive outcomes, are more effective at motivating change than loss-framed messages [70]. For example, a gain-framed message might be “Take only what you’ll eat—reduce waste, save money, and support a sustainable campus” whereas a loss-framed message would have a more negative slant: “Wasting food raises costs, harms the planet, and takes resources away from others.”

Furthermore, allowing individuals to feel they are making a voluntary and conscious decision—known as self-attribution—can enhance their commitment to behavior change [69]. By designing messages that encourage personal agency rather than imposing directives, communication materials can foster a sense of ownership and long-term adherence. As seen in Figure 4, posters used in the studies included in this review vary greatly in appeal, aesthetics, and messaging (Figure 4).

**(A)**




**(B)**


**Figure 4.** Examples depicting variation in poster messaging and quality. (**A**) Posters resulting in 15% reduction in FW [55]. (**B**) Posters resulting in 3.9% reduction in FW [25].

Although there is limited research, financial incentives to reduce FW uncovered through this review (Table 1) and elsewhere appear to be an effective strategy to motivate student behavior [27]. One study in this review quantifying the impact of economic incentives noted that financial rewards or savings did not reduce the amount of food students took. This indicates that the intervention may unintentionally incentivize increased food consumption and overeating (e.g., save money by forcing yourself to eat all your food instead of taking less to begin with) [45]. Universities implementing this intervention may want to consider promoting healthy food choices in tandem with financial incentives, to avoid exchanging one issue (FW) for another (poor diet). The type of food consumed is incredibly important, given associations between ultra-processed, high-calorie, high-sugar, high-salt, foods and poor health [71]. Since the 1970s in the U.S., the globalization of the food supply has been accompanied by a dramatic rise of obesity and diet-related chronic diseases, along with larger portion sizes and a reported increase of 50% in food waste [72]. Shared risk factors for overconsumption and waste involve the encouragement of excess consumer purchasing for industry profit and low value placed on food [73]. Notably, the global prevalence of obesity in university students ranges from 20% to 40% [74,75], escalating risks of chronic diseases [76]. Unhealthy diets are associated with depression and anxiety [77,78], and not only negatively impact sleep quality [79] and the immune system [80], it also has been found to have detrimental effects on academic performance [81].

Engaged education programs are similarly under-researched, despite their potential to drive meaningful behavior change. In the two studies that quantified the impact of student learning and instruction on FW, both resulted in statistically significant FW reductions [21,58]. These findings suggest that interactive, learning-based interventions can be effective in promoting sustainable food practices among students. However, such programs may require greater investment from universities in terms of faculty engagement, curriculum development, and student participation. The time commitment and resource demands associated with these initiatives could pose challenges for widespread adoption, particularly in institutions with limited funding or competing educational priorities. Further research is needed to assess how universities can effectively integrate FW education into existing curricula and ensure long-term behavioral shifts among students.

Across studies including student surveys, there was an overall consensus that students support university initiatives to improve sustainability and reduce FW [21,22,25,51,55]. Research suggests that when dining halls actively implement waste reduction efforts, students feel more empowered to act, increasing their engagement in sustainable practices [82]. However, students' perceptions of FW vary across cultural and geographical contexts.

In the United Kingdom, students were most concerned about the economic and environmental implications of FW, whereas students in India emphasized social issues, particularly food security and feelings of guilt [44]. Similarly, in the Netherlands, shame and guilt emerged as the main social emotions associated with FW [33]. While economic and environmental concerns appear prominent in some regions, the moral and ethical dimensions of FW take precedence in others. Furthermore, studies relying on self-reported survey data may not have fully captured actual FW behaviors, as students might have underreported their waste due to social desirability bias or guilt [24]. To obtain more accurate assessments, research incorporating physical auditing methods is preferable, as it provides objective data while also offering insight into the reliability of self-reported measures.

Studies differed on the type of FW that was quantified. For example, some studies included liquid waste in their measurements [22,29,54,58], while the majority of studies did not. Many studies only quantified edible, or avoidable FW—excluding non-edible, or unavoidable FW, such as eggshells, bones, peels, and skins [25,41,50,51,53,55]—while other studies quantified both categories of FW [22,48,54]. Two studies separated FW into edible compostables (or food scraps) and inedible compostables [21,46]. Studies utilizing digital auditing methods often did not separate types of FW [40,45] and excluded liquids [28]. The variability in how FW is quantified across studies has significant implications for research accuracy and policy development. Differences in measurement approaches—such as whether liquid waste is included or whether only avoidable FW is counted—complicate cross-study comparisons and meta-analyses. If studies exclude non-edible waste, it may underestimate the total volume of FW, potentially leading to incomplete assessments of waste management needs. Conversely, studies that lump all FW together without distinguishing between edible and inedible portions may obscure the impact of behavioral changes. Moreover, the exclusion of liquid waste limits the scope of findings and may lead to understated environmental and economic impact of waste in institutional settings. The reliance on digital auditing methods that do not differentiate FW types further adds to the inconsistency, making it difficult to identify trends or develop targeted reductions strategies.

Addressing methodological discrepancies is crucial for improving FW research and policy effectiveness. Standardized measurement protocols would allow for more accurate cross-comparisons and ensure that interventions are based on comprehensive and reliable data. This, in turn, could lead to better-informed strategies for reducing FW at institutions. Six interventions were implemented and audited for one week or less, which is a relatively short amount of time to measure behavior change and intervention impact. Research on long-term interventions is sorely needed. One study noted that after the intervention week, the amount of FW returned to previous levels [57]. Continuous campaigns may be more

effective, and further research is needed on how FW varies throughout the duration of the intervention and the course of the academic year. Short-term studies cannot measure how interventions, specifically posters that once may have been attention-grabbing, decrease in effectiveness of reducing FW over time. Of course, universities may face critical barriers in implementing FW reduction initiatives long-term. Paired with the potential time-consuming process of weighing and reporting FW, a high turnover rate of employees may require ongoing training on the FW tracking system [83].

Although our findings may be applicable to different populations, such as large businesses and educational institutions below the collegiate level—where FW is a relevant and pressing problem—concentrating on higher education limited our understanding of the effectiveness and applicability of certain interventions in other environments or with other populations. For instance, one study involved a male-only canteen [44]. Previous studies on campus FW have reported that female students tend to generate more FW than male students [34,59,84]. Additionally, factors such as age, education level, ethnicity, FW knowledge, and household size may also impact individual food sustainability efforts and FW [34,59]. Undoubtedly, cultural factors and beliefs about food and FW may also impact the efficacy of FW interventions [85]; likely, they will be most effective when they are context specific and tailored toward specific audiences.

This scoping review has potential limitations. The majority of studies in this review were conducted in the U.S. and Western Europe, likely limiting the global applicability of our findings. This regional concentration may in part reflect the geographical variability in the use and existence of university dining facilities. In contexts where university canteens are less popular or structured differently, FW interventions may not be possible on campus and/or a research interest and the applicability of certain interventions strategies may be minimal. Although our literature search strategy aimed to be comprehensive, it was restricted to English-only studies across six databases and may have missed some relevant publications. We excluded observational studies, narrative reviews, and non-original research that could have offered additional insight. With only 27 studies, all having unique methods, demographics, and interventions, direct comparison across studies was difficult. Lack of consistent results and robust data makes it challenging to make conclusive statements about the efficacy of the FW interventions included here. Additionally, there are numerous FW reduction strategies that were not captured in this review. For example, limiting back of house FW (from kitchen processing and procurement) as well as impact of landfill diversion strategies, such as traditional composting (windrow or other aerobic methods), industrial composting, use of biodigesters, vermicompost, or composting using other insects (such as the black soldier fly) were not included. These interventions and strategies are worthy of consideration given the breadth

and scope of FW. Some, such as composting FW, also involve consumer behavior and could be impacted by the interventions described above. Future research should investigate additional FW reduction strategies.

## CONCLUSIONS

A total of 27 studies met the inclusion criteria for this scoping review. Results varied widely and revealed inconsistencies in data collection methods and the efficacy of FW interventions. Analyses demonstrated that FW interventions at institutions of higher education fall into five primary categories: environmental changes, passive education, engaged education, financial incentives, and combined interventions. Environmental strategies, such as tray removal in dining halls, were the most implemented with FW reductions between 20% and 32%. Other strategies, like portion size reductions, showed great potential, with FW decreasing by as much as 66.4% for specific food items. Passive education had inconsistent results but was more effective when combined with environmental changes. Engaged education showed promise despite limited research, while financial incentives reduced FW but risked promoting overeating. Across studies, even simple interventions demonstrated meaningful reductions in FW, suggesting that small changes in dining environments can drive positive behavioral shifts. However, erratic measurement methods, relevant inconsistencies in the results (even if positive), and short intervention durations highlight the need for standardized protocols and long-term research to assess the sustainability of these effects.

Nevertheless, the implications of this review are significant. FW is an urgent issue, reflected by its inclusion in the United Nations Sustainable Development Goals (SDGs), which aimed to halve global FW and reduce food losses by 2023 [86]. Wasting food that would otherwise be suitable for human consumption undermines food security and nutrition, interfering with the SDGs objective of securing the human right to adequate food. Additionally, reducing GHG emissions from the global food supply chain is essential to achieve the Paris Agreement's objective of limiting global temperature rise to 1.5 °C or 2 °C above pre-industrial levels [87]. Our scoping review identified key research gaps, particularly in evaluating incentive-based interventions for postconsumer FW reduction. Existing studies often have short observation periods, limiting their ability to assess long-term impacts. Many audits capture waste from only a single meal rather than the entire day, restricting the scope of analysis. Inconsistencies in FW quantification further complicating comparisons—some studies include fluids and unavoidable waste, while others focus solely on edible waste. Standardizing measurement methods is crucial for accurately assessing intervention effectiveness. The selected FW studies were primarily implemented at U.S. educational institutions, suggesting a concentrated geographical research interest. Future research would benefit from a more diversified geographic focus, specifically in relation

to lower-resource and culturally diverse contexts; it should also explore differences in usage and structure of dining facilities.

Reducing FW requires more than just changes in student behavior. This scoping review highlights the importance of implementing multiple intervention types in tandem, specifically combining passive education with environmental changes, while also monitoring outcomes and gathering feedback from students and staff. Although survey results indicate that students care about decreasing waste, institutions—despite having the potential to lead in sustainability—often fall short. Addressing FW effectively requires a transdisciplinary approach, where solutions integrate diverse expertise: architecture and engineering to design efficient dining spaces; marketing to implement behavioral nudges; faculty leadership to guide dining priorities; sustainability science; and consumer behavior specialists to inform choice architecture. Universities are uniquely positioned to pioneer such comprehensive efforts, serving as a model for other institutions. By leveraging their ability to self-regulate and collaborate across disciplines, universities can serve as leaders in sustainable food systems and drive meaningful, large-scale changes.

## SUPPLEMENTARY MATERIALS

The following supplementary materials are available online at: https://doi.org/10.20900/jsr20250034, File S1: Complete Search Strategy.

## DATA AVAILABILITY

All data generated from the study are available in the manuscript or Supplementary Materials.

## AUTHOR CONTRIBUTIONS

Conceptualization, ODW, VJS, MLG, and JP; Methodology, ODW and VJS; Software, ODW; Validation, VJS; Investigation, ODW, VJS, and MLG; Resources, VJS; Data Curation, ODW; Writing—Original Draft Preparation, ODW and VJS; Writing—Review & Editing, MLG and JP; Visualization, ODW; Supervision, VJS; Project Administration, VJS.

## CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

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