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The Impact of Trayless Dining Implementation on University Diners' Satisfaction, Food Selection, Consumption, and Waste Behaviors

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Abstract: To evaluate the impact of trayless dining implementation on food selection, consumption, waste, and customer satisfaction, the authors used the quasi-experimental design to assess the attitudes and behaviors of on-campus diners at a university. Students dined as usual (i.e., with trays) while data were collected for one week and without trays for the second week. Digital photography and plate waste assessment of 329 trays evaluated participants' food selection, consumption, and waste behaviors. Surveys were used to assess students' attitudes and satisfaction with trayless dining (n = 73). An independent samples Mann–Whitney U test was utilized to analyze food selection, consumption, and waste differences. The result of the study revealed that the amount of food selected and consumed was reduced during trayless dining implementation. The total calories and fat content were lower during trayless dining implementation, and the participants reported reduced satiety. However, the data did not show significant food waste reduction but showed customer dissatisfaction and reluctance to change due to increased inconvenience. This study contributed to the existing literature by quantifying diners' food selection, consumption, and waste amounts, revealing the positive impact of trayless dining on food selection and consumption. Additionally, the detailed methodology will allow future researchers to replicate a similar intervention.

Keywords: university dining; food selection; food consumption; food waste; dining satisfaction

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1. Introduction

Food waste accumulated in landfills creates a series of negative impacts on the environment [1,2]. Overall, the amount of food waste equals one-fifth of the total Municipal Solid Waste (MSW) in the U.S. [1]. On average, each American discards 474.5 pounds of food per year or 1.3 pounds per day [1]. Of the almost 103 million tons of wasted food generated in the industrial, residential, commercial, and institutional sectors, the Environmental Protection Agency (EPA) [1] estimates that 35.6% is sent to landfills. Not only does biodegradable food waste in landfills require water, chemical treatment, and land for proper maintenance [2], but it also produces methane, which is 25 times more potent greenhouse gas than carbon dioxide [3,4]. Landfills are the third biggest anthropogenic source of methane emission in the U.S., and the concentration of methane in the atmosphere has increased by 167% over the last 250 years, significantly contributing to climate change [4]. In addition to the negative impact on environmental sustainability, food waste also poses a significant threat to economic sustainability. Globally, the full food waste costs amount to approximately USD 2.6T per year [5]. To combat the negative impacts of food waste, one of the goals of the United Nations is to halve per capita global food waste at the retail and consumer levels by 2030 and substantially reduce waste generation through prevention, reduction, recycling, and reuse [6].

One of the most significant contributors to the food waste challenges in the U.S. is commercial and onsite food service operations, including college and university dining facilities [7]. One study found that food waste generated by colleges and universities totaled over 1.3 billion pounds each year or 0.44 pounds per student per meal [8]. Over 60% of total plate waste was estimated to come from the traditional all-you-care-to-eat food service operations in colleges and universities [7]. Since the proportion of food waste in total MSW is the second largest, only after containers and packaging materials, the EPA [9] has suggested that source reduction is the most preferable and effective waste management strategy. Even though the food waste produced in university dining facilities may be used for animal feeding, composting, bioconversion, and biodiesel production, a study found that the majority of food waste ended up in landfills [10,11]. Therefore, a proper food waste management system dedicated to source reduction will help alleviate the negative impact of food waste on the environment. For example, many university dining centers in the U.S. provide patrons with trays to carry food and drink items. With the convenience of using a tray, patrons may take more food than they can consume [7,12–15]. Therefore, by taking trays away from patrons (trayless dining), the dining facilities may help to reduce food waste from the source and ultimately reduce the amount of food waste sent to landfills.

To effectively combat food waste challenges and reduce the total amount of food waste, this study examined the contributing psychological factors of consumers' food waste behavior. Several behavioral theories were developed and tested in the past to understand sustainable behaviors. For instance, the theory of reasoned action and the theory of planned behavior evaluated attitudinal factors to explain different behaviors. Both theories suggested that human behavior may be influenced by the individual's attitudes toward the target behavior [16,17]. Some researchers suggested that consumers' attitudes toward food waste may influence their intention toward food waste and their actual food waste behaviors [18–21]. However, these studies were mainly conducted in retail operations [18,21] or individual households [19,20], which have different characteristics from the setting of onsite food service operations, such as university dining centers. Therefore, the current study assessed university diners' attitudes and proposed that attitudes toward sustainability, food waste, and trayless dining are positively associated with each other, and diners' attitudes toward food waste are negatively associated with their food waste behavior. The following hypotheses were developed:

Hypothesis 1. *University diners' attitudes toward sustainability are positively associated with attitudes toward food waste reduction.*

Hypothesis 2. *University diners' attitudes toward sustainability are positively associated with attitudes toward trayless dining.*

Hypothesis 3. *University diners' attitudes toward food waste reduction are positively associated with attitudes toward trayless dining.*

Hypothesis 4. *University diners' attitudes toward food waste reduction are negatively associated with the amount of individual food waste.*

University dining facilities attempted to reduce food waste by informing college students [7,22], promoting sustainability awareness [12,23,24], utilizing portion plates [25,26], and adopting trayless dining [13–15]. More specifically, by using a simple messaging method (e.g., "All Taste No Waste" and "Eat What You Take, Don't Waste Food"), Whitehair et al. [7] found a 15% reduction in the total food waste amount. Manomaivibool et al. [22] documented reduced food waste by adopting multiple interventions to increase diner's awareness of food waste. These researchers placed stickers with food ordering tips and displayed information on dining tables to serve as a reminder for patrons to finish everything they had ordered. They also displayed posters and banners with pro-environmental-related information and images to elicit sustainable norms. Anderson et al. [25] and Richardson et al. [26] discovered that

by utilizing smaller or portioned plates, students' food waste was reduced by 16% and 35%, respectively.

Furthermore, trayless dining has become a popular method of improving the sustainability of university dining facilities. A few studies evaluated the effectiveness of trayless dining in reducing food waste [7,12–15]. ARAMARK [13] recorded that after taking trays away from patrons, individual plate waste amount was reduced by 1.2–1.8 ounces for each meal, which was a 25–30% decrease. Rajbhandari-Thapa et al. [15] reported that the number of dishes with at least a quarter leftover was reduced by almost 30% after the trayless dining implementation. Previous research showed that trayless dining effectively reduced the amount of food waste, which helps to alleviate food waste challenges in dining facilities.

In addition to the benefit of food waste reduction, other researchers also reported that trayless dining reduced the usage of detergent, water, and electricity. Furthermore, trayless dining was found to reduce food costs and to improve the sustainability awareness of diners [12,23,24], contributing to a positive impact on economic and environmental sustainability. However, despite the benefits of implementing trayless dining, some researchers suggested potential concerns and presented conflicting results on trayless dining [12,15,24]. Some of the concerns related to implementing trayless dining included reduced customer satisfaction, more frequent cleanups of tables and an increased number of broken glassware [12]. A few studies [27–29] evaluated the associations between university dining satisfaction and customer loyalty, return intention, and word-of-mouth endorsement, emphasizing the importance of diners' satisfaction on the aforementioned variables. Finally, Wansink et al. [24] reported that when trays were not provided, students consumed less salad, but did not consume less dessert, questioning that trayless dining may contribute to less healthy food choices. Contrarily, Rajbhandari-Thapa et al. [15] showed that diners selected less dessert but more salad during trayless implementation.

Despite the anticipated positive impact of trayless dining implementation toward food waste reduction, conflicting results were shown on the impact of trayless dining on diners' food selection. To further examine diners' food selection behaviors, some studies have examined hunger and satiety levels and revealed that diners' hunger and satiety levels have a significant impact on their food selection and consumption behaviors [30,31]. Therefore, it may be beneficial to evaluate diners' hunger and satiety levels before and during trayless dining implementation. In addition, some studies provided a detailed methodology for assessing or quantifying the amounts of food selected, consumed, and wasted, making it difficult for future studies to replicate similar designs. Finally, limited studies assessed the influence of trayless dining on the nutritional value of food selected and consumed, as well as diners' dining satisfaction, leaving the practicality of trayless dining unanswered. Therefore, the purpose of this study was to explore the impact of temporary trayless dining implementation on college students' food selection, consumption, and waste behaviors and on customer satisfaction at a university dining center. Specifically, this study aimed to assess (1) the amount of food selected, consumed, and wasted by college diners; (2) the nutritional value of food selected; (3) dining satisfaction; and (4) associations between and among variables before and during trayless dining implementation at a university dining center. The following sections include methodology, results, discussions, implications, limitations, and recommendations for future studies.

2. Materials and Methods

2.1. Population and Sample

This study targeted college-age adults who were studying in colleges or universities in the U.S. The study location was at a dining facility of a university located in the Midwest region of the U.S. The study sample was a group of students who were 18 years or older, lived in the surrounding dormitories, and signed up for meal plans to consume meals on-site during the 2-week data collection period. The average number of patrons at this dining facility was 1150 during dinner time. Only data from volunteers who consented to participate in the study and who ate at least five of six meals (i.e., three before and three

during trayless dining implementation) were included in the sample. No data from student-athletes or non-student diners were included to reflect typical college diners' attitudes and dining behaviors.

2.2. Study Protocol Development

There were two components for the data collection protocol for this study. The first component involved methods used to determine food selection, consumption, and waste, and the second component was a survey used to assess diners' attitudes toward sustainability, food waste, and trayless dining, as well as their dining satisfaction and demographic information. Specifically, digital photography methods—which have been used previously in food service settings to estimate intake [32–34]—were used to estimate diners' food selection. Plate waste methods [32,35,36] were used to assess food waste amount so that the amount of food consumed could be calculated by subtracting the food waste amount from the reference portion size.

2.2.1. Food Selection, Consumption, and Waste Assessment

The selected facility for data collection operates as an all-you-care-to-eat cafeteria style where consistent serving portion sizes are maintained by dining hall staff using standardized utensils to serve entrees and side items to all patrons. Therefore, recipe portion sizes were used when assessing the amount of food selected based on the photographs. Two photograph stations were set up in the dining center with one located next to a highly visible sign and the other next to a designated tray return area. Both cameras (e.g., Nikon D3100, Nikon: Tokyo, Japan) were set on a tripod, angled at 45° approximately 20 inches above the table to take clear pictures of the selected food items [32–34]. For self-served food items such as salads, desserts, and soups, the researchers weighed the food with the container. After recording the total weight, the weight of the container (e.g., bowls or plates) was subtracted to assess the weight of the food only to the nearest gram (Figure 1). The participants were instructed to return to the photo stations every time they returned to the serving lines for additional food items so that an accurate amount of total food selected could be recorded.

Figure 1. Food selection assessment.

The amount of food wasted was measured by the plate waste method, and the amount consumed was calculated by subtracting the weight of plate waste from the reference portion sizes. Additionally, the amount of consumption of self-selected food items (e.g., salad bar, dessert items) was assessed by subtracting the weight of plate waste from the initial weight of the food. The edible plate waste amount was recorded and categorized into seven food types: protein, starch, starchy vegetable, vegetable/salad, fruit, dessert, and condiment.

2.2.2. Nutrition Value of Food Selected

For nutrient value analyses, total kilocalories, the amounts of total protein, fat, carbohydrates, cholesterol, iron, and sodium were calculated based on the amount of food

selected and consumed. Nutrient values for individual food items were determined based on reference portion size using a food service automation software called Computrition.

2.2.3. Instrument Development

To explore the associations among diners' attitudes toward sustainability, food waste, and trayless dining, a self-administered questionnaire was developed based on the extant literature review [16,17,37–39] and was distributed among participants before trayless dining implementation. Diners' attitudes toward trayless dining (six items, e.g., "Not providing trays to carry my food items is acceptable to me"); food waste (nine items, e.g., "Throwing away food does not bother me"); and sustainability (seven items, e.g., "The present generation should ensure that the next generation inherits a community at least as healthy, diverse and productive as it is today") were measured using a five-point Likert-type scale, with 1 being strongly disagree and 5 strongly agree. Prior to analysis, all reverse-coded items were recoded to reflect the most positive answers being 5.

Additionally, hunger and satiety levels were assessed before and after each meal using an 11-point scale (1, experiencing the greatest hunger they could imagine; 6, being neither hungry nor full; and 11, experiencing the greatest fullness they could imagine) [30,31]. Demographic information was also included (i.e., gender, class standing, academic college, residency at the resident halls, and meal plans) at the end of the survey to determine if the characteristics of the sample matched the target population. On the last day of trayless dining implementation, the participants completed a survey to evaluate their dining satisfaction without a tray.

2.3. Pilot Study

Before collecting data from the participants, the researchers obtained approval from the university's Institutional Review Board (IRB) (IRB approval number 9019). Upon approval, a pilot study was conducted for one evening meal, one week before data collection. The pilot study participants (n = 20) were recruited and instructed to dine without trays after checking in with the researchers. The same data collection methods, described in the study protocol section, were pilot-tested to verify that the planned processes work. The pilot-study participants provided feedback on the logistics and feasibility of the intervention as well as the flow and clarity of the questionnaire. Based on the participants' suggestions, the research team improved the logistics of the intervention and modified the instrument, as appropriate.

2.4. Recruitment and Data Collection

One week prior to data collection, the research team set up an information table by the dining room to inform college diners about the upcoming trayless dining research and answer questions about the study. Research participants were recruited on the first day of the data collection, and a consent form was provided to each participant who was 18 years or older. Participation was encouraged by a drawing for two USD 50 payments upon completion of data collection (i.e., at least five of six meals reported, a pre-intervention survey completed, and feedback provided on dining satisfaction on the last day of data collection).

Food selection and waste data were collected during six dinner periods (three before and three during trayless dining implementation) by a team of researchers including doctoral and undergraduate students and a faculty member. The facility where data collection occurred implemented cycle menus that rotate every two weeks. Therefore, data were collected in two different weeks when similar food items were offered on the menu with a week of break in between. Before each meal, the participants checked in with one of the research team members, reported their hunger levels, and received a numbered tray card that was preassigned to track their food selection, consumption, and waste for each meal.

Before implementing temporary trayless dining, the participants dined as usual. Each student picked up a tray and proceeded to receive an entrée, then collected their beverages.

Once they gathered all entrees, side dishes, and beverages, they proceeded to one of the photograph stations and had a picture taken of their trays. The pictures were used later to identify the food items selected by the students. On the first day of data collection, the participants completed a survey that assessed their attitudes toward sustainability, food waste, and trayless dining along with their demographic information. After the participants finished their meals, they returned their trays to the dish-return area to have their food trays photographed and food waste weighed to the nearest gram.

After the pre-intervention data collection, the researchers withdrew from the facility. After one week of hiatus, trayless dining was implemented and the data collection resumed. During this week, the participants were not given trays but were asked to carry their plates of food and beverages by hand. Food selection and waste were recorded using the same aforementioned methods. The participants were asked to complete a survey that assessed their dining satisfaction without a tray on the last day of data collection.

2.5. Data Analysis

Both survey and observational data were analyzed by using SPSS (version 25). Descriptive statistics were calculated to summarize the data. The Cronbach's alpha coefficient was conducted to evaluate the internal consistency of each scale used in the survey assessing diners' attitudes toward sustainability, food waste, and trayless dining ($\alpha > 0.70$). Pearson bivariate correlation analyses were conducted to evaluate the associations between diners' attitudes toward sustainability, food waste, and trayless dining, as well as the amount of diners' average food waste ($p < 0.05$).

The amounts of selected and wasted food were recorded by using digital photography and plate waste methods. The amount of food consumed was calculated using Microsoft Excel to subtract the food waste amount from the reference portion size. Normality tests were conducted to test for kurtosis and skewness of the data. The significant normality test results indicated that the data in this study were not normally distributed. Therefore, a nonparametric test of an independent samples Mann–Whitney U test was conducted and reported along with the independent samples *t*-test as a reference. Previous research has suggested that nonparametric tests assume no specific distribution of the data and could be best utilized when analyzing nonnormal distributed data sets [40–42]. Specifically, the Mann–Whitney U test is conceptually similar to the *t*-test for determining whether two sampled groups are from the same population [43–45]. As a result, a Mann–Whitney U test was run to compare the mean amounts of total food selected, consumed, and wasted, and the survey's mean scores of the reported fullness level before and during trayless dining implementation. The amount of total plate waste left by each diner was categorized into six groups in 50 g increments (i.e., 0 g, 1–50 g, 51–100 g, 101–150 g, 151–200 g, 201 g, or more). The patterns and distributions of diners leaving different amounts of food waste before and during trayless dining implementation were evaluated by using the cross-tabulation with an χ^2 analysis. The significance level was set at $p < 0.05$.

3. Results

3.1. Descriptive Statistics

A total of 329 meals were evaluated before (n = 183) and during (n = 146) the temporary implementation of trayless dining. A total of 73 participants completed a survey about their attitudes toward food waste and trayless dining before trayless dining implementation and provided feedback on their dining satisfaction on the last day of trayless dining implementation. The majority of the participants were males (n = 49, 63%) between the age of 18 and 20 years (n = 71, 91%), who dined in the particular location 2–3 times a day (n = 72, 92%) (Table 1). The characteristics of this sample were consistent with the characteristics of the student population who dine in the study location.

Table 1. Descriptive statistics of respondents (n = 73).

	Number	*Percent (%)*
Age		
18 years	35	48%
19 years	17	23%
20 years	15	21%
21 years	3	4%
22 years	2	3%
23 years	1	1%
Gender		
Female	23	32%
Male	46	63%
Other	2	3%
Prefer not to disclose	2	3%
College		
Agriculture	18	23%
Architecture, Planning, and Design	2	3%
Arts and Sciences	12	16%
Business Administration	10	13%
Education	8	10%
Engineering	14	18%
Human Ecology	8	10%
Other	1	1%
Meal plans		
14 meals per week	34	47%
Unlimited	39	53%
Off-campus meal plans	0	0%
Dining frequency per day		
1 time	4	6%
2 times	48	66%
3 times	20	27%
More than 3 times	1	1%

3.2. Attitudes toward Sustainability, Food Waste, and Trayless Dining

Overall, the participants reported more positive attitudes towards sustainability (seven questions) (M = 3.8, SD = 0.7, Cronbach's α = 0.88) than towards food waste (nine questions) (M = 3.1, SD = 0.9, Cronbach's α = 0.80) or trayless dining (six questions) (M = 3.0, SD = 0.8, Cronbach's α = 0.79) (Table 2).

Table 2. Attitude toward sustainability, food waste, trayless dining, and the amount of diners' average food waste: correlations and descriptive statistics (n = 73).

Variables	***M (S.D.)***	**α**	**1**	**2**	**3**	**4**
1. Attitude toward sustainability	3.75 (0.67)	0.88	–			
2. Attitude toward food waste	3.07 (0.95)	0.80	0.47 **	–		
3. Attitude toward trayless dining	2.98 (0.79)	0.78	0.18	0.23 *	–	
4. Average food waste per person (in grams)	34.67 (1.04)		−0.09	−0.12	−0.03	–

* $p < 0.05$. ** $p < 0.01$ (two-tailed).

Pearson bivariate correlation analyses revealed that the attitude towards sustainability was positively associated with the attitude towards food waste (β = 0.47, $p < 0.01$), indicating that people who were more concerned about the environment and sustainable development exhibited more positive attitudes towards reducing food waste and preserving resources (Hypothesis 1 was supported). Furthermore, attitudes towards food waste and trayless dining were positively associated (β = 0.23, $p < 0.05$), indicating that college diners who had positive attitudes towards food waste reduction reported more positive attitudes towards trayless dining implementation (Hypothesis 3 was supported). However, diners' attitudes towards sustainability did not show a significant association with attitudes towards trayless dining

(Hypothesis 2 was not supported). Diners' concerns about the potential inconvenience without trays may have contributed to this insignificant association.

In addition, the findings of this study suggested that participants' attitudes towards sustainability, food waste, and trayless dining were not significantly associated with food waste behaviors, indicating that students' attitudes were not related to their food waste behaviors. This finding was similar to a previous study [32], which confirmed positive correlations between attitudes and self-reported behaviors but not between attitudes and actual food selection behaviors (Hypothesis 4 was not supported).

3.3. Food Selected, Consumed, and Wasted

The results of this study indicated that the total grams of food selected (before: $M = 448.9$, $SD = 215.3$; during: $M = 393.2$, $SD = 195.1$; $U = 16{,}556.50$, $z = 2.38$, $p < 0.05$) and consumed (before: $M = 419.6$, $SD = 220.8$; during: $M = 363.6$, $SD = 198.0$; $U = 15{,}462.50$, $z = 2.37$, $p < 0.05$) were significantly reduced during trayless dining implementation (Table 3). The participants also reported a lower level of fullness when trays were taken away (before: $M = 8.6$, $SD = 1.0$; during: $M = 8.3$, $SD = 0.8$; $U = 10{,}866.0$, $z = -2.61$, $p < 0.01$), potentially due to the reduced amount of food selected and consumed during trayless dining implementation. Furthermore, while previous researchers warned that students may consume less healthy food choices (e.g., less salad but the same amount of dessert) when trays were taken away [24], this study showed that the total amount of dessert and salad being selected did not change during trayless dining implementation. In fact, the amount of fat (grams) in the food selected decreased during the implementation (before: $M = 26.8$, $SD = 13.7$; during: $M = 20.2$, $SD = 14.6$; $U = 17{,}734.0$, $z = 4.54$, $p < 0.001$) (Figure 2), as well as the amount of energy (kilocalories) in the food selected (before: $M = 606.2$, $SD = 289.0$; during: $M = 544.2$, $SD = 298.1$; $U = 15{,}632.0$, $z = 2.14$, $p < 0.05$) (Figure 3). The independent samples *t*-test results were also reported in addition to the Mann–Whitney U test results for comparison purposes (Table 3). The results from both tests indicated similar statistical significances on the diners' reduced amount of food selected, consumed, fat selected, energy selected, and fullness level.

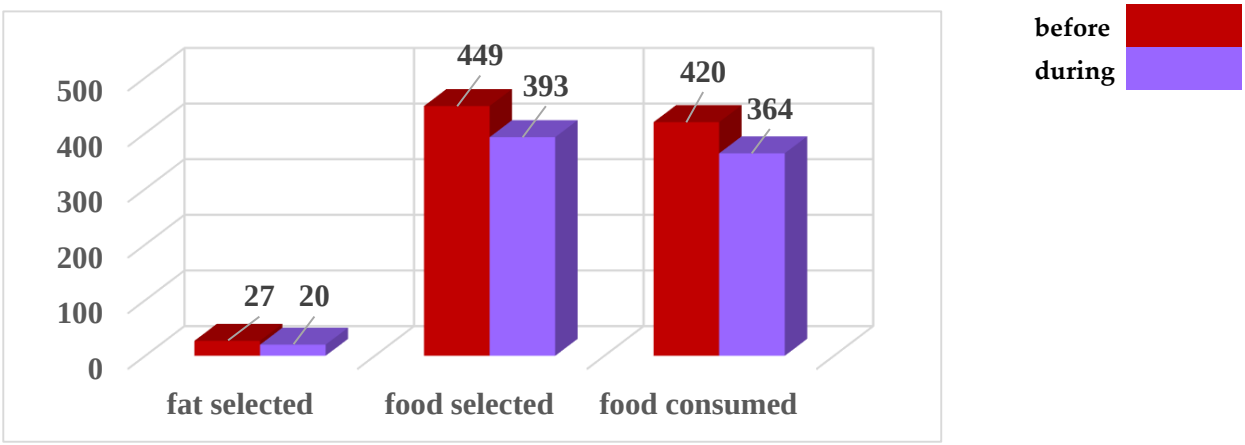

Figure 2. Total fat selected, food selected, and consumed (gm) per person. Note: total fat selected: $z = 4.54$, $p < 0.001$; total food selected: $z = 2.38$, $p < 0.05$; total food consumed: $z = 2.37$, $p < 0.05$.

Table 3. Average food selection, consumption, and waste information (in kilocalories and grams) before and during trayless dining implementation ($n = 183$ before and $n = 146$ during).

Variables	Before *M* (*S.D.*)	During *M* (*S.D.*)	*z*	*p*	*t*	*p*
1. Fullness level	8.6 (1.0)	8.3 (0.8)	−2.61	0.009	2.63	0.009
2. Average calories selected per person	606.2 (289.0)	544.2 (298.1)	2.14	0.032	1.92	0.046
3. Average fat selected per person	26.8 (13.7)	20.2 (14.6)	4.54	<0.001	4.23	<0.001
4. Average food selected per person	448.9 (215.3)	393.2 (195.1)	2.38	0.017	2.47	0.014
5. Average food consumed per person	419.6 (220.8)	363.6 (198.0)	2.37	0.018	2.36	0.019
6. Average food waste per person	37.2 (51.9)	34.9 (54.7)	−0.07	0.942	0.01	0.992

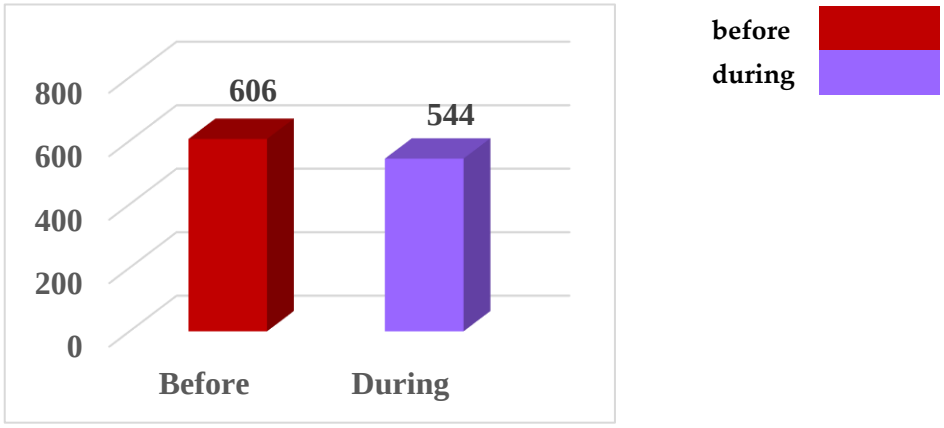

Figure 3. Total kilocalories selected (kcal) per person. Note: total kilocalories selected: $z = 2.14$, $p < 0.05$.

Even though trayless dining showed a positive influence on diners' food selection and consumption, the difference in the average amount of food waste in grams before and during trayless dining implementation was not significant (before: $M = 37.2$, $SD = 51.9$; during: $M = 34.9$, $SD = 54.7$; $U = 13{,}364.5$, $z = -0.07$, $p > 0.05$) (Table 3). Cross-tabulation with an χ^2 analysis was conducted to examine potential changes in patrons leaving various amounts of plate waste before and during trayless dining implementation. Although the result of the analysis (Table 4) did not show a significant difference in the proportion of patrons leaving varying amounts of plate waste ($\chi^2(5) = 2.99$, $p > 0.05$) before and during trayless dining implementation, valuable information may be extracted from the analysis. Out of the 329 trays evaluated (183 before, 146 during), 119 (60 before, 59 during) trays did not have any food waste on any selected days of data collection. Having approximately one-third of the participants leave zero waste on their plates before and during trayless dining implementation could be a potential reason for the insignificance of food waste reduction.

Table 4. Cross-tabulation analysis: food waste amount with and without trays ($\chi^2(5) = 2.99$, $p > 0.05$).

Food Waste Amount	With Trays		Without Trays	
	Count	% Within Phase	Count	% Within Phase
1. 0 g	60	32.8%	59	40.4%
2. 1–50 g	78	42.6%	51	34.9%
3. 51–100 g	22	12.0%	15	10.3%
4. 101–150 g	14	7.7%	13	8.9%
5. 151–200 g	6	3.3%	5	3.4%
6. 201 g or more	3	1.6%	3	2.1%
Total	183	100%	146	100%

4. Discussion

The results of the study showed that the temporary implementation of trayless dining in a college food service facility led to a positive influence on college diners' food selection and consumption behaviors. Specifically, college diners tended to choose less food when they were not given the convenience of using a tray. Consequently, the average amount of energy and fat in the food selected decreased, which may indicate that there is a potential for healthy food selection behaviors.

However, the result did not show a significant change in food waste reduction. This result is not consistent with the previous studies, which reported a significant per-person food waste reduction on days without trays [13–15]. A potential reason for no differences before and during the implementation in this study may be due to one-third of the participants not leaving any plate waste before or during trayless dining implementation. One of the reasons for the large proportion of participants leaving little to no waste may be

participation bias. As the facility where this study was conducted offered trays to their diners, the authors depended on voluntary participation. Since the purpose of the study was fully disclosed from the beginning, it is likely that those who were already interested in sustainability and perhaps more aware of food waste challenges may have participated in this study. Conducting quasi-experimental research such as this cannot be free of this bias [46,47]. The sample selection bias may have also caused a lack of normality in the data set. However, as shown in Table 3, the results of the nonparametric Mann–Whitney U test were similar to the parametric *t*-test. The only way to assess the effectiveness of trayless dining implementation on food selection, consumption, and waste behavior may be, while it is extremely difficult to implement, to remove trays from everyone and collect data from everyone. Only then, non-biased and normally distributed data may be collected for assessing the effectiveness of trayless dining implementation on food waste reduction.

In addition, the large standard deviations in the amount of food waste may also have contributed to the lack of significant differences in the amounts of food waste both before and during trayless dining implementation. While almost one-third or more of the participants left no food waste, the number of individuals leaving a large amount of food waste did not change, resulting in large standard deviations. The cross-tabulation analysis showed that the proportion of patrons who left zero plate waste was different before (32.8%) and during trayless dining implementation (40.4%). However, the proportion of patrons who left more than 100 g of food was somewhat consistent before and during trayless dining implementation (12.6% before and 14.4% during trayless dining implementation). More specifically, 23 participants before trayless dining implementation and 21 participants during trayless dining implementation left over 100 g of edible plate waste, leading to large standard deviations.

Finally, the diners' lack of satisfaction with trayless dining implementation may have contributed to insignificant differences. The voluntary participation may have attracted not only those who may have strong interests in sustainability, but also those who may have strong feelings against trayless dining. In fact, some participants voiced their concerns in the written comments section of the survey during trayless dining implementation, expressing their reluctance to move toward trayless dining due to inconvenience and safety concerns. Specifically, some participants reported inconvenience due to poor building layout ("Trayless dining at the dining center creates a major inconvenience for me and other diners due to the dining center's awkward layout. The distance from one food area to another (i.e., wok to grill) is a pretty annoying walk even with the tray"). Others suggested that trayless dining may create safety concerns, stating "Without a tray, walking from one end of the dining center to the other creates an extremely large inconvenience and risk for dropped food", and "Plates are typically really hot when you get food from the lines so not having trays becomes a safety hazard because students can burn their hands on the hot plates". Several diners suggested that to address the inconvenience of going trayless, the change of dining room layout as well as the change to providing larger plates and cups were needed ("If we have to move to trayless dining, the layout should be more open, so every food station is easily accessible", and "I think that if the center goes trayless, they need to have bigger plates and cups"). These students misunderstood the purpose of the study and might have thought we were assessing the feasibility of removing trays from their dining center. Such misunderstanding and concerns might have led to potential sabotaging behaviors of leaving a large amount of food on their plates.

5. Theoretical and Practical Implications

This study adds value to the existing food service research by providing theoretical implications about food waste reduction in university food service operations. First, few researchers have evaluated attitudes as an antecedent of behavior in the setting of university dining facilities. This study found that attitudes towards sustainability, food waste, and trayless dining were positively associated with each other. However, attitudes towards food waste were not significantly associated with actual food waste behavior, indicating

that positive attitudes may not always lead to positive actions towards a certain sustainable action [21,38].

Additionally, this research examined diners' food-related behaviors by measuring the amount of food selected, consumed, and wasted. Quantifying the amounts of food selected, consumed, and wasted offered a more accurate picture of the diners' true food-related behavior. Previous research has suggested that participants' self-reported behaviors may not always align with their actual observed behavior [32]. Therefore, by quantifying food selection, consumption, and waste amounts, this research captured a more accurate picture of the food-related behaviors of college diners.

Practically, by implementing trayless dining, this research recorded significant changes in college diners' food-related behaviors. The intervention and procedural protocols developed in this research may help college and university food service practitioners in implementing similar interventions which aim to influence diners' behaviors. First, the positive changes in college diners' behavior found in this research may imply that college and university food service practitioners may develop a similar intervention to influence the behavior of their diners. However, despite some significant findings, the patrons in this study were reluctant to change to trayless dining due to the lack of understanding of the intervention and the inconvenience of dining without a tray. Therefore, evaluating the feasibility of trayless dining as well as improving the logistics and layout of the existing dining facility will be crucial to the success of trayless dining implementation. Specifically, management may facilitate students to make trayless dining feasible and attainable by providing larger glassware or plastic cups, in order to reduce the need for making multiple trips or handling multiple glasses or cups. This consideration may reduce the weight and breakage issues with trayless dining. Management would also need to adjust the temperatures of the plate heaters to ensure the heated plates are safe to carry with bare hands. Additionally, the participants in the study provided feedback on the inconvenience of having to walk the long distance between different food offerings and not having a tray to carry their food and beverages. Therefore, minimizing the walking distance from different food offerings to the dining tables may be another way to reduce dissatisfaction.

To decrease the number of patrons who are accustomed to using trays and, therefore, reluctant to change, the timing of implementing trayless dining may also be considered. Practically, considering that there are new incoming students at the beginning of each academic year and existing students graduating, dining centers may implement trayless dining at the beginning of the academic year instead of the middle of an academic year, making trayless dining the new custom to the new incoming students.

6. Limitations and Future Studies

There are several limitations based on the design of the study. First, data collection was conducted in only one large dining facility. Therefore, the findings from this study may need to be interpreted with caution. Since data were collected from a university dining center with unique characteristics, the results of this study may not be generalizable to other types of food service operations such as K-12 school dining, healthcare dining, and commercial food service organizations. Future researchers may conduct similar research with a larger number of participants and at an increased number of facilities or choose different types of food service operations from which to collect data, in order to address generalizability issues. Furthermore, this study was conducted across only six dinner periods. Increasing the duration of the study and including other meal periods—as food selection and waste behaviors may be different during breakfast or lunch [48] when diners allocate a shorter amount of time for their meals—may help with the collection of more generalizable data.

Additionally, the impact of trayless dining was unknown at the individual level. Therefore, to thoroughly assess the impact of trayless dining, future research may track changes within subjects by pairing their food selection, consumption, and waste data before and during trayless dining implementation. Individuals' self-reported food selection,

consumption, and waste behaviors may also be matched and evaluated with their actual behaviors to better understand the association between patrons' self-reported data and their actual behaviors.

Finally, this study showed that human behavior is difficult to change, especially without proper education and intrinsic motivations [49,50]. Simply applying an external constraint such as removing trays may not produce the best result in food waste reduction. Instead of taking trays away from patrons without their consent, it may be more effective to reduce food waste by properly creating awareness of sustainability, educating on food waste challenges, and promoting social responsibilities. Future research may assess variables such as diner's awareness, attitudes, subjective norms, and emotions towards food waste to better understand patrons' intrinsic motivations. Examining these factors may help researchers to better understand the contributing factors behind food waste behaviors. Having such an understanding may ultimately help researchers to develop particular interventions to influence diners' food waste behaviors.

7. Conclusions

The current study evaluated the impact of the temporary implementation of trayless dining in a large university dining center on the amount of food selected, consumed, and wasted, along with assessing college diners' attitudes toward sustainability and food waste. The results showed a significant reduction in the amount of food selected and consumed but not in the amount of food wasted. The authors also found no associations between sustainability-related attitudes and food waste behaviors. Through this implementation trial, the authors provide insights for successful trayless dining implementation and recommendations for future studies.

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