



Research Paper

Challenges in promoting pro-environmental behaviour to reduce food waste in schools

András József Tóth^{a,b,c}, Atilla Kunszabó^a, Dávid Szakos^a, Márton Battay^d, Miklós Süth^{a,c,*}, Gyula Kasza^{a,b}, András Bittsánszky^{a,b}

^a Institute of Food Chain Science, University of Veterinary Medicine, István u. 2, Budapest 1078, Hungary

^b InDeRe Institute for Food System Research and Innovation Nonprofit Ltd, Budaörsi út 15, Budapest 1115, Hungary

^c National Laboratory of Infectious Animal Diseases, Antimicrobial Resistance, Veterinary Public Health and Food Chain Safety, University of Veterinary Medicine Budapest, H-1078 Budapest, István utca 2., Hungary

^d Department of Exotic Animal and Wildlife Medicine, University of Veterinary Medicine, István u. 2, Budapest 1078, Hungary



ARTICLE INFO

Keywords:

Food waste
School catering
Pro-environmental behaviour
Awareness campaign
Behavioural change
Sustainability

ABSTRACT

Food waste in schools presents significant environmental, economic, and social challenges. This large-scale study investigates the effectiveness of an awareness-raising campaign aimed at reducing food waste in schools. The intervention included printed materials, campaign videos, and an online food waste tracker to inform students about the consequences of food waste and encourage behaviour change. The study employed a three-phase methodology: initial food waste measurement, an awareness campaign combined with a questionnaire survey, and post-intervention food waste assessment. The survey was conducted across 10 schools, where data were collected on food waste generated from a total of 52,421 prepared lunch menus. Food waste was measured during two separate 10-day survey periods in consecutive years; in the second year, an awareness-raising campaign was implemented in the selected schools. In addition, students' attitudes towards food waste were assessed through a questionnaire survey, yielding 1,480 responses. Data were analysed using statistical methods (Student's *t*-test, Pearson's correlation). On average, consumers left 103 g of food on their plates from each course, which accounted for 32% of the served meal. Although our hypothesis assumed that the campaign would reduce the amount of waste generated, the results did not support this expectation. The findings indicate that while students recognize the importance of reducing food waste, the campaign did not lead to a measurable reduction. This suggests that simply increasing awareness may not be sufficient to drive behavioural change, highlighting the need for alternative strategies.

1. Introduction

Environmental awareness has become a critical factor in addressing global ecological challenges, including climate change, biodiversity loss, and resource depletion (Kollmuss & Agyeman, 2002). It encompasses the understanding of environmental issues, the recognition of human impact on ecosystems, and the adoption of sustainable behaviours to mitigate adverse effects (Gifford & Nilsson, 2014). Environmental awareness also plays a significant role in shaping pro-environmental attitudes and behaviours (Calculi et al., 2021). According to Kollmuss and Agyeman (2002), environmental knowledge alone is insufficient to drive behavioural change; rather, a combination of knowledge, emotional engagement, and situational factors determines an

individual's ecological actions. Schools, universities, and informal education settings play a pivotal role in fostering an environmental ethos by integrating sustainability concepts into curricula and extracurricular activities (Monroe, 2003).

Food waste is a global issue that affects both the environment and the economy. In the school setting, food waste can be a significant problem, with considerable environmental, social, and economic implications. Studies show that school-aged children waste up to 40–50% of the food served to them, amounting to millions of tons of wasted food annually (Derqui et al., 2018; Kasavan et al., 2021; Sundin et al., 2024). This waste not only contributes to greenhouse gas emissions and resource depletion, but also represents a lost opportunity to feed those in need. Economically, food waste in schools leads to increased costs for catering

* Corresponding author.

E-mail address: suth.miklos@univet.hu (M. Süth).

<https://doi.org/10.1016/j.wasman.2026.115426>

Received 16 May 2025; Received in revised form 15 December 2025; Accepted 22 February 2026

Available online 2 March 2026

0956-053X/© 2026 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

operations and diverts funds that could be better utilized. Addressing school food waste is crucial for promoting sustainability, reducing malnutrition, and ensuring efficient use of resources.

Implementing awareness-raising campaigns targeting students can lead to significant reductions in the amount of food wasted in educational settings (Pinto et al., 2018). These campaigns often involve educational activities that teach students about the environmental and economic impacts of food waste, as well as strategies for minimizing waste, such as taking only what they can eat and properly disposing of leftovers. By fostering a sense of environmental responsibility and providing practical knowledge, these interventions have been found to increase students' pro-environmental behaviours and subsequently lower the amount of food being discarded in school cafeterias (Malefors et al., 2022; Sundin et al., 2024).

Among the most effective interventions, reducing plate size led to up to a 30% reduction in food waste in hospitality settings (Ravandi & Jovanovic, 2019). Modifying school nutrition guidelines can also be a measure to decrease food waste (Cohen et al., 2014; Reynolds et al., 2019; Schwartz et al., 2015). Information campaigns also proved effective, achieving food waste reduction in some cases (Antón-Peset et al., 2021).

The effectiveness of interventions remains uncertain, as outcomes vary significantly depending on the approach, target group, and measurement methods used. While some interventions show promising results, others have minimal or inconsistent impact, underscoring the need for more rigorous evaluation and standardized methodologies. Information-based interventions are particularly common, yet their effectiveness is often debated due to a lack of large-scale studies with precise waste measurement. Our study seeks to address this gap by providing robust evidence on the effectiveness of information campaigns through large sample sizes and accurate measurement methods, ensuring reliable and meaningful findings.

2. Materials and methods

2.1. Study design

The study was divided into three main phases.

1. Initial food waste measurement in the participating schools (10–31 March 2023).
2. Awareness raising campaign and questionnaire surveys (5–26 March 2024).
3. Post-intervention food waste measurements (12–26 March 2024).

2.2. Survey location and study samples

Ten school catering units in Budapest participated in the food waste survey. The primary criterion for selecting schools was a high number of cafeteria users, ensuring the inclusion of as many participants as possible in the study. The types of institutions average daily portions and student enrolment numbers are listed in Table S1 (Supplementary material). Elementary schools serve children aged 6 to 14, while secondary schools cater to students aged 14 to 18. All the surveyed catering units operated as serving kitchens, meaning food was not prepared on-site but delivered from production kitchens. The average number of the daily served portions across the 10 catering units was 2,539 in 2023 and 2,695 in 2024.

2.3. The school food system

This survey focused exclusively on hot meals served as lunch. Since food waste generation largely depends on the catering system, we will briefly present the lunch service system used in the participating educational institutions. In Hungary, a typical school lunch consists of two courses: the first is always a soup, followed by a second course. The second course can vary, including options such as meat with a side dish,

pasta with sauce or sweet toppings, casseroles, or vegetable stews. Most schools also offer salads or fruit. Students, or their parents, place meal orders for the whole upcoming month. In seven of the surveyed schools, there were no menu alternatives—students could only choose whether or not to order the single menu offered. However, in three schools (Institutes 2, 4, and 10), students could choose between two menu options, though these had to be selected well in advance, typically the previous month. No changes could be made on the day of service. Most schools offered the same menu for all students, aside from these few cases where alternative second courses were available. Meals can be cancelled until the morning of the previous day. Therefore, if someone falls ill, they cannot cancel their lunch for that day.

At lunchtime, students enter the cafeteria during their designated period and form a queue. Meals are served at counters or stations, where cafeteria staff distribute the first and second course according to pre-specified portion sizes. Students can request only smaller portions at this stage or refuse any of the courses. After receiving their meals, students sit in designated dining areas.

Once they have finished eating, students are responsible for bringing their dirty trays, dishes, and utensils to designated return stations. The process of separating food waste from dishes and utensils is managed by the kitchen staff. Inside the kitchen, leftovers returned by students are collected in designated bins.

2.4. Food waste measurement

The food waste measurements were conducted by technical staff, who had no other tasks during the survey period. The surveys were carried out over two 10-day periods, in the spring of 2023 and 2024. During both 10-day measurement periods, the meals served were nearly identical. Measurements were taken using an electronic scale, and data were recorded in grams. First and second courses were measured separately, with three data points collected for each (Fig. 1).

The first data point recorded was the weight of the delivered food (Measurement 1). Weighing the delivered food is a routine part of the quality control process in kitchens, but the accuracy of this measurement was verified by the survey staff. The second measurement recorded was the weight of the leftover food returned by students (Measurement 2), which is referred to as plate waste. At the end of the serving period, the weight of any unserved food was measured (Measurement 3). The number of ordered portions and the served portions were also recorded, which was determined by counting the returned plates. Since the plates used for the first and second courses differed, it was possible to precisely identify how much of each course was served.

2.5. Questionnaire survey

For questionnaire design, international literature was studied (Kwon et al., 2018; Machado et al., 2020), and the needs of catering operators were also considered. Completing the questionnaires was voluntary and anonymous, age, sex, and position (student/teacher/school worker) were asked. Pens were provided for completing the questionnaires, and participants were individually asked to fill them out.

For this study, we conducted two questionnaire surveys. Satisfaction with school catering was measured in the first survey session in all participant institutions simultaneously with waste measurement. The multiple-choice questionnaires contained 35 questions each year. The questionnaire covers various aspects such as the taste, temperature, and nutritional value of the food, the adequacy of meal times, the politeness of the serving staff, cleanliness of utensils and the dining environment, portion sizes, and food waste. It also explores personal eating habits and attitudes towards food, health, and environmental consciousness. The majority of the questions used a Likert scale, where 1 represented the worst case and 5 represented the best case.

The second questionnaire survey was related to the awareness raising campaign and it was conducted in those schools where the

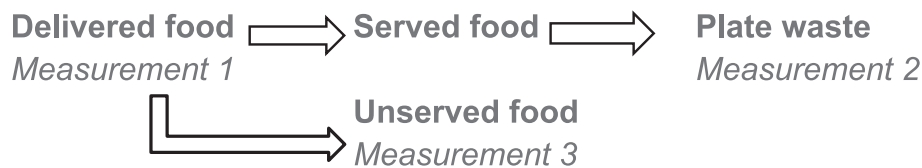


Fig. 1. Schematic process of school food waste measurement.

intervention took place (Institute 4, 7, 9, 10). The 12-question survey was completed during the meals after the campaign period. The questionnaire aimed to assess how effectively the campaign messages reached their target audience and how successful the applied methods were. Yes/No answers and Likert-scale were used in this questionnaire.

2.6. Awareness raising campaign

Four schools were selected for awareness raising campaign (Institute 4, 7, 9, 10). When selecting institutions, we aimed to ensure a similar number of consumers in both the intervention and control institutions. The intervention started one week before the food waste measurements and lasted for three weeks. The intervention consisted of three main parts:

- Placement of table talkers and printed materials on dining tables.
- Playing of awareness-raising videos on an LCD screen placed in the dining area, and displaying the results of daily measurements.
- The results of the daily measurements were published on a designated webpage, which could be accessed via a QR code.

2.6.1. Table talker and printed materials

The informational sign placed on the dining table (Malefors et al., 2022) included the survey date and purpose and a QR code where the school's daily food waste amount could be tracked using a mobile device (Fig. S1). The primary goal of the "Let's Reduce Food Waste Together" campaign is to "bring back less leftover food than in the same period of last year." The table talker reminds children that "more than 60 kg of food waste per person is generated annually in school meals," and therefore, "If you're not hungry, ask for less and eat what you get!". Leaflets and booklets issued by Project Wasteless (National Food Chain Safety Office, 2024; Szakos et al., 2021) was also circulated in the dining area.

2.6.2. Campaign video

In the campaign video, we share the annual number of portions served and the food waste data of the school cafeterias involved in the intervention with the consumers. An important part of awareness-raising is to ensure that the goals of the food waste reduction program are clear to everyone and that those involved feel they are part of the change. Nine short films created by Project Wasteless (National Food Chain Safety Office, 2024) were also played.

2.6.3. Online food waste tracker

A central element of the campaign communication was the daily tracking of the amount of food waste in each school cafeteria. Therefore, we created a webpage where the results of the waste measurements for each institution were presented in an easily understandable format. The webpage could also be accessed via a QR code displayed on the table talkers in the dining area. The daily quantities were provided in kilograms and percentages and were compared with the same period of the previous year (Fig. S2). This allowed students to see each day how much leftover they left on their plates the day before and during the same period the previous year. These quantities in kilograms and percentages were also displayed to the students by type of food.

2.7. Ethical aspects

Institutional leaders were informed in advance about the survey and the accompanying awareness-raising campaign, and their consent was obtained. The first questionnaire also functioned as a guest satisfaction survey; therefore, its development was carried out in collaboration with the food service provider. No personal data were collected, participation was entirely voluntary and fully anonymous, and for this reason parental consent was not required. Respondents were not subjected to any emotional or physical pressure during the process. The ethical aspects of the study were discussed both with the Ethics Committee of the Indere Institute Nonprofit Ltd. and with the organizers of the catering services.

2.8. Data analysis, statistics

The following indicators were calculated based on the collected data.

- Plate waste (g)/served portions, expressed in grams.
- Plate waste (g)/served food (g), expressed in percent.
- Unserved food (g)/ordered portions, expressed in grams.
- Unserved food (g)/prepared food (g), expressed in percent.
- Total waste (g)/ordered portions, expressed in grams. Total waste was defined as the sum of plate waste and unserved food.
- Total waste (g)/prepared food (g), expressed in percent. Total waste was defined as the sum of plate waste and unserved food.

Questionnaire data were recorded in Excel spreadsheets and prepared for analysis.

For statistical analysis the JASP software were used (JASP Team, 2025). Descriptive statistics, Student's *t*-test and Pearson's correlation were used for calculations.

3. Results

The aim of this study is to explore the impacts of the awareness-raising campaign. During the two ten-day survey periods, a total of 52,421 lunch menu were surveyed (representing 34,512 kg food), 25,467 lunch menu in 2023 (16,961 kg food) and 26,954 lunch menu in 2024 (17,551 kg food) Table 1. The number of absent students was calculated by subtracting the actual number of served portions from the number of ordered portions. The supplier kitchens delivering to the cafeterias did not change between the survey periods. The number of portions were increased by 5.8%.

3.1. Plate waste

Plate waste refers to food that has been served but not consumed. Table 2 shows the amount of plate waste returned by consumers from the lunch menu. Data are presented by courses. Statistically, the amount of plate waste is significantly higher in the institutions selected for the campaign (Student's *t*-test, $p < 0.001$), despite the fact that the only criterion for selecting institutions was to ensure a nearly equal number of consumers. The possible reasons for the differences in plate waste could not be identified. Between the two survey years there is no statistically detectable difference in either the institutions selected for the campaign or the control institutions. The only statistically significant difference is the increase in the percentage of plate waste in the control

Table 1

Summary of the food waste data collected during the survey, including results from both years.

Institute	Delivered food	Unservd food	Plate waste	No. of ordered portions	No. of served portions	Unservd portions (Absence %)
Institute_1	6,994 kg	1,629 kg	1,812 kg	11,680	10,295	1,385 (12%)
Institute_2	3,178 kg	1,107 kg	874 kg	4,636	3,990	646 (14%)
Institute_3	1,049 kg	130 kg	176 kg	1,491	1,350	141 (9%)
Institute_4	6,895 kg	2,185 kg	1,258 kg	10,338	7,967	2,371 (23%)
Institute_5	1,980 kg	564 kg	403 kg	2,829	2,260	569 (20%)
Institute_6	2,408 kg	416 kg	431 kg	3,374	3,116	258 (8%)
Institute_7	3,757 kg	1,159 kg	970 kg	6,289	4,899	1,390 (22%)
Institute_8	7,23 kg	112 kg	143 kg	994	857	137 (14%)
Institute_9	3,179 kg	765 kg	448 kg	4,520	3,821	699 (15%)
Institute_10	4,363 kg	1,401 kg	1,148 kg	6,270	4,489	1,781 (28%)
Total	34,527 kg	9468 kg	7661 kg	52,421	43,044	9,377 (18%)

Table 2Plate waste / served portions returned by consumers (g) and plate waste/served food (%). Values are presented as mean $\pm$ SD with p-values calculated by Student's *t*-test comparing 2023 and 2024.

	Plate waste/served portions	Plate waste/served food
No campaign institutions	91 g $\pm$ 49 g	30% $\pm$ 18%
2023	87 g $\pm$ 53 g	27% $\pm$ 18%
2024	96 g $\pm$ 45 g	33% $\pm$ 18%
p-value	0.125	0.019*
Campaign institutions	113 g $\pm$ 57 g	35% $\pm$ 19%
2023 ¹	114 g $\pm$ 59 g	36% $\pm$ 19%
2024	112 g $\pm$ 55 g	34% $\pm$ 18%
p-value	0.695	0.455
Total	103 g $\pm$ 54 g	32% $\pm$ 19%

*Asterisk means significant statistical difference between 2023 and 2024, analysed by Student's *t*-test at $p < 0.05$.¹There were no campaigns in 2023; we are analysing separately the institutions where the campaign were implemented in 2024, solely for comparability.

institutions.

Since the plate waste from the first and second courses was collected separately, the data could also be analyzed independently. Course-specific data are presented in Table S2 (Supplementary material). In all comparisons examined, more leftovers were returned from the first course (which was always soup) than from the second course.

3.2. Unserved food and total waste

Unserved food refers to pre-ordered but not collected meals. The amount of unserved food waste is summarized in Table 3. Although unserved food is theoretically still suitable for human consumption, in

Table 3Unserved food / ordered portions (g) and unserved food / prepared food (%). Values are presented as mean $\pm$ SD with p-values calculated by Student's *t*-test comparing 2023 and 2024.

	Unserved food /ordered portions	Unserved food /prepared food
No campaign institutions	75 g $\pm$ 41 g	22% $\pm$ 12%
2023	75 g $\pm$ 42 g	22% $\pm$ 12%
2024	76 g $\pm$ 40 g	23% $\pm$ 13%
p-value	0.841	0.362
Campaign institutions	102 g $\pm$ 42 g	31% $\pm$ 12%
2023 ¹	104 g $\pm$ 44 g	32% $\pm$ 11%
2024	100 g $\pm$ 39 g	31% $\pm$ 13%
p-value	0.412	0.952
Total	90 g $\pm$ 44 g	27% $\pm$ 13%

^a There were no campaigns in 2023; we are analysing separately the institutions where the campaign were implemented in 2024, solely for comparability.

the absence of the necessary conditions for its safe redistribution, it must nonetheless be classified as waste. The volume of unserved food is primarily influenced by the number of ordered but uneaten meals (e.g. the student does not show up for lunch), as well as by partially requested portions (e.g., when someone only asks for the second course but skips the soup). Over the entire survey period, 27% of the prepared food was not served, which is slightly less than the amount of plate waste. However, the trends are fully consistent with the data on plate waste: no significant decrease was observed during the 2024 survey period.

Table 4 presents the average amount of total waste generated per ordered menu during the surveys. Total waste is defined as the sum of plate waste and unserved food waste and serves as an appropriate indicator of the overall amount of waste generated from an ordered meal. Similar to returned waste and unserved food, this value was higher in institutions selected for the campaign. The total amount of waste over the entire survey period was 50%. Based on data from the two survey years, the amount of waste increased in control institutions but decreased in those affected by the campaign. However, the differences are not statistically significant. This means that the campaign did not lead to a reduction in food waste.

We also conducted a separate analysis of the first and second courses for both unserved food and total waste (Tables S3–S4, Supplementary Material). Similar to the plate waste results, in every case examined a greater amount of waste was generated from the first course.

3.3. Questionnaire data

A total of 1,480 participants completed the questionnaire. The distribution of respondents across institutions, as well as the breakdown between students and teachers/staff, is presented in Table S5 (Supplementary material). Out of the 35 questions, statistically significant differences were observed in 11 cases between respondents from the

Table 4Total waste / ordered portions (g) and total waste / prepared food (%). Values are presented as mean $\pm$ SD with p-values calculated by Student's *t*-test comparing 2023 and 2024.

	Total waste/ ordered portions	Total waste / prepared food
No campaign institutions	148 g $\pm$ 63 g	44% $\pm$ 19%
2023	143 g $\pm$ 67 g	42% $\pm$ 20%
2024	154 g $\pm$ 58 g	47% $\pm$ 19%
p-value	0.186	0.038*
Campaign institutions	175 g $\pm$ 57 g	54% $\pm$ 18%
2023 ¹	180 g $\pm$ 60 g	55% $\pm$ 18%
2024	171 g $\pm$ 54 g	53% $\pm$ 18%
p-value	0.192	0.453
Total	163 g $\pm$ 61 g	50% $\pm$ 19%

*Asterisk means significant statistical difference between 2023 and 2024, analysed by Student's *t*-test at $p < 0.05$.¹There were no campaigns in 2023; we are analysing separately the institutions where the campaign were implemented in 2024, solely for comparability.

campaign-designated and control institutions (Table 5). However, the responses do not provide clear insights into why food waste levels were higher in the campaign schools. For instance, despite reporting longer meal times (Question 8), lower food temperatures (Question 17a), and a greater emphasis on healthy eating (Question 24), the campaign schools still generated more waste. While these factors could theoretically influence food waste generation, our results do not support this assumption.

3.4. Campaign questionnaire

The campaign questionnaire were completed by 495 respondents. The distribution of respondents across institutions, as well as the breakdown between students and teachers/staff, is presented in Table S6 (Supplementary material).

The questionnaire results indicate that 65% of respondents were exposed to the campaign messages in some form, with printed informational materials proving to be the most effective (Table 6). In contrast, the online food waste tracker accessible via QR code failed to achieve its purpose. This may be because many students do not bring or are not allowed to bring their smartphones into the cafeteria. The majority considers food waste reduction important and is willing to take action. However, they did not necessarily find the implemented campaign to be an effective method for achieving this goal.

4. Discussion

4.1. Food waste in school catering

Our hypothesis was that if we draw high school students' attention to the problems caused by waste, they will take action within their own means to reduce food waste, and this reduction will be measurable. However, the data did not support our hypothesis. Our data show that in the second year, food waste increased in the control institutions; however, this rise was mitigated by the campaign. Nevertheless, statistical analysis only partially supports this observation.

The amount of plate waste varies widely across countries, ranging from 9 to 133 g per courses per meal (Feng et al., 2024). Our data fall within this range, with an average of 103 g per course. However, since a student typically consumes two courses at lunch, the average amount of plate waste per person is approximately twice this value, corresponding to about 206 g.

For all the waste indicators examined, the values for the first course were consistently higher than for the second course, which can primarily be attributed to the relatively low popularity of soups (Tóth et al., 2023). However, the overall trends were similar for both courses: the effects of year and of the awareness campaign influenced the first and second courses in the same way (Tables S2–S4, Supplementary Material).

Absenteeism, in the context of school catering, refers to meals that have been pre-ordered or allocated based on enrollment but remain “unserved” or “not collected” because the student does not attend lunch on the service day. The quantity of such unserved food shows a strong correlation with the number of absent consumers (Pearson's correlation $r = 0.698$, $p < 0.001$), indicating that absenteeism is the primary driver of unserved food generation. Additional waste arises when students request smaller portions than prescribed or decline either the first or the second course, further increasing the amount of unserved food. In the present study, our awareness-raising campaign primarily aimed to reduce plate waste, as this type of waste is generated exclusively by students who actually consume meals in the cafeteria. For this reason, plate waste was always interpreted in relation to the amount of food served, meaning that it is not influenced by absenteeism. The international literature has largely examined school food waste in relation to portioning practices and consumer behaviour, while the issue of absenteeism leading to pre-ordered but uncollected meals has received little attention (de Souza et al., 2025; Vici et al., 2025).

Table 5

Customer satisfaction questionnaire completed by school meal consumers. The questions type was Likert scale form 1 to 5 where 1 means the most negative case (do not agree at all, not true at all, never, etc.), 5 means the most positive case (totally agree, true, always, etc – for exception see footnotes). The exact possible answers were adopted to the questions. P value was calculated by Student's *t*-test.

	Question	Campaign n = 784	No campaign n = 696	p
1	Tasty	3.27 ± 0.91	3.24 ± 0.97	0.471
2	Smells good	2.98 ± 1.09	3.09 ± 1.14	0.081
3	Nutritious	3.34 ± 1.08	3.32 ± 1.12	0.695
4	Healthy	3.34 ± 1.02	3.23 ± 1.13	0.063
5	Looks good	2.74 ± 1.36	2.82 ± 1.33	0.264
6	Cold foods are cold enough	3.09 ± 1.42	3.00 ± 1.46	0.270
7	Hot foods are hot enough	3.94 ± 1.08	3.77 ± 1.24	0.007*
8	Is the lunch break long enough to eat lunch?	3.06 ± 1.41	2.67 ± 1.44	<.001*
9	What is your opinion about the courtesy of the service staff?	3.76 ± 1.29	3.99 ± 1.13	<.001*
10	What is your opinion on the cleanliness of the cutlery and the restaurant?	3.64 ± 1.01	3.12 ± 1.2	<.001*
11	What are your thoughts on the condition of the restaurant and the restaurant environment?	3.73 ± 0.89	3.36 ± 0.99	<.001*
12	What do you think about the portion size of the food? ^a	2.71 ± 0.78	2.67 ± 1.14	0.405
13	How does the food in the school cafeteria compare to the food at home?	1.87 ± 0.79	1.96 ± 0.88	0.027*
14	Do you usually cook at home?	1.81 ± 0.86	1.81 ± 0.89	0.991
15	In general, are you satisfied with the school cafeteria?	3.38 ± 0.98	3.34 ± 2.23	0.702
16	Do you think the quality of food has changed in the past?	3.86 ± 1.44	3.65 ± 1.3	0.005*
17	What do you think causes food waste in the school cafeteria?			
a	The food is too hot.	2.16 ± 1.13	2.47 ± 1.32	<.001*
b	The food is not tasty enough.	3.36 ± 1.16	3.15 ± 1.25	0.002*
c	The portions are too large.	2.2 ± 1.11	2.1 ± 1.12	0.105
d	There is too little time to eat.	3.28 ± 1.39	3.42 ± 1.5	0.082
e	Students have different food preferences	3.68 ± 1.12	3.67 ± 1.16	0.945
f	They order food even when they are not hungry.	3.33 ± 1.45	3.27 ± 1.27	0.382
g	The food is not spicy or salty enough. ^b	2.93 ± 1.33	3.14 ± 1.4	0.007*
18	Do you often leave food on your plate? ^b	2.96 ± 1.12	2.9 ± 1.56	0.468
19	Compared to others, how much food do you think you waste? ^b	2.38 ± 0.94	2.36 ± 0.97	0.650
20	I am afraid to try foods I have never eaten before. ^b	2.04 ± 1.16	2.09 ± 1.28	0.417
21	I enjoy tasting unique and exotic flavors.	3.59 ± 1.25	3.68 ± 1.33	0.243
22	I like eating vegetables or pickles with my main course.	3.95 ± 2.03	3.55 ± 1.38	<.001*
23	I am happy to eat meat-free dishes.	2.75 ± 1.4	2.73 ± 1.37	0.749
24	Healthy eating is important to me.	3.85 ± 1.63	3.63 ± 1.22	0.006*
25	Sustainable eating is important to me.	3.44 ± 1.28	3.39 ± 1.35	0.490

(continued on next page)

Table 5 (continued)

	Question	Campaign n = 784	No campaign n = 696	p
26	Food has emotional and cultural value to me, not just monetary worth.	3.13 ± 1.28	3.21 ± 2.46	0.429
27	I live sustainably and do not waste food.	3.18 ± 1.12	3.16 ± 1.16	0.786
28	Environmental protection is important to me.	3.97 ± 1.06	3.88 ± 1.19	0.123
29	When we throw away food, we waste the effort of those who prepared it.	3.96 ± 1.15	3.94 ± 1.23	0.818

*Statistically significant differences at $p < 0.05$ calculated by Student's t-test.

^aFor this question the option 3 (appropriate) was the best case whereas 1 (to little) and 5 (to much) was the two extreme value.

^bFor these question 1 is the positive case and 5 is the negative case.

Table 6

Questionnaire administered in the 4 campaign schools at the end of the awareness raising campaign. (n = 495).

Part A.	Yes	No
Did you complete the satisfaction survey distributed last week?	63%	37%
Did you read the printed document placed on the table?	65%	35%
Did you watch the videos played on the television?	59%	41%
Did you track the amount of food waste generated at school using the QR code on the printed document on the table?	11%	89%
Part B.	Likert scale (1–5)	
In your opinion, how has the amount of leftover food on your plate changed over the past 10 days?	3.25 ± 0.67	
Do you consider such awareness-raising initiatives important?	3.62 ± 1.01	
How important do you think reducing food waste is?	4.37 ± 0.85	
Would you like to continue making efforts to reduce your food waste in the future?	4.02 ± 0.85	
How much did you like the waste reduction awareness campaign?	3.30 ± 0.96	

Although the primary aim of this study was to test the impact of awareness-raising interventions on the quantity of waste generated, a substantial amount of school waste data was also collected during the research. This dataset is suitable for comparison with large-scale school waste surveys whose sole objective was to quantify institutional waste production (Abreu et al. 2025; Falasconi et al. 2025). Therefore, beyond assessing behavioral change, the study also contributes valuable empirical data to the broader field of school waste characterization and benchmarking.

4.2. Awareness raising in schools

More than 60% of the students obtained information from the printed brochures. The online food waste tracker was clearly ineffective, as the survey data shows that students did not actively follow the information published online. In the assessed schools, students often did not have their smartphones with them, preventing them from scanning the QR code. This system is not suitable for the age group studied. The campaign survey results show that students consider waste reduction important, as the related questions received high ratings.

Although various studies produced conflicting results, we initially expected that increasing awareness and delivering the right messages could improve pro-environmental behaviour and thus reduce school food waste. The effectiveness of food waste reduction interventions largely depends on the type of messaging used to engage individuals. Environmental messages are effective in increasing waste reduction intentions, demonstrating greater efficacy compared to financial and taste-oriented messages (Bretter et al., 2023). However, this approach was entirely unsuccessful in this study, and we can only speculate about the reasons behind it. Our core messages aimed to appeal either to

consumers' conscience and guilt, but it's possible that we might have achieved better results by focusing solely on positive messages and emotions (Romero-Luis et al., 2023). Positive emotions can better motivate than fear or guilt in environmental messages.

Several studies have demonstrated that awareness-raising efforts can lead to varying degrees of food waste reduction. For example, a Swedish study on school food services for children aged 6–19 reported a significant reduction in plate waste — by 13 g per portion, or 35% — following an awareness campaign (Malefors et al., 2022). This study focused on school food services catering to children aged 6–19 years. Antón-Peset et al. (2021) followed the lunch plate waste in a primary school where 9–10 years old children participated in the project. They observed significant reduction when awareness campaigns have been implemented. In university settings, however, the impact of awareness campaigns appears to be less consistent. For instance, providing information about food waste alone did not lead to a measurable reduction in waste in university canteens (Visschers et al., 2020). Although a campaign in Chinese universities did not significantly reduce food waste (Qian et al., 2024), other findings suggest that increasing awareness and promoting positive attitudes can still play a role in reducing waste, as shown in a study among Chinese university students (Li et al., 2025). On the other hand, a targeted campaign at a Portuguese university successfully reduced the amount of waste generated (Pinto et al., 2018). The awareness and educational campaign implemented in Latvian school for 6–13 years old schoolchildren did not lead to significant reductions in plate waste (Lonska et al., 2025), achieving meaningful change in reducing school food waste requires practical, flexible catering systems that actively involve students in the process (Deksne et al., 2025). The reviewed studies collectively indicate that interventions aimed at reducing food waste in educational institutions can achieve varying degrees of success—their effectiveness largely depends on the type of approach and its implementation.

Being aware of an issue does not always lead to taking action. As awareness of food waste continues to grow, it is crucial to explore ways to bridge the gap between awareness and action. Research highlights this disconnect, often referring to it as a 'value-action gap' (Marwood et al., 2023).

Generational differences in environmental awareness and pro-environmental behaviour are evident across European regions. Younger and older generations approach sustainability differently, shaped by cultural, economic, and informational factors. As a result, a universal strategy is ineffective; instead, targeted approaches should be designed to address the specific motivations and challenges of each age group.

As highlighted by the studies mentioned above, efforts to reduce food waste are being made worldwide. However, direct comparisons between findings remain difficult, as the data originate from diverse catering cultures, different national school meal systems, and, in many cases, distinct target age groups. The novelty of the present research lies in conducting one of the largest school-based intervention studies in Central Europe that applied direct food waste measurement. In addition, the study incorporated an attitude survey, thereby enabling a more comprehensive evaluation of the effectiveness of the awareness campaign.

5. Study limitations

This study is subject to several limitations that should be considered when interpreting the findings. The Hungarian school catering system requires meals to be ordered in advance, which means that student absenteeism inevitably contributed to the amount of unserved food waste. Absences may arise for a variety of reasons, including the possibility that students, upon viewing the daily menu, decide not to attend the cafeteria, which could have influenced the outcomes of our study. Furthermore, although catering staff adhered to standardized portioning guidelines, some variability in serving sizes was unavoidable in practice.

Since food waste quantities were measured in aggregated form, such differences may have introduced a degree of measurement error in both plate waste and unserved food categories. A further limitation concerns the questionnaire surveys, which relied on voluntary self-reported data and were therefore subject to variable levels of respondent attention and accuracy. Finally, as the study was conducted in a single metropolitan setting in Budapest, the results may not be directly generalisable to other contexts with different catering systems, food cultures, or institutional arrangements.

6. Conclusion

The findings of this study challenge the assumption that awareness alone is enough to reduce food waste among students. Despite the campaign's efforts to communicate the environmental and economic impacts of food waste, no significant decrease in waste was observed. This suggests that while students may acknowledge the importance of sustainability, behavioural change requires more than information dissemination. Future initiatives should consider integrating interactive engagement, incentives, and structural changes in school catering services to make waste reduction more actionable. Additionally, campaigns that focus on positive reinforcement rather than guilt-based messaging may yield better results. Bridging the gap between awareness and action remains a critical challenge in fostering pro-environmental behaviour in school environments.

CRediT authorship contribution statement

András József Tóth: Supervision, Methodology, Investigation. **Atila Kunszabó:** Project administration, Methodology. **Dávid Szakos:** Conceptualization. **Márton Battay:** Resources, Funding acquisition. **Miklós Süth:** Writing – review & editing, Resources. **Gyula Kasza:** Conceptualization. **András Bittsánszky:** Writing – original draft, Validation, Formal analysis.

Declaration of competing interest

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

Acknowledgements

The project was supported by the Ministry of Culture and Innovation of Hungary from the National Research, Development and Innovation Fund (Project No: PD 142198; ADVANCED 151318), by the Recovery and Resilience Facility (RRF), financed under the National Recovery Fund (Project No. RRF-2.3.1–21–2022–00001) and by the European Health and Digital Executive Agency (Project No: 101112149). Project no. 2024-1.2.3-HU-RIZONT-2024-00098 has been implemented with the support provided by the Ministry of Culture and Innovation of Hungary from the National Research, Development and Innovation Fund, financed under the 2024-1.2.3-HU-RIZONT funding scheme. Dávid Szakos's work on this paper was supported by the János Bolyai Research Scholarship of the Hungarian Academy of Sciences.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.wasman.2026.115426>.

Data availability

Data will be made available on request.

References

- Antón-Peset, A., Fernández-Zamudio, M.-A., Pina, T., 2021. Promoting Food Waste Reduction at Primary Schools. A Case Study. *Sustainability* 13 (2), 600. <https://doi.org/10.3390/su13020600>.
- Abreu, M., Carvalho, J., Gonçalves, C., 2025. Evaluation of nutritional and economic impact of food waste in a school canteen. *Meas.: Food* 19. <https://doi.org/10.1016/j.meafoo.2025.100234>.
- Bretter, C., Unsworth, K.L., Russell, S.V., Quested, T.E., Kaptan, G., Doriza, A., 2023. Food waste interventions: Experimental evidence of the effectiveness of environmental messages. *J. Clean. Prod.* 414. <https://doi.org/10.1016/j.jclepro.2023.137596>.
- Calculi, C., D'Uggento, A.M., Labarile, A., Ribecco, N., 2021. Evaluating people's awareness about climate changes and environmental issues: a case study. *J. Clean. Prod.* 324, 129244. <https://doi.org/10.1016/j.jclepro.2021.129244>.
- Cohen, J.F.W., Richardson, S., Parker, E., Catalano, P.J., Rimm, E.B., 2014. Impact of the new U.S. Department of Agriculture school meal standards on food selection, consumption, and waste. *Am. J. Prev. Med.* 46 (4), 388–394. <https://doi.org/10.1016/j.amepre.2013.11.013>.
- de Souza, E. R., BinMowyna, M. N., Altheaid, H. A., Raposo, A., da Fonseca, P. G., Lima, M. J., Albaridi, N. A., Alslamah, T., Alqarawi, N., & Guimarães, N. S. (2025). Nutritional Intervention Programs for Sustainability: A Scoping Review on Full Food Utilization and the Clean Leftovers Reuse. In *Nutrients* (Vol. 17, Issue 11). Multidisciplinary Digital Publishing Institute (MDPI). <https://doi.org/10.3390/nu17111829>.
- Deksne, J., Lonska, J., Kodors, S., Litavniece, L., Zvaigzne, A., Silicka, I., Kotane, I., 2025. Insights into Awareness and Perceptions of Food Waste and School Catering Practices: A Student-Centered Study in Rēzekne City, Latvia. *Resources* 14 (4). <https://doi.org/10.3390/resources14040059>.
- Derqui, B., Fernandez, V., Fayos, T., 2018. Towards more sustainable food systems. addressing food waste at school canteens. *Appetite* 129, 1–11. <https://doi.org/10.1016/j.appet.2018.06.022>.
- Falasconi, L., Boschini, M., Giordano, C., Cicatiello, C., Alboni, F., Nassivera, F., Troiano, S., Marangon, F., Segrè, A., Franco, S., 2025. Who Cleans the Plate? Quantity and Type of Food Waste in 78 Primary Schools' Canteens in Italy. *Sustainability* 17 (17), 7836. <https://doi.org/10.3390/su17177836>.
- Feng, L., Luo, R., Liu, X., Prescott, M.P., Li, W., Song, J., Yang, Y., 2024. Global school plate waste estimates highlight the need for building a sustainable food education system. *Nat. Food* 5 (10), 860–868. <https://doi.org/10.1038/s43016-024-01046-2>.
- Gifford, R., Nilsson, A., 2014. Personal and social factors that influence pro-environmental concern and behaviour: a review. *Int. J. Psychol.* 49 (3), 141–157. <https://doi.org/10.1002/ijop.12034>.
- JASP Team. (2025). *JASP* (Version 0.95.1).
- Kasavan, S., Ali, N.I.B.M., Ali, S.S.B.S., Masarudin, N.A.B., Yusoff, S.B., 2021. Quantification of food waste in school canteens: a mass flow analysis. *Resour. Conserv. Recycl.* 164, 105176. <https://doi.org/10.1016/j.resconrec.2020.105176>.
- Kollmuss, A., Agyeman, J., 2002. Mind the Gap: why do people act environmentally and what are the barriers to pro-environmental behavior? *Environ. Educ. Res.* 8 (3), 239–260. <https://doi.org/10.1080/1350462020145401>.
- Kwon, S., Kim, O., Lee, Y., 2018. Effects of students' satisfaction with school meal programs on school happiness in South Korea. *Nutr. Res. Pract.* 12 (4), 342. <https://doi.org/10.4162/nrp.2018.12.4.342>.
- Li, Y., Liang, Y., Yu, D., Xu, L., Song, Q., 2025. Reducing food waste behaviors from the viewpoint of university students through the E-TPB model. *Circular Economy* 4 (3), 100154. <https://doi.org/10.1016/j.cec.2025.100154>.
- Lonska, J., Kodors, S., Deksne, J., Litavniece, L., Zvaigzne, A., Silicka, I., Kotane, I., 2025. Reducing Plate Waste in Latvian Schools: evaluating Interventions to Promote Sustainable Food Consumption Practices. *Foods* 14 (1), 126. <https://doi.org/10.3390/foods14010126>.
- Machado, S.S., Ritchie, L.D., Thompson, H.R., Madsen, K.A., 2020. The Impact of a Multi-Pronged intervention on students' Perceptions of School Lunch Quality and Convenience and Self-Reported Fruit and Vegetable Consumption. *Int. J. Environ. Res. Public Health* 17 (16), 5987. <https://doi.org/10.3390/ijerph17165987>.
- Malefors, C., Sundin, N., Tromp, M., Eriksson, M., 2022. Testing interventions to reduce food waste in school catering. *Resour. Conserv. Recycl.* 177. <https://doi.org/10.1016/j.resconrec.2021.105997>.
- Marwood, S., Byrne, N., McCarthy, O., Heaven, C., Barlow, P., 2023. Examining the Relationship between Consumers' Food-Related Actions, Wider Pro-Environmental Behaviours, and Food Waste Frequency: a Case Study of the more Conscious Consumer. *Sustainability* 15 (3), 2650. <https://doi.org/10.3390/su15032650>.
- Monroe, M.C., 2003. Two avenues for encouraging conservation behaviors. *Hum. Ecol. Rev.* 10 (2), 113–125.
- National Food Chain Safety Office. (2024). *Project Wasteless*. <https://maradeknelkul.hu/en/about-wasteless/>.
- Pinto, R.S., dos Santos Pinto, R.M., Melo, F.F.S., Campos, S.S., Cordovil, C.-M.-S., 2018. A simple awareness campaign to promote food waste reduction in a University canteen. *Waste Management* 76, 28–38. <https://doi.org/10.1016/j.wasman.2018.02.044>.
- Qian, L., Zhao, X., Liu, G., 2024. The association between the awareness campaign and food waste among university students in China. *Resources, Conservation and Recycling* 202, 107361. <https://doi.org/10.1016/j.resconrec.2023.107361>.
- Ravandi, B., Jovanovic, N., 2019. Impact of plate size on food waste: Agent-based simulation of food consumption. *Resources, Conservation and Recycling* 149, 550–565. <https://doi.org/10.1016/j.resconrec.2019.05.033>.
- Reynolds, C., Goucher, L., Quested, T., Bromley, S., Gillick, S., Wells, V.K., Evans, D., Koh, L., Kanyama, A.C., Katzeff, C., Svenfelt, Å., Jackson, P., 2019. Review:

- Consumption-stage food waste reduction interventions – what works and how to design better interventions. *Food Policy* 83, 7–27. <https://doi.org/10.1016/j.foodpol.2019.01.009>.
- Romero-Luis, J., Carbonell-Alcocer, A., Levratto, V., Gertrudix, M., del Carmen Gertrudis Casado, M., & Hernandez-Remedios, A., 2023. Design and assessment of an experimental model for evaluating the effectiveness of audiovisual products on the circular economy aimed at promoting environmental awareness. *Journal of Cleaner Production* 423, 138820. <https://doi.org/10.1016/j.jclepro.2023.138820>.
- Schwartz, M.B., Henderson, K.E., Read, M., Danna, N., Ickovics, J.R., 2015. New School Meal Regulations increase Fruit Consumption and do not increase Total Plate Waste. *Childhood Obesity* 11 (3), 242–247. <https://doi.org/10.1089/chi.2015.0019>.
- Sundin, N., Halvarsson, R., Scherhauer, S., Schneider, F., Eriksson, M., 2024. From plate to waste: Composition of school meal waste and associated carbon footprint and nutrient loss. *Resources, Conservation and Recycling* 206. <https://doi.org/10.1016/j.resconrec.2024.107656>.
- Szagos, D., Szabó-Bódi, B., Kasza, G., 2021. Consumer awareness campaign to reduce household food waste based on structural equation behavior modeling in Hungary. *Environmental Science and Pollution Research* 28 (19), 24580–24589. <https://doi.org/10.1007/s11356-020-09047-x>.
- Tóth, A.J., Dunay, A., Illés, C.B., Battay, M., Bittsánszky, A., Süth, M., 2023. Food liking and consumption in schools: Comparison of questionnaire-based surveys with real consumption. *Food Quality and Preference* 103, 104692. <https://doi.org/10.1016/j.foodqual.2022.104692>.
- Vici, G., Giustozzi, D., Camilletti, D., Zufolino, S., Malandrino, L., Renzi, S., Pucciarelli, S., Vincenzetti, S., Belli, L., Polzonetti, V., 2025. An evaluation and optimization of nutrition, environmental footprint, and food waste in italian primary school menus: a case study. *Journal of Translational Medicine* 23 (1). <https://doi.org/10.1186/s12967-025-06626-9>.
- Visschers, V.H.M., Gundlach, D., Beretta, C., 2020. Smaller servings vs. information provision: results of two interventions to reduce plate waste in two university canteens. *Waste Management* 103, 323–333. <https://doi.org/10.1016/j.wasman.2019.12.046>.