Acceptance of Low-Carbon School Meals with and without Information—A Controlled Intervention Study

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ORIGINAL PAPER

Acceptance of Low-Carbon School Meals with and without Information—A Controlled Intervention Study

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Abstract
This controlled intervention study focused on optimizing a school lunch menu to achieve a 20% reduction in greenhouse gas emissions. The objective was to evaluate the impact of introducing a low-carbon menu on pupils' acceptance of school meals, as well as to assess whether providing information about the menu change independently influenced pupils' acceptance. The study was conducted across six compulsory schools in a Swedish municipality, divided into three groups: schools implementing a menu change only (Menu), schools implementing a menu change with clear information provided to pupils (Menu + Info), and control schools serving the standard menu (Control). During a seven-week baseline period, all schools served the standard menu. Subsequently, for seven weeks, Menu and Menu + Info schools transitioned to a low-carbon menu achieved through the utilization of low-carbon recipes—reducing the proportion of food items with significant climate footprints while maintaining the recommended nutritional standards. In Menu + Info schools, pupils were presented with an informative video about the menu change during class. The acceptance of the low-carbon menu was evaluated through daily measurements of food consumption, plate waste, and meal satisfaction surveys. The study's findings revealed that neither the menu change nor the information significantly affected the pupils' acceptance of the new menu. These results align with prior studies, reinforcing the viability of employing low-carbon recipes to reduce the climate footprint of school meals. Moreover, this study demonstrates that providing supplemental information for transparency or educational purposes can be implemented without adversely affecting menu acceptance.

Food production and consumption generate about a quarter to a third of the global anthropogenic greenhouse gas (GHG) emissions (Crippa et al., 2021; Poore & Nemecek, 2018). The Intergovernmental Panel on Climate Change (IPCC) has identified dietary change

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as a demand-side opportunity with a large potential to mitigate emissions (Mbow et al., 2019) and thus help to achieve the targets of the Paris Agreement (Clark et al., 2020). At the same time, suboptimal diets are one of the main causes of ill-health globally (Murray et al., 2020). Dietary shifts will also be critical in achieving the Global Sustainable Development Goals of Zero Hunger, Good Health and Well-Being, and Responsible Consumption and Production (Vågsholm et al., 2020). It is well-established that food from livestock, and especially from ruminants (mainly beef, lamb, and dairy production), accounts for a major part of the GHG emissions from food (Hallström et al., 2021; Poore & Nemecek, 2018). However, dietary shifts for reduced GHG emissions do not necessarily mean the total exclusion of meat from the diet (e.g., Bryngelsson et al., 2016; Willett et al., 2019).

Research shows that market-based (e.g., taxes) and regulatory instruments (e.g., limiting availability) are effective policy instruments to promote sustainable food consumption but at the same time intrusive and not widely supported among consumers (Ammann et al., 2023). Information-based instruments and nudges are less effective in that the effects are generally smaller and often more short term, but they are also less intrusive and have greater support among consumers. Similarly, Diepeveen et al. (2013) found that support was higher for less intrusive interventions to promote healthy diets, and Pechey et al. (2022) found that support was lower for the regulatory policy of banning meat advertisements than for less intrusive policies such as labels and media campaigns. However, another regulatory option, limiting the availability of meat in hospital meals, received moderate support.

Given the effectiveness of regulatory instruments in promoting sustainable diets, it becomes of interest to explore platforms where such instruments could be both effective and more readily accepted. School meal programmes, given their widespread reach, emerge as one such potential platform. These programmes affect children across all socio-economic classes for over a decade of their lives and at an age when they are shaping their food habits (Oostindjer et al., 2017). As such, school menus could play a significant role in shifting social norms towards more sustainable dietary habits (Sparkman et al., 2020; Stok et al., 2016).

The fundamental determinant of food-related GHG emissions is the type of food produced and consumed. While food waste also contributes to these emissions, its impact is comparatively smaller. Moreover, the shares of transportation, processing, and packaging in the overall climate footprint are relatively small (Crippa et al., 2021; Poore & Nemecek, 2018). Therefore, to effectively reduce the climate footprint of school meals, the focus should be on decreasing the use of climate-intensive ingredients, especially ruminant meat, other types of meat, and dairy products. Other common strategies for sustainable school meals include increasing the proportion of organic food, reducing food waste, and procuring local production (Batistela dos Santos et al., 2022). While these strategies have other potential benefits, they play a minor role in reducing the climate footprint of the school lunches.

Today, across the globe, over 400 million children in pre-primary, primary, and secondary schools receive school meals, with a coverage in primary schools of over 40 percent of all children worldwide (WFP, 2022). Different types of school meal programmes exist around the world, with some being universal and free for all school children (e.g., in Estonia, Finland, and Sweden), others being open for all at a cost, and some free for pupils from families with low income. Thus, the circumstances vary between countries, but school meal programmes are widespread globally and are often used as platforms for delivering complementary education, nutrition, and health activities.

In Sweden, all pupils in compulsory schools (grades 0–9) receive a free hot lunch every school day. These lunches are self-served, and usually include two dishes to choose from, along with a salad buffet, crispbread, butter, and milk. Many Swedish municipalities are implementing policies to increase sustainability, such as shifting

towards organic products and reducing food waste. To reduce the climate footprint and the amount of meat consumed, a common measure adopted is mandatory vegetarian days (Orkla Foods Sverige, 2021; Swedish Food Agency, 2022). However, the introduction of vegetarian days has sparked protests in several instances. Critics, including parents, pupils, teachers, and political parties, have voiced a range of concerns. Among these are arguments that pupils remain hungry with only vegetarian food, struggle to focus during lessons, miss out on essential nutrients, and should have the autonomy to choose their meals (e.g., Andersson, 2020; Flores, 2013; Kotka & Roskvist, 2022; Lindskog, 2014; Rogsten, 2019). Similar protests have also been observed in other countries around the world when mandatory vegetarian or meat-free days have been introduced in schools, for example in South Korea (Eun-ji, 2020), France (O'Brien, 2021), Denmark (Levitt, 2020), and in the UK (Busby, 2020). Notably, in the UK, Jamie Oliver's campaign to promote healthier school meals also faced similar opposition (Shepherd, 2009; Wainwright, 2006).

An alternative to mandatory vegetarian days, which might garner higher acceptance, is a concept we call "low-carbon recipes," aiming to reduce the use of food items with a large climate footprint (CO_2eq), without emphasizing vegetarian days. With this approach, the primary focus is on the reduction of the amount of items with a large climate footprint, while changing the menu and recipes as little as possible. The Swedish research project Optimat has developed an optimization method that supports meal planners in modifying existing menus so that GHG emissions are reduced according to a set target, while keeping within the limits of other parameters, including nutritional content and cost of meals (Eustachio Colombo et al., 2019). This method has previously been tested in two intervention studies conducted at seven Swedish compulsory schools in total. In these studies, the GHG emissions of school lunch menus were reduced by 28 and 40 percent, respectively (Elinder et al., 2020; Eustachio Colombo et al., 2020). The new menus were also shown to have a good level of acceptance among pupils, as indicated by food waste and consumption being unchanged.

However, these studies did not include control groups or any pedagogical components. If such a measure were to be widely implemented, responsible authorities would likely communicate the policy both for transparency and as a potential means to enhance its effectiveness.

While information on its own is generally a weak instrument to promote pro-environmental behaviour (Schultz, 1999; Staats et al., 1996), a meta-review by Grundy et al. (2022) on interventions that influence the consumption of animal products concluded that providing information about environmental consequences can reduce meat consumption, especially if the message aligns with prior attitudes (Vainio et al., 2018). Similarly, Ammann et al. (2023) in their review of policy instruments for sustainable food consumption concluded that information is less effective than more intrusive instruments such as taxes and regulation. However, it can play an important role as a complement to these more intrusive instruments. Conversely, there is also evidence indicating that providing explicit information that food is plant-based can backfire, leading to reduced consumption of plant-based meal alternatives (Bacon & Krpan, 2018; Hielkema & Lund, 2022; Krpan & Houtsma, 2020).

Thus, information could both increase and decrease pupil acceptance of low-carbon menus, and it could elicit positive or negative reactions among the pupils that were not found in prior studies of low-carbon recipes within the Optimat project. Indeed, many pupils in prior studies did not even notice the menu changes (Eustachio Colombo et al., 2021). Information could increase acceptance by justifying the change or decrease it by

emphasizing changes that contradict the pupils' food preferences and attitudes regarding food and climate change.

In this study, we included information to determine whether making pupils overtly aware of the menu change affects their acceptance. Given that information about the menu change could either increase or reduce acceptance, we adopted an exploratory approach. Building on experiences from previous interventions, we conducted a controlled study including an informational component to explore: (1) if the introduction of a new low-carbon school lunch menu has an effect on pupils' acceptance of school meals, and (2) if information about the menu change has an independent effect on pupils' acceptance of the school meals.

Methods

Study Design

The study employed a controlled study design, with two treatment groups and one control group (see Fig. 1). Six schools in Lund Municipality in southern Sweden participated in the study and were assigned to three groups, with two schools per group: schools implementing a menu change only (Menu group), schools introducing a menu change with salient information to pupils (Menu + Info group), and schools without any intervention (Control group). During a seven-week baseline period, all participating schools served the standard menu. Immediately after the baseline period, a seven-week intervention period followed where the pupils in the Menu and Menu + Info groups were served a new low-carbon menu. In addition to this, the schools in the Menu + Info group provided salient information to the pupils about the new menu (see section Information Materials—Video and Posters). The schools in the Control group were served the same menu during the intervention period as during the baseline period.

The Schools

This research was conducted in collaboration with Lund Municipality, in southern Sweden, as they were partners in a large research programme regarding sustainable development (Mistra Sustainable Consumption, 2022). Lund Municipality has worked for several years to reduce the climate impact of public meals. The Meal Services Administration chose six
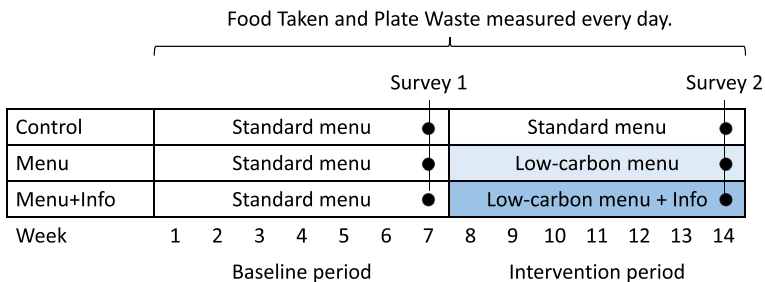

Fig. 1 Study Design. Note: Design of the study and treatment in each group. The participating schools were divided into three groups, with two schools in each group

out of the 40 compulsory schools to participate in the study. This selection was a convenience sample determined by the Administration based on the study criteria. The criteria included having the equipment and experience needed to measure food variables, not delivering food to other schools or institutions, capturing all age groups, and including both urban and rural schools.

The six schools were non-randomly assigned into three groups, with each group having one larger and one smaller school, and one school in an urban area and one in a rural area. School sizes ranged from 164 to 857 pupils, spanning grades 0–9 (ages 6–16). The gender distribution was approximately even across all schools. While the same menu was served to all pupils at a given school, only those in grades 4–9 participated in the surveys. Across the groups, pupils exhibited similar dietary habits regarding meat and vegetarian consumption, as well as comparable levels of concern about the climate impact of their food choices. More detailed descriptive statistics regarding the schools, and the dietary habits and climate concerns of the pupils who responded to the survey, are provided in Supplementary Tables 1 and 2 (Online Resource 1).

Optimization of the School Menu

Standard Menu

Lund Municipality serves the same menu in all schools. The menu is planned for a period of seven weeks in advance and comprises 70 dishes (2 dishes/day for 35 school days). Each day one dish is always vegetarian, and the other dish varies between meat, chicken, fish, and vegetarian. The menu is designed to fulfil the Swedish nutritional guidelines for school meals (Swedish Food Agency, 2021) based on the Nordic Nutrition Recommendations (Nordic Council of Ministers, 2014).

The municipality's Meal Services Administration provided the research team with their standard seven-week menu, including the recipes, planned for the first seven weeks of the autumn term 2021, henceforth called the "standard menu." The recipes indicated the amount (kg) and price of all food items used for each dish, including the salad buffet. Nutritional values for each food item were obtained from the Swedish Food Agency's food database (Swedish Food Agency, 2020). The total weight of each food item from all dishes in the baseline menu was determined. This resulted in a baseline food list of 126 food items with their respective total weight, cost, and nutritional content. Data for the climate impact of each food item was added to the list, expressed as carbon dioxide equivalents (CO_2eq) per kg food. This data was obtained from the RISE food climate database maintained by the Research Institutes of Sweden (RISE, 2022). The climate database contains carbon footprints, calculated using life cycle assessment methodology, for approximately 750 foods linked to the items in the Swedish Food Agency's food database. The calculations of nutrient content were based on the edible shares of prepared (cooked, simmered, fried, baked, etc.) foods, while calculations of cost and CO2eq were based on the amount of raw food, as purchased. The edible proportions and yields of raw foods were calculated as described by Parlesak et al. (2016). Based on this data, the climate footprint, nutritional content, and cost were calculated for a reference meal for a 10–12-year-old pupil, fulfilling the Swedish guidelines for school meals (Swedish Food Agency, 2021). This age group represents the middle of the three age categories specified in the guidelines for school meals, and it is commonly used as a benchmark in school meal planning in Sweden.

Low-Carbon Recipes

The baseline food list was optimized using a method that was developed and tested within the Optimat project, yielding an optimized, low-carbon food list (Elinder et al., 2020; Eustachio Colombo et al., 2019, 2020). This method is based on the use of linear programming (LP), using an algorithm for optimization based on the chosen variables. For the optimization of the food list, minimization of the total relative deviation from the baseline food list was used as the objective function, i.e., the amounts of each food item in the low-carbon food list should be as similar as possible to the baseline. The reason for this was to minimize the differences between the baseline and low-carbon menus, to prevent reduced pupil acceptance of the school meals.

The primary constraint was a 20 percent reduction in the climate footprint (CO_2eq), representing two-thirds of the reduction required to achieve Lund Municipality's target of 500 g CO_2eq per meal by 2030. This is equivalent to about 1.25 kg CO_2eq per kg food, aligning with the targets of the most ambitious municipalities in Sweden (Krewer, 2020; Swedish Food Agency, 2022). It is also in line with the WWF One Planet Plate target for a climate friendly main meal (WWF, 2019), which is based on resources from the IPCC (Rogelj et al., 2018). This constraint was collaboratively set with Lund Municipality's Meal Services Administration. The aim was to harmonize climate ambitions with the potential for pupil acceptance, mitigating the risk of negative reactions. Drawing from both the Meal Services Administration's experience and insights from prior studies, gradual changes emerged as a pragmatic strategy to achieve the long-term climate objectives for school meals. Considering that this incremental approach would likely be adopted and implemented widely as policy, it is both relevant and timely to examine.

The other constraints were that the nutritional guidelines would be fulfilled for each nutritient, that the cost was not allowed to increase, that the proportion of organic food was the same as the baseline (85 percent), and that the amount (weight) of each food item would not increase by more than 100 percent or decrease by more than 75 percent. Also, no new food items were to be added. An initial low-carbon food list was created based on these criteria. This list was discussed with the municipality's meal planner who provided inputs to how the food list could be made more feasible. For example, it was more realistic for the menu planning to completely remove some food items, rather than maintaining a small amount of them. A final linear optimization of the baseline food list was performed, implementing these modifications of the model. The food items that were reduced were red meat, cream, and rice. The food items that were increased were bread, potato, pasta, and rapeseed oil. The low-carbon food list and its changes relative to the baseline menu can be found in the Supplementary Information (Online Resource 2).

The Meal Services Administration then developed a low-carbon menu based on the optimized food list, according to their normal routine for developing menus. On average, two out of ten dishes per week were different compared with the baseline menu. Some dishes were completely new whereas some dishes were modified, i.e., where the proportion of products with a large climate footprint was lowered compared to the original recipe.

The climate footprint of the low-carbon menu was 572 g CO_2eq per meal, which aligns with the pre-set target of a 20 percent reduction from the baseline menu's 715 g CO2eq per meal. The low-carbon menu fulfilled all nutritional recommendations, and the cost was the same as for the baseline menu (SEK 13.29 per meal for the low-carbon menu, SEK 13.36 for the baseline menu).

Information Materials—Video and Posters

The purpose of the information that the Menu + Info group received was to provide clear and salient information to the pupils that the school was changing the menu to reduce the climate footprint. The main information component to achieve this was an animated video, designed to suit children in grades 4–9. The video was developed by the researchers in collaboration with a media production company specializing in making information films for children.

The video was shown in class to the pupils in grades 4–9 at the beginning of the intervention period. The three-min video described how food production affects the climate and that the school was going to reduce the use of ingredients with a high climate impact (e.g., beef and other meat) and increase the use of ingredients with a low climate impact. The video was supplemented by posters in the school restaurant with the same message, using graphics from the video. The video is available in the Supplementary Information (Online Resource 3).

Variables and Data Collection

Four variables were used to assess the pupils' acceptance of the new lunch menu. Two variables were daily weight measurements: how much food they took from the buffet (Food Taken) and how much food they threw away (Plate Waste). The other two variables were from the surveys, one during the baseline and one during the intervention periods: their rating regarding the taste of the food (Taste) and their overall rating of the school meals (Overall Rating).

The Food Taken and Plate Waste variables were based on weight measurements made by the kitchen staff at gross level for each school using kitchen scales and a form to record the daily amounts of all food prepared (Food Prepared), all food saved to be used another day (Food Saved), all food that was served but not taken by the pupils and that had to be thrown away (Serving Waste), and finally, all food that was thrown away by the pupils into the collective waste bin (Plate Waste). These measurements were used to calculate the amounts of food taken (Food Taken = Food Prepared − Food Saved − Serving Waste). One school in the Control group did not report any measurements for Food Saved. To be able to use the observations from this school in the analysis of Food Taken, the mean values of Food Saved of all the other schools during the baseline and intervention period, respectively, were imputed. The number of plates used each day was used to estimate the number of pupils and thus the average weight of food taken per pupil. See Supplementary Table 3 (Online Resource 1) for an overview of the measurement data from the schools in the treatment groups during the intervention period.

Data for the Taste and Overall Rating variables were collected through an anonymous online survey distributed in class to pupils in grades 4–9, at the end of the baseline period and again at the end of the intervention period, using Qualtrics software. For the questions regarding Taste and Overall Rating, the pupils were asked to indicate their response by changing the expression of a smiley face by moving a slider. There were five response choices which were coded 1 to 5 for the analysis: "very sad" (1), "sad" (2), "neutral" (3), "happy" (4), and "very happy" (5). The survey was a modified version of one that is regularly used by Swedish schools to monitor meal satisfaction (SkolmatSverige, 2022). The version used in this study also incorporated questions that allowed pupils to create a

self-generated identification code. This facilitated a paired analysis of responses between the baseline and intervention periods.

The variables Food Taken and Plate Waste were used to assess the pupils' acceptance of the low-carbon menu. Food Taken was assumed to reflect the pupils' acceptance of the food based on reading the menu and viewing the buffet, i.e., "does this look tasty to me," whereas Plate Waste was assumed to indicate how much they liked the food when eating it.

Statistical Analysis

The software Stata (version 16.1) was used for all statistical analyses, with p-values < 0.05 assumed to indicate statistical significance for all tests.

Two-way ANOVA tests, including both main (Group and Time (baseline/intervention)) and interaction (Group*Time) effects, were performed to examine the effects of the two treatments (menu change with and without information) on Food Taken and Plate Waste. As described in the section Variables and Data Collection, imputed data was used to calculate Food Taken for one of the schools in the Control group. Analyses for Food Taken were performed both with and without imputed data, i.e., with and without including this school.

In the analysis of the survey data, the question was whether the pupils changed their responses for the variables Taste and Overall Rating between the baseline and the intervention periods, and if they did, whether this change differed between the groups. To analyse this, two new variables—Change Taste and Change Overall Rating—were generated by subtracting the value for Taste/Overall Rating at baseline from the value during the intervention period for each respondent. Thus, a negative value indicated a lower rating during the intervention, while a positive value indicated a higher rating. Given that both Taste and Overall Rating ranged from 1 to 5, the change variables could range from -4 to $+4$. We then analysed the distribution differences of these change variables across groups using cross tabulation and Fisher's exact test.

Results

Descriptive Statistics for Weight Measurements

Descriptive statistics for food taken (Food Taken) and food waste (Plate Waste) are presented in Table 1 and illustrated in Fig. 2. Food Taken was lower in the Menu + Info group and higher in the Control group in the intervention period compared to baseline. The Menu + Info group showed a larger variability in Food Taken than the other groups. Plate Waste was slightly higher in both treatment groups during the intervention period.

Acceptance of the Menu Change with and without Information

The results of the two-way ANOVA test comparing Menu with Control revealed that there was no statistically significant interaction between group (Control vs. Menu vs. Menu + Info) and time (baseline and intervention) for either Food Taken ($p = 0.074$) or Plate Waste ($p = 0.164$) (Table 2). Analysis without imputations did not reveal any significant results. This indicates that the menu change and the information did not have any significant effects on Food Taken or Plate Waste. However, there was a significant main effect of group on both Food Taken and Plate Waste, meaning that there was an overall significant difference

Table 1 Descriptive statistics for Food Taken and Plate Waste (g/pupil/day)

Group	Baseline period				Intervention period				Change
	Mean	SD	95% CI	n^a	Mean	SD	95% CI	n^a	Mean
Food Taken									
Control	324.8	66.1	308–342	58	349.6	65.7	334–366	66	+ 24.9
Menu	298.4	73.2	281–316	66	300.6	67.7	284–318	61	+ 2.3
Menu + Info	337.9	87.8	315–360	59	319.5	80.1	300–340	62	− 18.4
Plate Waste									
Control	25.0	7.3	23–27	52	24.1	6.2	22–26	54	− 0.9
Menu	21.9	6.6	20–24	52	24.1	8.7	22–27	50	+ 2.2
Menu + Info	17.7	7.2	16–20	55	22.3	21.8	16–28	50	+ 4.6

The unit is grams of food per pupil and day

[a]The number of observation days varies due to missing data. The primary reasons for missing data were errors in measurements or that no measurements were made on certain days for practical reasons. Also, all days with soup were excluded from Plate Waste since soup waste is poured down the drain, rather than being collected and weighed. Furthermore, one new dish in the low-carbon menu was baked potatoes, which yielded a high plate waste due to peelings (in Sweden it is common to eat baked potatoes by scooping them out with a small spoon, often leaving a portion of the flesh adhered to the peel); thus, these four observations were excluded from the plate waste analysis
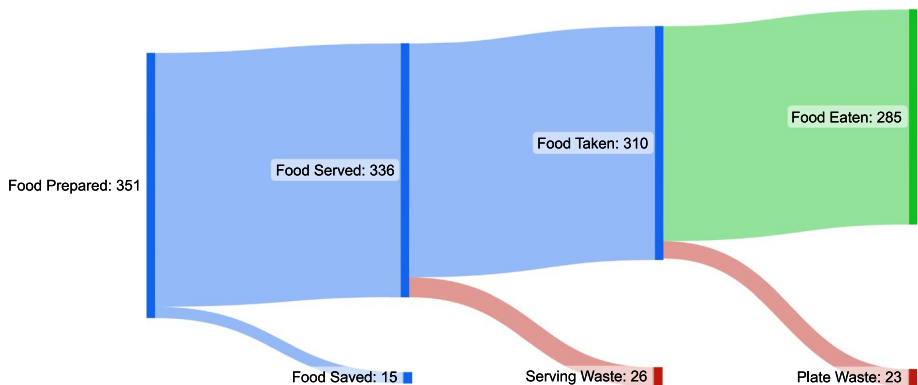

Fig. 2 Graph of food weight measurements. Notes: The data in the graph represents averages of food (g/pupil/day) for the four schools in Menu and Menu + Info during the intervention period. Food Prepared, Food Saved, Serving Waste, and Plate Waste were measured every day. Food Served, Food Taken, and Food Eaten were calculated based on these measurements. The sums of each node and flow in the graph are not completely balanced due to differing numbers of observations for each variable, due to missing data. Descriptive statistics for all treatment groups can be found in Supplementary Table 3 (Online Resource 1)

between the groups with regard to the amount of Food Taken and Plate Waste both at baseline and during the intervention period.

When analyzing the survey results, the variables Change Taste and Change Overall Rating were calculated for all observations where repeated responses from the same individual during both baseline and intervention period were available (Table 3 and 4). Fisher's exact tests did not reveal any significant differences between the groups in the distribution of the two change variables: Change Taste ($p = 0.880$) and Change Overall Rating ($p = 0.897$).

Table 2 ANOVA Summary table: Control versus Menu versus Menu + Info

Source	Df	MS	F	p
Food Taken				
Time[a]	1	783.13	0.14	.705
Group[b]	2	49,071.63	9.02	<.001
Time X Group interaction[c]	2	14,303.78	2.63	.074
Within groups	366	5439.23		
Total	371	5718.69		
Plate Waste				
Time	1	261.78	1.92	.167
Group	2	1730.63	12.69	<.001
Time X Group interaction	2	247.55	1.82	.164
Within groups	385	136.38		
Total	390	145.65		

Df degrees of freedom, *MS* mean squares

[a]Baseline period versus Intervention period

[b]Control versus Menu versus Menu + Info

[c]The interaction effect between time and group

Table 3 Cross-tabulation of Change Taste: Control versus Menu versus Menu + Info

Group	Change Taste[a]									Total
	− 4	− 3	− 2	− 1	0	+ 1	+ 2	+ 3	+ 4	
Control	0	0	5	24	84	18	2	1	0	134
	0.0%	0.0%	3.7%	17.9%	62.7%	13.4%	1.5%	0.8%	0.0%	100.0%
Menu	0	1	7	50	150	43	4	1	0	256
	0.0%	0.4%	2.7%	19.5%	58.6%	16.8%	1.6%	0.4%	0.0%	100.0%
Menu + Info	0	1	4	41	133	49	5	1	0	234
	0.0%	0.4%	1.7%	17.5%	56.8%	20.9%	2.1%	0.4%	0.0%	100.0%
Total	0	2	16	115	367	110	11	3	0	624
	0.0%	0.3%	2.6%	18.4%	58.8%	17.6%	1.8%	0.5%	0.0%	100.0%

The table shows the frequency and percentage of respondents for each level of change in the Taste variable between the baseline period and the intervention period. Fisher's exact test, $p = .880$

[a]Change Taste = Taste (intervention) − Taste (baseline)

Analysis stratified by gender, age, dietary habits, and climate concern yielded no significant differences.

Discussion

Main Findings

The results of this study indicate that a 20 percent reduction in GHG emissions can be achieved by implementing low-carbon recipes, without significantly affecting the pupils'

Table 4 Cross-tabulation of Change Overall Rating: Control versus Menu versus Menu + Info

Group	Change Overall Rating[a]									Total
	−4	−3	−2	−1	0	+1	+2	+3	+4	
Control	0	3	3	19	96	17	2	0	0	140
	0.0%	2.1%	2.1%	13.6%	68.6%	12.1%	1.4%	0.0%	0.0%	100.0%
Menu	0	1	5	34	175	44	6	3	0	268
	0.0%	0.4%	1.9%	12.7%	65.3%	16.4%	2.2%	1.1%	0.0%	100.0%
Menu + Info	0	3	3	32	159	39	5	3	1	245
	0.0%	1.2%	1.2%	13.1%	64.9%	15.9%	2.0%	1.2%	0.4%	100.0%
Total	0	7	11	85	430	100	13	6	1	653
	0.0%	1.0%	1.7%	13.0%	65.9%	15.3%	2.0%	0.9%	0.2%	100.0%

The table shows the frequency and percentage of respondents for each level of change in the Overall Rating variable, between the baseline period and the intervention period. Fisher's exact test, $p = .897$

[a]Change Overall Rating = Overall Rating (intervention period) − Overall Rating (baseline period)

acceptance of the school meals. Our analysis did not reveal any significant effects of the menu change or the provided information on any of the variables for the amount of food pupils took to their plates, the plate waste, their taste ratings, or their overall assessment of the school lunches. While the Menu + Info group took less food during the intervention period and both treatment groups showed a slight increase in plate waste, these changes were not statistically significant. Conversely, there was an unanticipated increase in the amount of food taken in the Control group, for which we were unable to identify any cause. The survey data remained consistent, with no evident shifts in acceptance across any of the groups. The majority of pupils maintained their taste ratings and overall assessment of the lunches between the basline and interventions periods. Among those who modified their ratings, there was a balanced distribution between minor increases and minor decreases.

The findings from this controlled intervention suggest that our strategy for designing optimized low-carbon school lunch menus is feasible and acceptable in practice, thus corroborating previous findings for this approach (Elinder et al., 2020; Eustachio Colombo et al., 2020). This mirrors previous research in which the acceptance of the programme "Thursday Veggie Day" in Ghent, Belgium was assessed by comparing consumption between vegetarian menu days and regular days. The programme was introduced in 2009, with all public meals on Thursdays being vegetarian, and the study including two compulsory schools showed that the vegetarian lunches were as well accepted by the pupils as the conventional main courses (Keyzer et al., 2012). Our findings do, however, contrast with previous research from Helsinki, Finland, (Lombardini & Lankoski, 2013) where one mandatory vegetarian day a week was introduced in 2011. Four months into the intervention, acceptance of the school meals on vegetarian days was lower, with lower attendance, less food taken, and more plate waste than before the intervention. However, acceptance increased and nine months after the vegetarian days were introduced; the only sign of reduced acceptance was lower attendence. The differences in relation to our study could be explained by the fact that the intervention in Helsinki was preceded by much debate in the media. Similar reactions have also been observed in the Swedish media when municipalities have announced that school menus will be fully vegetarian on some days of the week for sustainability reasons. In Lund Municipality, the public meal services had already been working on reducing the climate footprint of public meals for a decade, which meant that

pupils in the local schools were already used to being served vegetarian meals long before our study. Their pre-existing acceptance of vegetarian meals is therefore likely to have been higher than among the Finnish pupils, which is something that could explain why providing information did not change acceptance of the low-carbon meals in this study. Furthermore, our intervention menu was presented as "low-carbon recipes," and not as "vegetarian days" as in the Finnish context. This indicates that the packaging of sustainable school meals as low-carbon might be more appealing and culturally acceptable to pupils.

Another factor that may have contributed to maintaining the acceptance of the meals in our study is the approach to limit the GHG reduction to 20 percent, based on the overarching strategy of gradual changes. However, while larger reductions of 40 and 28 percent did not reduce acceptance in previous studies using the low-carbon recipes strategy, many pupils in these studies did not notice the menu change (Elinder et al., 2020; Eustachio Colombo et al., 2020). Although the reduction was smaller in the current study, pupils in the Menu + Info-group were explicitly made aware of the menu change via an informational video, yet this did not lead to any significant effects on acceptance.

The video, which explained the menu change and its reasons and was shown to pupils in class before implementing the new menu, neither increased nor decreased their acceptance of the new meals. The use of information has not been examined in previous studies focusing on low-carbon recipes (Elinder et al., 2020; Eustachio Colombo et al., 2020), and the finding is encouraging, suggesting that information can be implemented alongside the introduction of low-carbon menus in Swedish schools without adverse effects on acceptance. When interpreting the results concerning the provision of information, it is important to take into account that information interventions may be designed in a range of ways. In this study, the information was designed to merely make the pupils aware of the fact that the menu would be changed to reduce the climate footprint and how this was going to be implemented. The information design did not employ any nudges or similar measures to increase acceptance.

To conclude, this study offers added evidence that low-carbon recipes, with or without additional information, is a feasible concept for reducing the climate footprint of school meals at compulsory schools (ages 6–16) without observable negative effects.

The emphasis to reduce the climate footprint of food consumption has often been on increasing the share of vegetarian meals. However, the alternative strategy explored in this study—low-carbon recipes—does not prescribe a specific diet but focuses on the overarching goal of reducing climate footprint. This is achieved by minimizing the use of food items with large climate footprints (e.g., beef, dairy, and rice) and increasing those with smaller footprints, while fulfilling nutritional guidelines. We find this approach promising, as it can lead to significant reductions in menu climate footprint while maintaining acceptance from consumers.

Policy Implications

This study, together with previous studies (Elinder et al., 2020; Eustachio Colombo et al., 2020), provides support for low-carbon recipes as a concept with good acceptance among pupils in Swedish schools. It does not provide support for using information to increase acceptance of the new menu, neither does it indicate that such information reduces acceptance. The inclusion of information interventions may still be desirable however, for transparency and for educational purposes. Making the menu change and the reasons behind it more salient may lead to a change in social norms and pupils adopting more sustainable

food habits outside of school (positive spill-over). This is, however, something that needs further research to investigate. There is also a risk that information in other contexts may stir up negative attitudes and protests against the menu change.

Strengths and Limitations

This study lends weight to the argument that the low-carbon recipes strategy works in practice. In previous studies employing this strategy, there were indications that some pupils did not notice the menu change (Eustachio Colombo et al., 2021). The main strength of this study is that it shows that despite pupils clearly being made aware of the menu change, their acceptance did not diminish.

The main limitation of this study is the context in which it was conducted, i.e., compulsory schools that already had a relatively low climate footprint from school meals and where pupils were accustomed to having vegetarian alternatives on the menu every day, as well as having days with only vegetarian options. Therefore, generalizations should be made with caution; the acceptability of low-carbon recipes is likely to be affected by local discourses and norms regarding food and climate, as well as meat-eating habits. However, even under other conditions, the applied methodology for changing menus could be useful, as it is flexible and can be modified to accommodate the priorities and needs of various stakeholders. Furthermore, it should be noted that with a larger sample size, the differences between groups might have been significant.

Future Research

Even though this and previous studies lend support to the acceptability of employing low-carbon recipes as a policy measure to reduce the climate footprint of Swedish school meals, further research in other contexts is needed, for example, in areas with different norms and local discourses regarding food, climate, and meat eating. Furthermore, if a longer intervention period were to be used, it would increase the potential to detect long-term effects. However, increased exposure is known to positively (rather than negatively) affect the acceptance of new foods (Appleton et al., 2018). In a longer term trial, it might instead be more interesting to assess the potential of information to affect pupils' awareness of the climate footprints of different foodstuffs and how this awareness affects their food habits outside of school. To further investigate the different effects of low-carbon recipes and vegetarian days, it would also be interesting to conduct a study where these concepts were compared. Lastly, from a societal perspective it would also be valuable to evaluate this method in diverse settings beyond schools, such as in restaurant lunch menus and in the ready meals available in supermarkets.

Data Availability The questionnaire and data supporting the findings of this study are available from the corresponding author upon request.

Declarations

Ethics Approval and Consent to Participate This study was granted exemption by the Swedish Ethical Review Authority with an advisory opinion (No. 2021–03896). The study was performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. Information about the study was provided through their internal weekly newsletter to pupils and parents before school-based data collection began. All pupils were included in the data collection unless they declined to respond. Therefore, consent and assent were implied by responding anonymously. The data collection was carried out by school staff as part of the regular school day.

Competing Interests The authors declare no competing interests.

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
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