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No need for meat as most customers do not leave canteens on Veggie Days

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Switching to a diet lower in red meat has the potential to reduce greenhouse gas emissions. Using a unique time series of daily sales data from three German university canteens from 2017 to 2019, we analyse the effects of a monthly Veggie Day in a food-away-from-home context. We find that the temporary ban on meat dishes did not lead to a widespread boycott – as the heated public debates might have suggested. In our setting, a Veggie Day could reduce greenhouse gas emissions by up to 66%. However, especially at the site with a higher share of meat eaters on regular days, up to 22% of customers bypassed the meat-free main dishes on Veggie Days and ate at other on-site alternatives where meat was available. However, total on-site sales did not decrease significantly. Students were less likely to switch to alternatives than staff and guests. A less stringent implementation of a Veggie Day where only beef dishes were removed from the menu, did not result in a significant shift to alternatives but could reduce emissions by up to 51%.

Switching to more healthy and sustainable diets has the potential to reduce greenhouse gas (GHG) emissions substantially[1]. In 2015, the global food system caused about a third of all anthropogenic GHG emissions: 18 $GtCO_2$ equivalents (eq)[2]. These emissions are expected to rise as demand for meat is growing and in comparison to other sectors, technological development will only play a limited role in reducing emissions[3,4]. Instead, demand-side changes through dietary adjustments by decreasing meat consumption and adopting more plant-based diets will play a central role in reducing emissions from the global food system[5–7]. While a vegan diet (i.e., plant-based diet that excludes any animal products) has the highest mitigation potential, up to 8 $GtCO_2$ eq yr^{-1} by 2050[8], already 'plausible low-meat diets' could reduce GHG emissions by 4.3–6.4 $GtCO_2$ eq yr^{-1}[9]. Additionally, a change in diet can provide important health benefits, such as a decrease in cardiovascular and cerebrovascular diseases, diabetes, or the risk of various forms of cancer[10,11] and reduce significant negative effects on the environment such as deforestation, loss of biodiversity and nitrogen pollution[8].

Nevertheless, there is a clear lack of awareness among the general public regarding the environmental and health benefits of a vegetarian (i.e., excluding meat and fish) or vegan diet (i.e., excluding meat, fish, dairy products and eggs)[12]. Additionally, social, economic, and cultural constraints still hinder many consumers from adopting a vegetarian or vegan diet or from even reducing meat consumption[13,14]. Considering all these constraints and lock-ins, the question arises how individuals can be induced to adopt a healthier and more sustainable diet to reduce the negative externalities of livestock farming and meat production.

Soft interventions to make individuals' diets more climate-friendly such as providing information or nudging people towards 'better' choices without force have so far shown limited success[15–19]. Meat taxation has gained political attention in recent years[20]. However, a recurring argument against a meat tax is its potential regressivity[21]. Another option is to temporarily ban meat, e.g., by offering only vegetarian and/or vegan dishes one day a week or having days with reduced meat offerings at cafeterias or canteens. Such approaches have been popularized as 'Veggie Day', 'Meatless Monday', or 'Sustainable Monday'. In Germany, this idea has become notorious when the Green Party suggested the introduction of a 'Veggie Day' at canteens during their 2013 election campaign. Media outlets and political opponents used it to discredit the party as restrictive. The 'Veggie Day' campaign was later in part blamed for their defeat[22]. As the scepticism and opposition toward such interventions lingers[21,23–25], the implementation of a vegetarian day raises fears that customers might boycott canteens on these days and get their lunch elsewhere thus not realizing the full potential of emission reductions. For example, an attempt to implement a 'Meatless Monday' at the dining halls at the University of Michigan was disbanded because students complained and attendance went down[26,27]. It remains, however, unclear whether such complaints come from just a few very vocal customers or are broadly supported and

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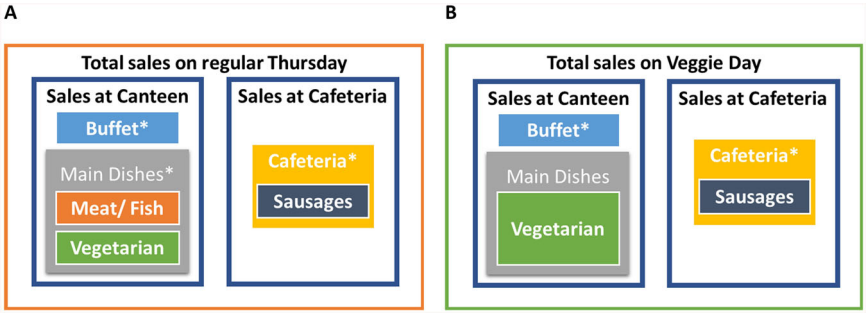

Fig. 1 | Lunch options at the sites. *Meat, fish, or seafood dishes were available. **A** On Regular Thursdays, all options could offer meat, fish or seafood dishes; **B** on Veggie Days, main dishes did not contain meat, fish or seafood, while the Buffet and Cafeteria still offered such options. For information on average sales per site, lunch option and customer group, see Supplementary Fig. 1 and Supplementary Table 1.

would lead to widespread and long-lasting drops in sales because people stay away.

There are only few studies that analyse the empirical effectiveness of such interventions. Measures of effectiveness include changes in food waste[28,29], environmental impacts such as GHG emissions or the water footprint[27,30], and the number of customers[29]. These studies find either no significant change in food waste[28] or an increase in food waste on vegetarian days compared to regular days[29]. Reductions in GHG emissions range from 31% on 'Sustainable Mondays' (i.e. a menu which is low in red meat on Mondays) at residential dining halls of the University of Michigan[27], to 74% and a reduction of 50% in the water footprint on 'Meatless Mondays' compared to regular Mondays for school lunches in a US district[30]. Only Lombardini and Lankoski[29] looked also at changes in the number of customers and found that in the short-term fewer students ate at the canteen but in the medium-term numbers did not change on vegetarian days.

To the best of our knowledge, up to now only our study analyses the question what the effects of a Veggie Day on sales of dishes are and to what extent customers evade it eating elsewhere, as we also observed the sales at nearby alternatives where meat dishes were available on Veggie Days. With our study, we increase the external validity compared to earlier studies in three aspects: (1) We did not only observe the behaviour of indifferent or motivated customers, but also those who clearly preferred meat dishes and opted out of the intervention[31,32]. (2) The choice situation was less restricted: Our study analyses the effects of a Veggie Day in a non-institutional food-away-from-home setting, where we could observe to what extent customers evaded the temporary ban of meat and switched to nearby alternatives, such as the cafeteria, where they could still have meat. Other studies were conducted in college dining halls[26,27] or schools[28–30], where customers buy meal plans at the start of the semester or are underage pupils who must stay on school grounds and are therefore limited in their choice of where to eat. (3) We extended the subject pool, comparing sales to students with the group of external guests and university staff. As we can differentiate between these two groups, we can analyse whether students react differently to Veggie Days compared to the other, typically older group. For these two groups, we analyse a unique cross-sectional timeseries data set with daily sales data from 2017 to 2019 of three university canteens at three university campuses in Germany run by the same operator. The observed intervention periods of earlier studies were shorter ranging from 4 days[28] to 10 months[29] or a school year[26], which neglects medium- and long-term effects of habituation. We observed the effects of an already established programme over a period of three years.

The university canteens at our three study sites were the main providers of warm lunches for students and staff. Due to very limited alternatives in the vicinity of all three sites, guests from nearby offices also ate there. Between 71 and 84% of customers at the three sites were students, the remaining customers (including university staff) were categorized as guests. Veggie Days happened on every first Thursday of the month and the canteens only offered vegan or vegetarian main dishes (i.e., meat, fish, or seafood were not available). Not all sites implemented the Veggie Days strictly on all occasions but offered fewer meat dishes and just removed ruminant meat from the menu instead. These days are categorized as Regular Thursdays in the main analysis, and we ran additional robustness checks to assess effects of such No-beef Thursdays on sales. Please note that in the following, the terms Veggie Day and Veggie Thursday are used interchangeably and 'vegetarian' refers to both vegan and vegetarian options. Besides the main dishes, the sites offered further lunch options. Figure 1 shows the six categories of lunch options at the sites on Regular Thursdays and Veggie Days. The buffet with salads, pasta, and pizza was next to main-dish counters in the canteens. The cafeterias, which offered smaller dishes, sandwiches and sausages, were in the same building as the canteens. These two alternatives offered some meat options on Veggie Days, including sausage with curry sauce and fries, an iconic German fast-food dish. Importantly, in addition to changes in the sales of main dishes, we can also track changes in the sales at the buffet and the cafeteria. Changes in total sales at the sites on Veggie Days show the share of customers who opted for off-site substitutes.

The daily menus were similar at all sites as all canteens were run by the same operator. The largest canteen, which offered five main dishes and served on average 1547 main dishes on Regular Thursdays, sold a lower share of vegetarian main dishes than the other two sites (47% to students, 38% to guests). Therefore, we refer to the site as Conventional. The other two sites were similar in terms of main dishes (836 and 958) and vegetarian meals served (students: 51 and 54%; guests: 46 and 45%). We, therefore, refer to these sites as Green I and Green II.

Results

Table 1 summarizes the effects of Veggie Days compared to Regular Thursdays on guests' and students' choice. Listed are the percentage changes on Veggie Days compared to Regular Thursdays in the sales of the six lunch options (compare Fig. 1: sales of vegetarian dishes, of main dishes, at the buffet, at the cafeteria, of sausages sold at the cafeteria and at the sites in total) for the two customer groups, guests and students (see Supplementary Tables 4–21 for full regression results). Total sales capture the effect of the decision of guests and students to eat on-site at all or not. To provide a better understanding of the magnitude of the effect, we included the average sales for Regular Thursdays in the table below the percentage change.

The comparison of the total sales figures at all sites reveals that the decline in sales at the canteen and cafeteria on Veggie Days was not as pronounced as might have been expected. At the sites Conventional and Green I, there was a slight decrease in the sales and at Green II, more students ate compared to Regular Thursdays. However, none of these changes were statistically significant. This means some customers switched to on-site alternatives that offered meat on Veggie Days and only few customers ate off-site.

Many customers that would have eaten a meat dish on a Regular Thursday chose a vegetarian main dish and did not switch to alternatives such as the buffet, the cafeteria, or ate elsewhere. Sales of vegetarian main dishes increased significantly at all sites for students and for guests (between 74 and 139%), while the total number of dishes sold did not decline significantly as explained above.

However, we find significant differences between the categories of lunch options. Looking at the number of main dishes sold, we observe

Table 1 | Percentage change in the sales of vegetarian main dishes, all main dishes, at the buffet, at the cafeteria, of sausages at the cafeteria, and of total sales at the sites on Veggie Thursdays compared to Regular Thursdays for guests and students (average sales on Regular Thursdays in parentheses)

Sales		Conventional	Green I	Green II
Vegetarian Main Dishes	*Guests*	+139% ***	+80% ***	+106% ***
		(166.2)	(60.7)	(85.3)
	Students	+100% ***	+74% ***	+92% ***
		(525.8)	(359.5)	(428.2)
All Main Dishes (incl. veg. main dishes)	*Guests*	−19% ***	−22% **	−13% **
		(444.8)	(134.4)	(189.5)
	Students	−11% *	−14%	−1%
		(1101.9)	(702.0)	(767.8)
Buffet	*Guests*	+16% **	+9%	+6%
		(112.8)	(22.4)	(55.2)
	Students	−0%	−13%	−10%
		(227.6)	(41.5)	(82.4)
Cafeteria	*Guests*	+65% ***	+56% ***	+51% ***
		(89.8)	(21.4)	(41.6)
	Students	+17% *	+26% **	+26% ***
		(479.9)	(287.0)	(427.8)
Sausages	*Guests*	+127% ***	+111% ***	+141% ***
		(16.1)	(5.0)	(4.0)
	Students	+48% ***	+57% ***	+84% ***
		(83.4)	(70.9)	(53.7)
Total	*Guests*	−1%	−8%	−0%
		(647.4)	(178.2)	(286.4)
	Students	−2%	−2%	+7%
		(1809.4)	(1030.6)	(1278.0)

Full results from OLS regressions for Veggie Thursdays by site, controlling for year, time trend, and lecture period see models (1) and (4) in Supplementary Tables A-4–A-21. In parentheses are average sales on Regular Thursdays. Please note that the percentage changes are marginal changes based on the regression results. The average sales are based on summary statistics to give an impression of the order of magnitude of changes rather than the expected average sales based on the regression.

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

significant drops for guests when only vegetarian options were available. At Green II 13% ($p < 0.01$), at Conventional 19% ($p < 0.001$), and at Green I 22% ($p < 0.01$) fewer main dishes were sold to guests. For students, we only find a significant drop of 11% at the Conventional site ($p < 0.05$), while the reductions at Green I and Green II were not significant. At the Conventional site, significantly more guests (16%, $p < 0.01$) ate at the buffet, where meat options were available on Veggie Days, compared to Regular Thursdays. This share also increased at the other two sites for guests, but not significantly. For students, we observe decreases in the sales at the buffet at Green I and Green II, but these were insignificant. There was no change for student sales at the buffet at the Conventional site. Thus, apart from guests at the Conventional site, the buffet does not appear to have been a substitute for customers who would otherwise have eaten a meat dish.

Some guests and students compensated the lack of meat in the main dishes by going to the cafeteria instead. For guests, the cafeteria sales significantly ($p < 0.001$) increased by 65% at the Conventional site, by 56% at Green I, and by 51% at Green II compared to Regular Thursdays. For students, sales increased by 17% at the Conventional site ($p < 0.05$), and by 26% at Green I and Green II ($p < 0.01$, $p < 0.001$). At all cafeterias, particularly the sales of sausages increased significantly: Between 48% for students at the Conventional site ($p < 0.001$) and 141% for guests at the site Green II ($p < 0.001$). It should, however, be noted that the very high increase for guests at Green II is relative to the very low baseline of on average of four sausage dishes sold on Regular Thursdays (Table 1). For students, these figures were about an order of magnitude higher. At the sites Green I and Green II, students ate on an average Regular Thursday 71 and 54 sausages, respectively.

Veggie Days were well-known and publicized at the sites via posters. Therefore, we tested whether customers changed their behaviour on Wednesday in anticipation of a Veggie Thursday or compensated for the lack of meat on Veggie Day on the following Friday. We compare the sales on Wednesdays before and Fridays after Veggie Days to the respective days around Regular Thursdays (Supplementary Tables 22–27). The sales of vegetarian main dishes were not significantly different on Wednesdays before or Fridays after Veggie Days at any of the sites or for any of the customer groups. This means that there were no anticipatory or compensatory reactions to Veggie Days. There was, however, one exception: On Wednesdays before a Veggie Day sausage sales to students at the Conventional site were 23% lower ($p < 0.05$). This implies that customers anticipated that they would rather eat the sausage on Veggie Thursday and not have it on two days in a row.

The results reported so far apply for Veggie Days where all main dishes contained neither meat nor fish or seafood. Especially at the Conventional site, the operator "cheated" and offered one dish with fish or white meat on some of the Thursdays labelled as Veggie Days. So far, we treated such No-beef Thursdays as Regular Thursdays in the analysis. We ran additional analyses distinguishing between Regular Thursdays, No-beef Thursdays, and Veggie Days, to test the effect of offering no beef on the sales of the lunch options (see results Supplementary Tables 4–21). We do not find significant changes in total sales (Supplementary Tables 19–21) or in the sales of main dishes (Supplementary Tables 7–9) on No-beef Thursdays compared to Regular Thursdays. Across sites and customer groups, sales of vegetarian main dishes were significantly higher on No-beef Thursdays compared to Regular Thursdays. However, the increases were smaller compared to actual Veggie Days (Supplementary Tables 4–6). Furthermore, customers did not evade No-beef Thursdays by going to the buffet instead (Supplementary Tables 10–12). We observe fewer significant shifts to the cafeteria or the sausages compared to Veggie Days; for example the sales of sausages to guests increased by 39% at the Conventional site ($p < 0.01$). This means that No-beef Thursdays had similar but smaller effects compared to Veggie Days.

Turning to the environmental benefits, the potential to reduce GHG emissions by introducing a Veggie Day ranged between 41% for students at the Conventional site to 66% for guests at the site Green II compared to Regular Thursdays. Figure 2 exemplifies potential reductions for a menu of main dishes typical on Thursdays at our three sites. The reduction potentials vary because customers at the sites showed different propensities to choose vegan dishes instead of vegetarian dishes on Veggie Days, as the latter can be more emission-intensive if they contain dairy products. The strongest lever for reducing emissions was to not serve beef dishes. Replacing a beef dish on a Regular Thursday with a white meat dish such as pork or poultry could already result in a reduction in emissions by between 29% (students at Conventional site) and 51% (guests at Green II, students at Green I).

Discussion

In our study of sales data at three university canteens between 2017 and 2019, we find that a Veggie Thursday significantly increased the consumption of vegetarian and vegan dishes compared to a Regular Thursday. At the same time, some customers bypassed the temporary ban of meat and ate at on-site alternatives, i.e., the buffet or the cafeteria where meat dishes were available also on Veggie Days. We find no significant decline in total sales, which means that customers did not look for offsite alternatives. In conclusion, the extent of evasive behaviour was considerably lower than

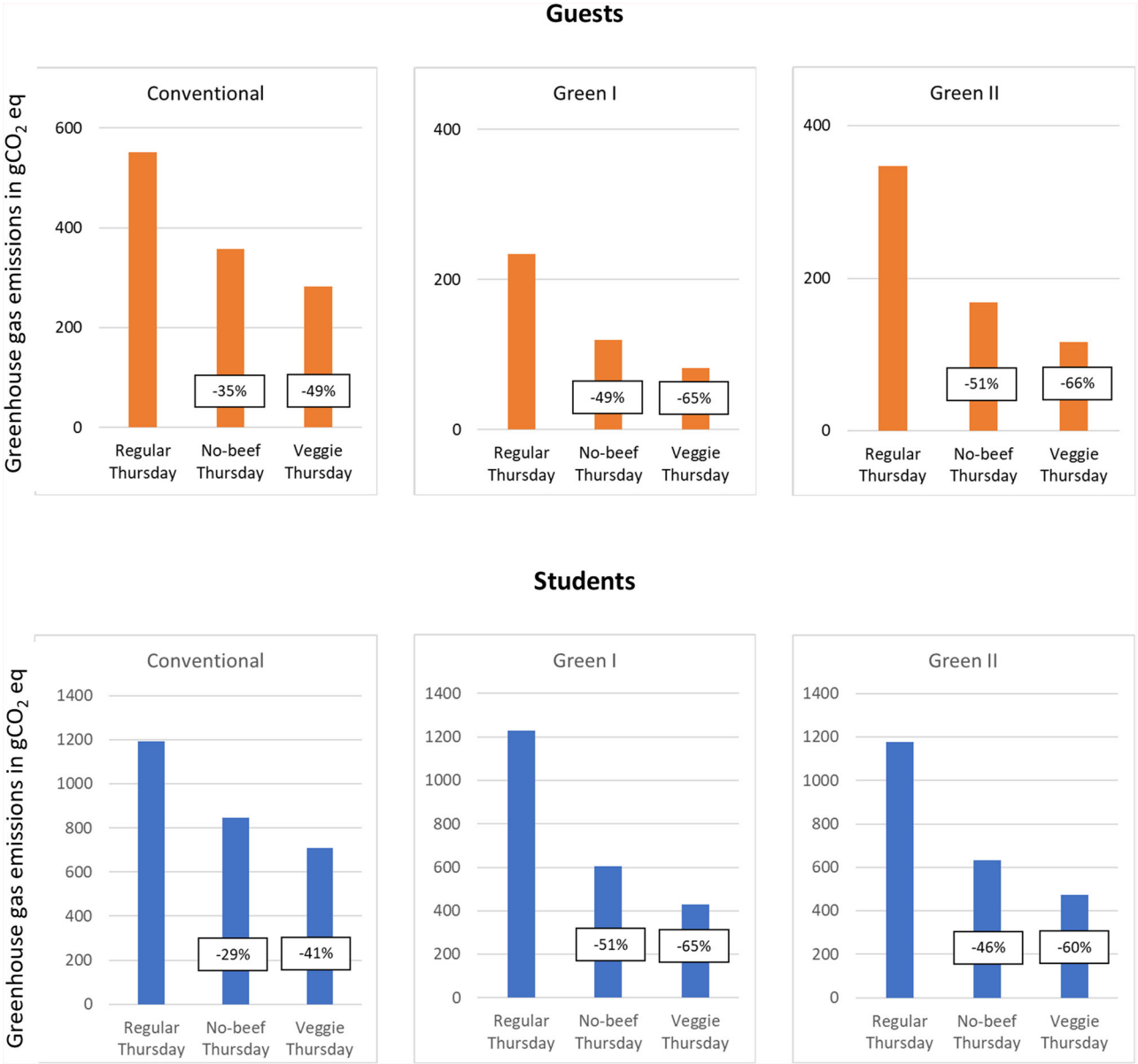

Fig. 2 | Exemplary greenhouse gas emissions in gCO_2 eq from the main dishes on a Regular Thursday, a No-beef Thursday, and a Veggie Thursday, by site and customer group. The emissions are calculated for exemplary dishes and the propensity to choose the respective dish of the customers at the respective site on comparable day.

expected considering how contentious the debate around Veggie Days had been in Germany[22].

The level of evasive behaviour in terms of sales at on-site alternatives ranged between 1 and 24% of customers who did not eat a main dish on a Veggie Day compared to a Regular Thursday where meat was offered. The effect varied between sites and customer groups. The students in our study were less likely to bypass Veggie Days compared to guests who work at the university or nearby offices. At the sites that offered and sold higher shares of vegan or vegetarian dishes on Regular Thursdays, we find lower levels of evasive behaviour on Veggie Days. This implies that there was already a higher level of openness toward meat-free dishes. Nonetheless, sales at the nearby alternatives increased. We find increases in sales at the buffet, and the cafeterias and therein of sausages with fries. Notably, at the site Green II, where we find low levels of evasive behaviour of guests and no evasive behaviour of students, sales at the cafeteria increased significantly and total sales at the site increased as well – though not significantly. This implies that the main dishes attracted additional customers on Veggie Days that compensated for the loss of regular customers who ate at the cafeteria instead.

Compared to the general population, more highly educated, and more affluent groups tend to be more open towards Veggie Days[33]. Therefore, the results from our study population of students and knowledge workers might be a lower bound of the level of protest behaviour that should be expected among the general population. Furthermore, the sites in our study were the closest and cheapest option to get food on campus; a warm lunch somewhere else was more costly in terms of money and time. Sites where additional alternatives are more accessible might see stronger evasive behaviour on Veggie Days.

The potential reduction of GHG emissions on a Veggie Day compared to a day with a mix of beef, pork, vegetarian, and vegan dishes in our setting is substantial and reduces emissions by up to 66% depending on the type and the relative shares of dishes sold. This potential is not fully reached where customers avoid the main dishes on a Veggie Day, choose to eat elsewhere, or when only a No-beef Thursday instead of a full Veggie Thursday is implemented. Furthermore, individuals might have compensated the lack of meat at lunch by a meat dish for dinner. While fewer meat, especially beef dishes, were sold and emissions were avoided at lunch on a Veggie Day, customers might just have shifted or even overcompensated for their lack of

meat at another meal. At our study sites, however, we do not find a compensatory spike in the sales of meat dishes on the Friday following a Veggie Thursday. We only find that the sales of curry sausages at the cafeteria were lower on Wednesdays before a Veggie Day as customers seemed to anticipate that they would eat it on the next day. To our knowledge, this is so far the only study to analyse evasive and compensatory reactions to Veggie Days. In future studies, it might be interesting to look at individual behavioural changes and investigate whether people tend to compensate for the lack of meat at other occasions or become more open toward vegetarian options over time.

The site with the highest level of evasive behaviour in terms of sales at on-site alternatives was also the one with the least stringent implementation of the Veggie Days. Other studies before had also found a lack of support by kitchen staff or failed attempts to introduce meat-less days[25,26,34], that had led to the implementation of less stringent versions such as 'Sustainable Mondays' where no red-meat was served. In our case, the sites still offered meat on some Thursdays that should have been Veggie Days but reduced the number of meat options and took beef off the menu. When canteen operators are confronted with strong evasive behaviour and complaints, this is a viable strategy to already reduce GHG emissions considerably. We find no significant decreases in the sales of main dishes on these days compared to Regular Thursdays. At our sites, the GHG reduction potential for such a No-beef Thursday ranged between 26 and 57% compared to a Regular Thursday. This can already reduce the GHG emissions substantially, though more encompassing lifecycle assessments[35] suggest that the positive environmental effects of switching to non-ruminant meat could be significantly smaller when other environmental and health outcomes are also considered.

Methods

We have daily sales data from the years 2017 to 2019 for the canteens and cafeterias at three German university sites run by the same operator. On weekdays, the canteens served between three and six warm main dishes for lunch. In addition, they offered salads, pizza, and pasta at a buffet. At least one of the main dishes was a vegetarian or vegan option. The nearby cafeterias mainly offered snacks, sandwiches, and pastries, but also a few warm dishes such as an iconic German fast-food dish: Sausage with curry sauce and fries.

In 2012, the canteen operator introduced a Veggie Day on the first Thursday of every month on which none of the main dishes contained meat or fish. Figure 1 shows how the main dishes, the buffet, and the cafeteria data related to each other and how they differed between Regular Thursdays and Veggie Days. To test the effect of this temporary ban of meat and fish dishes, we compare the sales of main dishes on Veggie Days to the sales on Regular Thursdays. We also analyse the sales data of the buffet, and sales at the cafeteria on these days to check whether customers bypassed the vegetarian main dishes and ate at the buffet or the cafeteria instead where some meat options were still available. Analysing total sales at the sites, i.e. canteen plus cafeteria, we can check whether customers were more likely to stay away and choose outside options on Veggie Days. The observational data set does not contain any individual data. We only know what customers bought and whether they are guests or students. We did not contact any of the customers and they were free to eat at any of the sites or to stay away. There was no deception. According to the guidelines of the first author's home institution this type of research does not require ethics approval.

The three sites were run by the same operator and offered the same dishes, but there were differences in the number of dishes served per day, the share of vegetarian dishes on regular daily menus, and the customer base, i.e. the ratio of students to guests. Dishes were prepared on site, and the chefs had some discretion in what and how they cooked. We call the largest site Conventional because on regular days it offered the smallest share of vegetarian options and the share of sold vegetarian dishes was lowest among students and guests. It substantially catered to guests, i.e. employees of the university and offices nearby, which made up 29% of customers, while the remaining 71% were students. It was also the largest of the three canteens with on average about 1500 dishes per day. We call the other two canteens Green I and Green II because 61–64% of the main dishes on their menu were vegetarian, 58–61% of students and 53–54% of guests ate vegetarian at lunch. Their customers were mainly students (84 and 81%). Both sites served substantially fewer customers during lunch hours compared to the Conventional site with 820 and 951 dishes per day, respectively. Conventional and Green II were in the same city on different parts of the campus of the same university. Green I was in another city. The University of the sites Conventional and Green II had a gender balance with a share of female students of approximately 53% during our observation period. The University of Green I had a female student population that ranged between 57 and 59%[36–38].

Unlike the canteen, the cafeteria was open most of the day and, while specialized in selling snacks like sandwiches or pastries, coffee, and other drinks, it also sold a few warm meals. The cafeterias were unaffected by Veggie Days and continued to sell meat. We analyse the cafeteria sales of warm meals and sandwiches during the opening hours of the canteen plus/minus 30 min when they could be considered as a substitute for lunch at the canteen.

For the analysis, we perform OLS regressions on the number of sales of the six lunch options *i* for guests or students *j* at sites *s* (Eq. (1)) on Thursdays using *Stata 18*. To make the effects between the regressions comparable, we use the log of sales and transform the coefficients into percentage changes (Table 1). Our main variable of interest is *Veggie Day*, which indicates, whether it is a Regular Thursday or a Veggie Thursday. The variable *week* controls for the time trend and takes the values 1 to 153, numbering the weeks within the observation period from the first to the last. In addition, we control for fluctuations between *years* using dummy variables for the years 2018 and 2019 thus rendering 2017 the base year. The time trend, *week*, accounts for autocorrelation and together with the *year* dummies for an overall growing awareness about the negative effects of meat consumption and a trend towards vegetarianism[39,40]. As fewer students were on campus during the breaks, sales varied strongly between term break and lecture periods. We control for this by including the dummy variable *lecture period*. In addition, we exclude influential outliers based on how strongly they deviated from mean sales, an example is the first week in January as sales were very low because most guests and students were still on winter break. The Breusch-Pagan-test for heteroskedasticity indicates the use of robust standard errors.

$$Sales_{ijs} = c_{ijs} + \beta_1 * VeggieDay + \beta_2 * week + \beta_3 * year + \beta_4 * lecture\ period + \varepsilon_{ijs} \quad (1)$$

$Sales_{ijs}$ log of sales of lunch options *i* to customer group *j* at site *s*

with *i* = lunch options (1) vegetarian main dishes, (2) main dishes, (3) buffet, (4) cafeteria, (5) sausages, (6) total and

s = sites Conventional, Green I, or Green II, and

j = 0 for guests; =1 for students

Veggie Day = 0 if Regular Thursday; =1 if Veggie Thursday

week = 1 for 1st week in observation period in January 2017, … =153 last week in observation period before Christmas in December 2019

year identifying the years 2017, 2018 and 2019

lecture period = 0 during term breaks; =1 during lecture periods

ε_{ijs} = error term Like other studies before[25], we find that the Veggie Days were not always strictly implemented. Instead, a dish with low-emission meat like poultry or pork might have been on the menu. Especially at the Conventional site, we observe fewer actual Veggie Days. On such No-beef Thursdays, one out of five main dishes contained white meat or fish, whereas on Regular Thursdays three out of five were non-vegetarian. In 2017, there were five, in 2018 only two and in 2019 seven fully implemented Veggie Days at the Conventional site. Implementation was stricter at the other two sites. The site Green I had six (2017) and seven (2018 and 2019) actual Veggie Days. Green II served only vegetarian dishes on seven out of ten in 2017 and 2018 and seven out of nine first Thursdays of the month where the canteens operated in 2019. We run robustness checks to find out what the impact of No-beef Thursdays on the sales of the lunch options were compared to Regular Thursdays and Veggie Days (Supplementary

Tables 4–21). As we do not find any significant effects of No-beef Thursdays on sales of main dishes and total sales, we treat them as Regular Thursdays in the analysis (Table 1).

In the robustness analysis of an anticipation effect on the Wednesday before a Veggie Day and a compensatory effect on the Friday after a Veggie Day, the variables *Wednesday* and *Friday* are dummy variables that indicate the respective days around a Veggie Day.

Calculating potential reductions in GHG emissions

To gauge the potential greenhouse gas savings of a Veggie Thursday and a No-beef Thursday compared to a Regular Thursday, we design representative menus of five dishes for the Conventional site and four for Green I and Green II for the three types of days. We then calculate the GHG emissions in terms of CO_2 equivalents (eq) for the ingredients of the recipes but without the emissions for the preparation of the dishes. We use the database of the Institute for Energy and Environmental Research[41] that accounts for Carbon Dioxide (CO_2), Methane (CH_4) and Nitrous oxide (N_2O) emissions of typical products in Germany following ISO 14067[42] converting these into CO_2 eq based on commonly used conversion factors[43]. Also included are emissions from land use change following the attributive land-use change approach[44]. This database covers most ingredients. We fill in the few missing values using other databases that also account for emissions from land-use changes[45–47].

The dishes selected for the representative menus along with their respective emissions per 100 servings are listed in Supplementary Table 28. For a Regular Thursday it consists of one beef dish, one pork dish, two vegetarian dishes, and one vegan dish at the Conventional site. As sites Green I and Green II normally served one dish less, we do not include the pork dish in their respective menu. For the No-beef Thursday, the beef dish on the menu of a Regular Thursday is replaced by a poultry dish. Finally, on the Veggie Day all meat dishes are replaced by a vegetarian or vegan dish. We calculate the emissions per day by multiplying the emissions per portion with the average number of sales of a dish on days with menus that have the same number of beef, pork, poultry, vegetarian, or vegan dishes, respectively. These calculations of emissions reductions are only exemplary to show the difference in emissions between menus. Especially the absolute values depend strongly on the selection of dishes.

Data availability

Access to the operator's cash register data is restricted and can only be shared on an aggregated level due to a data protection clause. Interested parties can contact the corresponding author to be put in touch with the data provider.

Code availability

The code for analysis is available upon request.

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C.M.: Acquisition of data, concept, data preparation, analysis, writing & revision of the manuscript. L.M.: Data preparation, analysis, writing & revision of the manuscript. A.G.: Data preparation & revision of the manuscript. S.H.: Acquisition of data, concept & revision of the manuscript. U.S.: Acquisition of data, concept & revision of the manuscript. K.R.: Acquisition of data, concept, writing & revision of the manuscript.

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Competing interests

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