The climate- and energy-efficient school kitchen

Making school meals climate friendly and child friendly

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Abstract

In Germany, the consumer sector "food" is responsible for around 15% of greenhouse gas emissions (GHG). Due to the high demand for food outside the home, changes in this area have the potential to significantly boost climate-efficient nutrition, and this includes changes in school kitchens. Currently, about 264 kg of GHG emissions per year are attributable to the food served to each school child who has school lunch year-round.

Therefore, the project "Climate and Energy Efficient Cooking in Schools" ("*Klima- und Energieeffiziente Küche in Schulen*" or KEEKS for short) sought to determine the status quo in the kitchens of 22 all-day schools serving a total of 5,000 lunches per day. This was done by taking energy measurements and analyzing the equipment, technology and processes used in the kitchens, and by interviewing kitchen managers using guided interviews. Greenhouse gas emissions arising from menus and kitchen processes were calculated, potential savings were identified, and recommendations for action were developed and tested. The most effective measures—the reduction and substitution of meat and meat products and the establishment of efficient waste management systems—save around 10% of a school kitchen's greenhouse gas emissions. The recommendations that have been developed can support kitchen staff in designing a climate-friendly, child-friendly, healthy and affordable menu in the school kitchen.

Keywords: School meals, climate efficiency, sustainability, greenhouse gas emissions, eating outside the home

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Introduction

Achieving greenhouse gas neutrality by 2050: this is the declared aim of the German Climate Action Plan 2050 [1]. To achieve this, the food system will need to be overhauled in order to drastically reduce the greenhouse gas emissions (GHG emissions) that it produces (currently it accounts for 15% of GHG emissions) while still ensuring that high-quality food is available [1–6]. In 2017/18, around 69% of German schools were operating on a full-day basis and they catered for around 3.2 million pupils [7]—and this trend is rising. The pandemic in 2020 and 2021 has led to some ups and downs in the business of school catering. As a consequence, smaller catering companies were forced to close down, meaning that a redistribution process took place: the orders previously dealt with by the small companies are now being dealt with by the large companies in the industry. It remains to be seen whether this development will have a positive or negative effect on GHG emissions.

The climate goals are now increasingly presenting schools with a challenge: they need to provide climate-friendly meals that are healthy, child friendly and affordable, in line with the public health nutrition perspective [8, 9]. Due to Germany's federal educational structure, there are no uniform guidelines for the implementation of school catering [8, 10], which makes such a project more difficult. The German Nutrition Society (DGE) Quality Standards [11] offer some guidance in this regard. Approaches to sustainable nutrition in commercial kitchens have been developed in the context of various research projects, such as *Große Küche auf kleiner Flamme*, *Essen in Hessen*, *SUKI*, *Bio kann Jeder* and *NAHGAST*. These projects have focused primarily on adapting menus and avoiding food waste.

In the research project "Climate and Energy Efficient Cooking in Schools" ("*Klima- und Energieeffiziente Küche in Schulen*" or KEEKS for short), which ran from May 2016 to April 2019, all sub-areas of catering outside the home were examined for the first time using the example of school kitchens with regard to their greenhouse gas saving and energy saving potential. Status quo analyses were carried out in cooperation with 22 school kitchens and recommendations for action were drawn up. Subsequently, a further 25 schools were included in an exchange of information about the results across the country [12].

Study question

School catering is divided into various key aspects: menus, kitchen technology and processes, purchasing and disposal. In order to identify where there is potential for savings, the most important aspects of school catering that are relevant to the climate must first be identified. This raises the question:

1. To what extent do each of the individual sub-areas of school catering contribute to the climate impact of a school kitchen? (Q1)

The aim of the KEEKS project was to develop proposals for climate-efficient and energy-efficient menus and processes in school cafeterias. The food must also meet the children's expectations in terms of taste, and must be healthy and affordable. Given the challenge of serving all of these interests, there is another question to be answered:

2. What are the practically feasible options for creating a climate-efficient and energy-efficient school cafeteria? (Q2)

Methodology[1]

Identification of aspects that are relevant to the climate

In the 22 school kitchens of the all-day elementary schools participating in the project, energy measurements were carried out, along with an analysis of the equipment, technology and processes used in the kitchens, and these data were used as a basis for determining GHG emissions.

In addition, the kitchen managers were interviewed in guided interviews about purchasing behavior, cost calculation, menu composition, use of kitchen technology, and food waste. Together with the menus themselves, this information formed the basis for the GHG calculations for the school menus. The calculations included all foods from the classic and vegetarian menu lines included in the menus from September 2016 to March 2017. There were 500 menus in total.

Development of practically feasible measures

The second step involved determining where GHG savings could be made and developing measures that school kitchens could take. Potential savings in the recipes were determined by means of ceteris paribus analyses. First of all, the values for the actual menus were calculated and then the calculations were carried out on selected variations in the composition of the dishes.

In order to identify potential savings in the area of kitchen processes, these processes were modeled based on the energy measurements. Refrigeration, cooking, serving, dishwashing, lighting, heating and air conditioning, washing and drying and hot water were all modeled. The models were based on average consumption and qualitative surveys of school kitchens. Next, average potential GHG savings were determined, extrapolated to one year, and then translated into specific measures.

This concept was tested in five school kitchens over a period of four weeks in order to identify any obstacles to implementation and to identify solutions that could be used to overcome these obstacles. The final step was the evaluation and optimization of the measures that had been tested [12].

Results

Results Q1: Status quo analysis

The GHG emission calculations for the selected recipes show that a school menu causes an average of 1.25 kg CO_2eq in emissions [12]. These emissions arise from different stages of the value chain, which are shown in ◆ Figure 1 along with their percentage share of total emissions. Upstream value-adding stages (stages prior to arrival at the school) were taken into account as well as the processes that took place in the school kitchen. The agricultural production of animal products alone accounts for more than a quarter of the total emissions from a school lunch, and when land use and land use change (accounting for 14%) are taken into account, agricultural production of animal products actually accounts for 41% (◆ Figure 1). Other factors that affect GHG emissions in this context include food waste (accounting for 15%) and the processing and provision of foods (13%).

The menus differ significantly from one another in terms of their climate impact, which strongly depends on the choice of ingredients, the menu composition, the amount of waste and the preparation methods (◆ Figure 2). ◆ Figure 2 shows that agriculture, land use and waste account for the largest share of GHG emissions here. Therefore, the selection of ingredients is a key area where school kitchens can take action to become more climate friendly.

The higher the climate impact of a food, the more CO_2eq is emitted as a result of the dis-

[1] Further information on the methodology, in particular with regard to life cycle assessment, can be found in the online supplement.

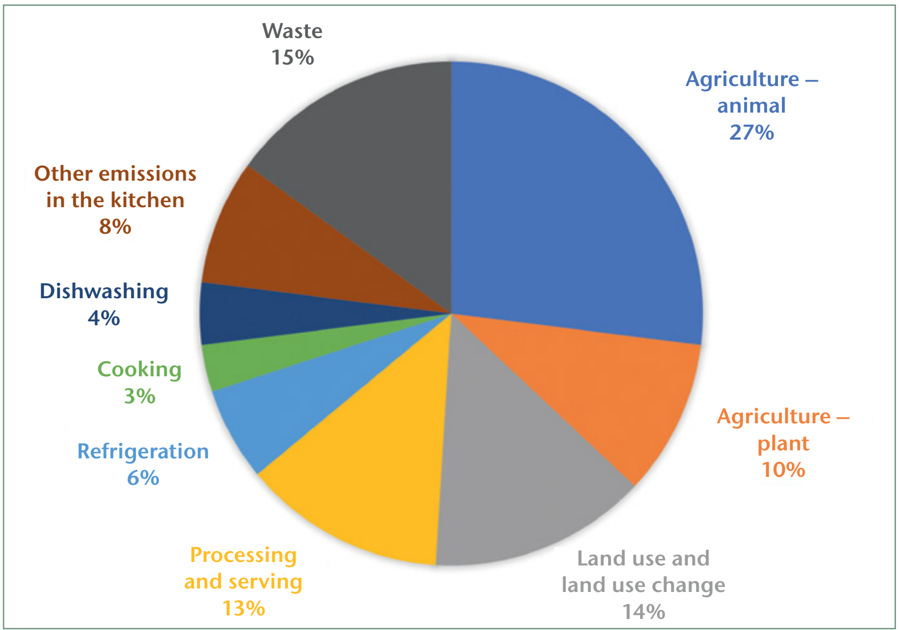

Fig. 1: **Total GHG emissions per school menu broken down according to the stages of the value chain** [13]
GHG = greenhouse gas

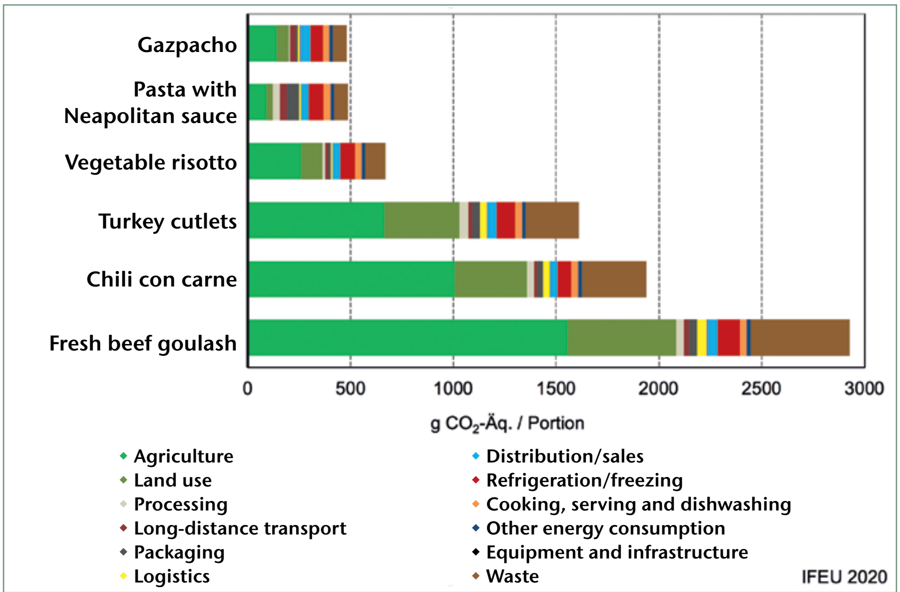

Fig. 2: **CO_2 equivalents of selected dishes (in g) of the schools involved in the project, broken down according to the stages of the value chain** [13]

posal of leftovers (compare goulash and gazpacho: 482 g vs. 66 g CO_2eq/serving). According to the results of the status quo analysis, a school kitchen produces between 40 and 50 liters of waste per day on average. Therefore, this is another area where action could be taken.

The status quo analysis revealed an average energy consumption of approx. 0.5 kWh per menu, which extrapolated to one year results in approx. 493,000 kWh per school kitchen per year. Freezing food accounted for the largest share of this—almost a third or approx. 155,000 kWh per year—followed by dishwashing (approx. 20%). Convection cooking accounted for just under 16% (76,000 kWh/year), and refrigeration accounted for about 9% (42,000 kWh/year). Although the emissions from these areas of energy consumption are relatively low compared to the other emissions (see ◆ Figure 2), they could be quickly reduced by adjusting the behavior of the kitchen staff purchasing new technical equipment. Therefore, two areas for action were identified here: behavior with regard to the use of technology, and optimizing the technology being used by investing in it [12].

Results Q2: The KEEKS measures for climate-friendly school catering

Based on the case studies of the school kitchens, a total of 19 measures were developed to address the four areas of action that were identified. These represent a key outcome of the KEEKS project and are summarized below.

Selection of foods

Since animal products result in particularly large GHG emissions, it is recommended that meat and meat products be offered at most two days a week, and preferably only once a week. This measure would save approx. 10% of the total emissions from school catering. A similar approach is described in the revised DGE Quality Standards for day-care center and school catering [11].

The DGE also recommends providing milk and dairy products at lunch at least twice a week [11]. In menus that contain amounts of milk and dairy products over and above these recommendations, the milk and dairy products could be replaced with plant-based ingredients. Dairy products that have a particularly high impact on the climate, such as butter, could be replaced with oils or plant-based alternatives [11]. Rice grown in wetland areas also generates relatively high GHG emissions. It is therefore recommended to replace rice with an alternative such as spelt. In addition, tap water should be made available as a climate-friendly and cost-effective alternative to bottled mineral water. Furthermore, the increased use of organic products and seasonal and regional products would . two measures that would result in relatively modest GHG emission savings, but would also have positive effects on other relevant factors such as animal welfare, biodiversity and groundwater protection [14].

In some cases, the kitchen managers involved in the KEEKS project were concerned that the modified recipes would result in additional costs. It is true that some individual measures can lead to investment costs or permanently higher costs, which may be a barrier to implementation in practice. However, some measures can be cost-neutral, or can even lead to cost savings. The most significant cost savings can be achieved by reducing the amount of meat and meat products used, as these products are expensive compared to other products. For example, replacing ground beef with textured soy protein in spaghetti bolognese can save up to 80% of the cost of the dish. Nevertheless, some other measures, such as using more organic foods, may incur additional costs. But even partially switching to organic products can have an impact at very little additional cost. For instance, if a conventional pumpkin is replaced with an organic pumpkin in a pumpkin and ginger soup, the additional cost is about 7%. However, cream is actually the ingredient that accounts for the largest portion of the cost of this dish. If the half of the cream is replaced with organic milk, then there is actually a cost saving

Measure		Potential GHG emission savings[a]
MF-1	climate-optimized menu plan through substitution and reduction of meat	10.30%
MF-2	weekly replacement of a meat dish with a plant-based dish	1.90%
MF-3	partial or total replacement of milk and dairy products	5.40%
MF-4	partial replacement of rice with spelt	2.10%
MF-5	using climate-friendly packaging	0.75%
MF-6	provision of tap water	2.50%
MF-7	using more organic foods	1.50%
MF-8	using seasonal and regional products	0.65%

Tab. 1: **Measures in the area of action "Selection of foods"**
[a] The potential GHG emission savings refer to the average value per project school per year.
GHG = greenhouse gas

of 5%. Therefore, especially when switching to organic products, it is worthwhile to check how much the additional cost of each ingredient switch is. It is often possible to offset a small increase in cost by making targeted savings elsewhere in the recipe.
The measures in the area of action "Selection of foods" are summarized in ◆ Table 1.

Optimizing technology through investment

Energy-efficient appliances reduce energy consumption in kitchens. Freezers play a pivotal role in terms of energy consumption because they are operating continuously. When inefficient freezers are replaced with freezers that have an average annual consumption of 500 kWh, this saves about 3.7% of the emissions. Furthermore, using more refrigeration in place of freezing and using more efficient dishwashers can also save GHG emissions (about 1.40% each). Purchasing new, more efficient kitchen appliances will initially incur high investment costs, but these investments will pay for themselves in just a few years. A sample cost calculation was carried out using freezers from two kitchens involved in the project. In each case, both the freezer with the highest and the freezer with the lowest energy consumption used in the kitchen was compared with an exemplary new, energy-efficient freezer. The results showed that investing in the best freezer from the practical test pays for itself after around 2.6 years, and when upgrading from the freezer with the highest consumption, it pays for itself after just 1.1 years.
All of the measures in the area of action "Optimizing technology through investment" are shown in ◆ Table 2.

Measure		Potential GHG emission savings[a]
MT-1	using efficient freezers	3.70%
MT-2	using efficient refrigerators	0.95%
MT-3	more refrigeration in place of freezing	1.40%
MT-4	efficient use of convection ovens and cooking appliances	0.75%
MT-5	upgrading to LED lighting	0.90%
MT-6	using efficient dishwashers	1.40%

Tab. 2: **Measures in the area of action "Optimizing technology through investment"**
[a] The potential GHG emission savings refer to the average value per project school per year.
GHG = greenhouse gas

Behavior with regard to the use of technology

The way technology users use appliances is an area where there is further potential for making the school kitchen more climate efficient. Dishwashing in particular is very energy-intensive and therefore represents a large potential for improvement. Only running the dishwasher when it is full saves around 1.20% of the GHG emissions. Other measures pertain to refrigerators and freezers. When these appliances are regularly serviced and maintained (cleaning vents, checking door frame seals, defrosting freezers), this saves around 0.70% of the GHG emissions. In addition, further savings can be made by switching off the equipment during school vacations.

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[2] Various studies [e.g., 13, 14] and the assessments of the participating kitchen managers were used to determine these potential savings.

Measure		Potential GHG emission savings[a]
MB-1	efficient dishwashing	1.20%
MV-2	switching off freezers and refrigerators during school vacations	0.80%
MV-3	servicing and maintaining freezers and refrigerators	0.70%
MV-4	switching off appliances left on stand-by	0.15%

Tab. 3: **Measures in the area of action "Behavior with regard to the use of technology"**
[a] The potential GHG emission savings refer to the average value per project school per year.
GHG = greenhouse gas

◆ Table 3 provides a summary of the measures in the area "Behavior with regard to the use of technology" and their associated potential savings.

Avoiding food waste

An improved waste management system would contribute GHG emission savings of about 10%[2] of total potential savings. It can be assumed that all school kitchens prepare on average 5–10% more food than they need due to daily fluctuations in pupil numbers. The main cause of this incorrect planning is pupils being absent but not being taken off the lunch list. An effective management system needs to be set up to tackle this. It must provide the kitchen with the exact number of people attending lunch each day so they can plan more accurately. To avoid food waste, it would also be a wise to make the as food appealing and child friendly as possible, and to educate children about the effects of food waste as well as the value of food, for example by using transparent waste containers.

Cross-functional recommendations

Kitchen managers and staff cannot be the sole drivers of climate-friendly diets. That is why this project included the development of cross-functional recommendations aimed at fostering acceptance of climate-friendly measures and integrating climate-friendly nutrition into catering concepts in a structured manner.
One key proposal is to set up a cafeteria committee made up of students, teachers, parents and the school's kitchen management. In this way, preferences could be communicated directly and obstacles could be removed, making it possible in to design a menu that all stakeholders can agree on. Furthermore, nutrition education, for example in the form of project weeks about sustainable nutrition, could improve awareness of the topic and familiarize students and teachers with the concept of climate-friendly cuisine.

Discussion

The KEEKS project focused on the transformation of all aspects of school catering—everything from the technical equipment used to the design of the meals and the underlying responsibility to educate. The research shows that the 22 kitchens involved in the project, which together produce 933,500 school meals annually, are responsible for 478 t CO_2eq per year in emissions. This is an important issue for society as a whole, because extrapolated to 3.2 million pupils and 211 catering days per school year, the German school catering sector produces annual GHG emissions of more than 844,000 t CO_2eq.
The KEEKS project has been successful in that it has been able to identify concrete recommendations for action for the entire school catering system. A special feature of this project is that it compares the measures with each other in terms of the potential emissions savings, thus clearly showing the effects of each. Volkhardt et al. 2016 [15] demonstrated that such a system is feasible for commercial kitchens. Working within the sensitive area of child nutrition, the KEEKS project aimed to develop a diet that conformed to German Nutrition Society (DGE) standards and that would also be accepted by the relevant stakeholders [12]. In addition, it was important not to exceed the schools' budget guidelines, in order to keep the price of the meals as constant as possible. The example calculations carried out for the measures showed that many measures offset each other. The long-term effects of such changes in cost structures will have to be investigated in subsequent research projects.
It was not investigated whether the children liked the climate-optimized meals. However, it can be assumed that the optimized dishes will be accepted to the same extent as the original dishes because the optimized dishes were created in cooperation with the kitchen staff. The dishes that were tested were predominantly dishes that sell well according to the experience of the staff. Any dishes whose composition was not child friendly were removed from the menus. In addition, the KEEKS project has inspired many of the participating school kitchens to pursue DGE certification.
The waste measurements that were carried out did not involve measuring specific components because such detailed waste monitoring would have created too much work for the school kitchens and this was not the focus of the project. Instead, avoidable waste was recorded by interviewing kitchen managers, and this information was supplemented with relevant assumptions from other research projects. The potential GHG emission savings were then calculated on this basis [16–18].
Valid statements about quantitative indicators, such as average energy consumption or the po-

tential savings from a given measure, can only be made with reference to the individual school or menu, and not the school catering setting in general. The extent to which these results apply to other types of catering or catering companies was not the subject of this study. This requires further research in subsequent projects. In order to obtain a broader understanding of the environmental impact of school meals, it will be necessary to make input-based calculations and to take the resource consumption of the meals into account, among other things. However, the stated aim of the KEEKS project—to contribute to climate protection—was achieved despite the limitations mentioned above because practical measures were deduced from the results. Knowledge was imparted through poster exhibitions and cooking courses, an e-cookbook for practitioners, explanatory videos, as well as a guide and a web app. The training manual provides educational content for teachers, including teachers at vocational schools. In addition, there is a "transformation concept" aimed at political decision-makers and other stakeholders. All materials are available free of charge on the project website (→ www.keeks-projekt.de).

Conflict of Interest
The authors declare no conflict of interest.

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