Sustainable nutrition in company and educational facilities as well as prisons

Nutritional and ecological improvements of catering services

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Abstract

This article presents results from the project "Eating in Hesse – On the culinary path to sustainability", in which the topics of a "resource-saving and balanced diet" and the "reduction of food waste" were linked. For this, the analysis and optimisation tool susDISH and the Waste analysis tool from United Against Waste for collecting food waste were combined. In cooperation with eight model companies for community catering, 411 recipes were evaluated according to their nutritional value and environmental impact over four to six-week periods. At the same time the food waste in the kitchens was collected. After the baseline survey and the implementation of measures, the follow-up found that the nutritional-physiological quality of 224 recipes was improved and the environmental impact of 112 recipes was reduced. Projected over a period of twelve months, the project achieved total savings of 281.5 tonnes of greenhouse gas emissions, 6 million litres of water and 29.2 hectares of agricultural land through recipe optimisation and waste avoidance. In parallel, the average food quality increased from 10.1 to 10.3 health points.

Keywords: out-of-home dining, company catering, carbon footprint, water footprint, land footprint, ecological scarcity, sustainable diets

Citation

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Introduction

Nutrition and the reduction of food waste are key issues to meet global challenges such as climate change, loss of biodiversity and the excessive use of limited resources. All Sustainable Development Goals (SDGs) are directly or indirectly linked to the food system (production – consumption – disposal) [1]. Global food production threatens climate stability and the resilience of ecosystems. That makes a radical transformation of the global food system urgently necessary [2].

Out-of-home catering plays a central role in the issue of environmental protection through a more resource-saving diet. In 2018, each of the 11.8 billion guests in the German out-of-home market consumed an average of 6.84 € worth of food and drink per visit. Although the COVID-19 pandemic has led to a drop in sales, the out-of-home market remains the second most important sales channel (after food retail) for the food industry in Germany [3]. In community catering, the purchase of large bundled quantities of goods and the recipe design offer just as much potential for optimisation as the preparation and waste avoidance of food.

However, this market not only offers opportunities for environmental improvement, but can also contribute to the prevention of noncommunicable diseases in combination with high quality food. Reducing sugar and salt and increasing the amount of fibre in the diet can reduce the risk of cardiovascular disease, type 2 diabetes and various types of cancer in the population [4, 5].

In the project "Eating in Hesse – On the culinary path to sustainability" (duration 2016–2019), the central themes of a resource-conserving and balanced diet were combined with the reduction

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susDISH

SusDISH is an analytical tool for recording and optimising the nutritional, ecological and economic performance of catering concepts. The abbreviation "susDISH" stands for "sustainable dish". The aim is to improve the health and ecological qualities of recipes by making minor but effective adjustments while retaining the corresponding menu characteristics. Application is possible at menu, menu line and operating level [9, 10]. Further information → www.nutrition-impacts.org.

of food waste. The analysis tool susDISH, a software for recipe optimisation, and the waste analysis tool from United Against Waste e. V. (UAW) were combined. The aim of the project was to optimise the range of food offered from an ecological and nutrition physiological point of view, while at the same time minimising food waste, in cooperation with eight model companies from the community catering sector (CC).

A further focus of work was the establishment of a dialogue platform in Hesse to bring representatives from politics, business, science and civil society together. Approaches to solutions and recommendations for action for politics and business were developed jointly [6–8].

Methods

The optimisation tool susDISH (◆ Box) was used to evaluate the meals offered in the participating companies with regard to their nutritional and ecological qualities and these were optimised where necessary [9, 10]. In addition, in all kitchens the waste quantities during (i) storage, (ii) production, (iii) overproduction and (iv) plate return were recorded by the project partner UAW.[1]

The model companies were selected by the Hessian Ministry for the Environment, Climate Protection, Agriculture and Consumer Protection (HMECAC) after consultation with the project partners. The project involved four company canteens, three prison kitchens (each one for male, female and juvenile inmates) and a restaurant run by a vocational training institution.

[1] Further details on waste measurement can be found in the online supplement.

	Company catering (19 to 64 years, PAL 1.4[b])	Company catering (19 to 64 years, PAL 1.6b[b])	Company catering (19 to 64 years, PAL 1.8b[b])	Tolerance range
Energy (kcal)	716	817	917	± 10%
Protein (g) max.	≤ 35	≤ 41	≤ 45	± 5%
Essential amino acids (g) min.	≥ 4	≥ 4	≥ 4	± 5%
Fat (g) max.	≤ 24	≤ 28	≤ 36	± 5%
Carbohydrates (g) min.	≥ 88	≥ 101	≥ 102	± 5%
Fibres (g) min.	≥ 10	≥ 10	≥ 10	± 5%
Vitamin B_1 (mg) min.	≥ 0.4	≥ 0.4	≥ 0.5	± 5%
Folate (µg) min.	≥ 100	≥ 100	≥ 100	± 5%
Vitamin C (mg) min.	≥ 33	≥ 33	≥ 33	± 5%
Vitamin E (mg) min.	≥ 5	≥ 5	≥ 5	± 5%
Calcium (mg) min.	≥ 333	≥ 333	≥ 333	± 5%
Magnesium (mg) min.	≥ 117	≥ 117	≥ 117	± 5%
Iron (mg) min.	≥ 5	≥ 5	≥ 5	± 5%
Vitamin B_{12}[a] (µg) min.	≥ 1.0	≥ 1.0	≥ 1.0	± 5%
Cholesterol (mg) max.	≤ 99	≤ 99	≤ 99	± 5%
Sodium (g) max.	≤ 0.79	≤ 0.79	≤ 0.79	± 5%

Table 1: **Reference values for company catering for a balanced lunch meal per person (19–64 years, PAL 1.4–1.8)** [9, 11]

[a] For vitamin B12, the old reference value was still taken into account in the data analysis (2017–2018). Now a daily intake of 4 µg per person is recommended [12].

[b] PAL value (Physical Activity Level) expresses the daily activity level of a person as a number.
PAL 1.4 = exclusively sedentary activity, e.g. office worker
PAL 1.6 = sitting activity with additional energy expenditure for walking or standing activity
PAL 1.8 = predominantly walking and standing work

	Environmental Indicator	Effect	Footprint
1	CO_2 (carbon dioxide)-emissions	greenhouse effect	carbon footprint according to ISO 14067 (2013) [15]
2	CH_4 (methane)-emissions	greenhouse effect	
3	N_2O (nitrous oxide)-emissions	greenhouse effect	
4	NH_3 (ammonia)-emissions	acidification, air pollution, greenhouse effect, eutrophication (as NH_4^+)	
5	NO (nitrogen monoxide)-emissions	air pollution, acidification	
6	NMVOC (non-methane volatile organic compounds)-emissions	air pollution, ozone formation	
7	SO_2 (Sulfur dioxide)-emissions	acidification	
8	H_2S (hydrogen sulfide)-emissions	acidification	
9	HCl (hydrochloric acid)-emissions	acidification	
10	N-surplus from mineral and agricultural fertilisers	eutrophication, human toxicity	
11	P-surplus from mineral and agricultural fertilisers	eutrophication	
12	blue water demand	water scarcity, water stress	water footprint according to ISO 14046 (2014) [16]
13	pesticide use (as a.i.)	human and ecotoxicity	
14	primary energy consumption	resource consumption/scarcity	
15	area required (conventional, organic agriculture) arable land grassland permanent crop forest area industrial land	resource consumption/scarcity, biodiversity loss (loss of species)	land footprint according to Meier et al. 2014 [17]

Table 2: **Environmental indicators considered for the calculation of the environmental impact points (Eco-Points) and the sub-indicators climate footprint, water footprint and land footprint**

Nutritional assessment

The evaluation of the nutritional quality of the recipes is based on the official reference values for community catering of the German Nutrition Society (DGE, *Deutsche Gesellschaft für Ernährung*) [11]. In order to expand the significance of the nutritional assessment, susDISH considers four further nutritionally relevant criteria: the contents of essential amino acids, of sodium, of cholesterol and of vitamin B_{12}. This means that a total of 16 evaluation criteria at nutrient level are taken into account per recipe. ◆ Table 1 provides an exemplary overview of corresponding reference quantities for a nutritionally balanced lunch meal in company catering with a physical activity level (PAL) of 1.4 to 1.8. These reference values are based on the one-third principle, which states that a third of the daily nutrient intake should be provided by lunch [9, 11].

In addition to this nutrient-specific individual evaluation, susDISH also allows an aggregated health assessment in the form of so-called health points (HP). In order to calculate these, the degree of compliance is determined for each criterion on the basis of the quotient of the actual situation and the corresponding reference value. A 100% match between the actual situation and the reference value results in a quotient of 1, a 50% match results in a quotient of 0.5 and a 0% match results in a quotient of 0 (etc.). In the ideal case, a recipe can thus achieve a maximum of 16 HP [6]. In order to maintain a certain variability in the recipe design, a tolerance range of 5% was integrated into the analysis algorithm of susDISH, i. e. with a quotient between 0.95 and 1.05 resulting in a HP of 1. In the case of the energy supply a tolerance range of 10% was applied [9].

Environmental assessment

A total of 15 environmental indicators are considered within the ecological quality assessment of the recipes (listed in ◆ Table 2). In order to communicate this spectrum in a practical way, these are weighted using the method of the ecological scarcity and indicator-specific environmental impact points (Eco-points) are derived [13]. On the basis of current environmental policy targets in Germany, the various environmental impacts can be compared and thus offset against each other. In susDISH, the system boundaries are

set from cradle-to-fork comprising the life cycle inventory from agriculture/fishery, food processing up to the use of the food products in canteens, including transport, packaging and storage/preparation in the kitchens [14].
In the project, the carbon, water and land footprint and the overall environmental indicator Eco-points were determined for each recipe. These environmental impacts are determined by taking into account sustainability-relevant key figures for the energy and water supply of the kitchens.[2]
Within the scope of the collection of food waste, a combination of the waste analysis tool of UAW with the calculation bases of susDISH allowed to determine the carbon, water and land footprint as well as the Eco-points also per kg of food waste.

As a first step, nutritional and ecological baseline analyses of the dishes offered were carried out in the eight participating companies over a period of four to six weeks. During the same period, food waste was measured in the model kitchens by UAW.
Afterwards each kitchen received a status report with the nutritional and ecological evaluations of its recipes. Optimisation recommendations were formulated for recipes that achieved health points in the lower third and/or Eco-points in the upper third compared to the overall result range. In addition, the reports contained the results of the food waste analysis combined with possible measures to reduce the amount of waste.
One year after the baseline, the recipes and the food waste were evaluted another time over a further four-week period. The aim of this second survey was to check which recommendations of the recipe optimisation and which measures to reduce food waste were implemented.

Results

Within the scope of the project, a total of 411 recipes were evaluated. For 128 recipes, specific recommendations for optimisation were formulated due to their very low nutritional quality and/or very high environmental impacts (Eco-points). These recommendations were fully implemented for 27 recipes and partially implemented for 43 recipes. For 58 recipes no modifications were made in the kitchens. However, the kitchens independently transferred some of the optimisation recommendations to other recipes. Thus, after the second survey we observed that the nutritional quality of 224 recipes was improved and the environmental burdens of 112 recipes were reduced.

Nutritional quality

In the baseline assessment, an average of 10.1 health points (HP, max. 16), varying between 13.4 (aubergine/zucchini piccata with potatoes and carrots; Eco-points: 60) and 3.5 HP (vegetarian potato stew; Eco-points: 13), were determined. By implementing the recommendations, the range of nutritional quality for the entire range of dishes was improved to an average of 10.3 HP, varying between 14.2 GP (pollack fillet, potatoes and lettuce, Eco-points: 47) and 5.5 HP (pork gyro with tzatziki, coleslaw, rice, Eco-points: 62).

The nutrient-specific evaluation (◆ Figure 1) shows that the energy content (kcal), protein supply and vitamin supply of the recipes on average corresponded to the reference values of the DGE during the initial survey (actual mean value). The exception is a slightly critical shortfall in vitamin E. The carbohydrate and calcium content were classified as critically undercut compared to the DGE reference values. Although the recommendations for increasing the carbohydrate content were largely implemented, it was not possible to achieve a practical increase in accordance with the DGE guidelines. After the second survey, the supply remained critical.
With regard to the calcium content, the optimisation recommendations, such as increasing the proportion legumes and of dairy desserts, were independently transferred from the kitchens to other recipes, so that in the second survey the recommended target value was even exceeded. A critical excess of the reference values was observed for sodium (salt) due to the use of salty convenience products and vegetable broths. Although the salt content of the recipes was reduced remarkebly by implementing the optimisation recommendations, it remains critical. Exceeding reference values were also identified for fat (slightly critical) and cholesterol (critical). After implementing the optimization recommendations, the cholesterol could be reduced to such an extent that it is now within the scope of the reference values. A slight reduction of the fat content was recorded in the second survey.

Environmental quality

◆ Figures 2 and 3 show the ecological evaluation of the recipes in context of the nutritional analysis. In the illustrations, the entire range of dishes is divided into recipe classes. In the baseline survey (◆ Figure 2), dishes with beef or lamb achieved on average the highest environmental impacts (from 68 to 353 Eco-Points). Recipes with pork (62 to 185 Eco-Points) and poultry (40 to 160 Eco-Points) were in the middle range. Fish dishes, ovo-lacto-vegetarian (olv), vegetarian sweet (vs) and vegan (v+) recipes had the lowest environmental impacts (fish dishes: from 19 to 109 Eco-points, olv: from 13 to 123 Eco-points, vs: from 17 to 69 Eco-points, v+: from 12 to 53 Eco-points).

[2] The detailed basis for calculating the environmental indicators can be found in the online supplement.

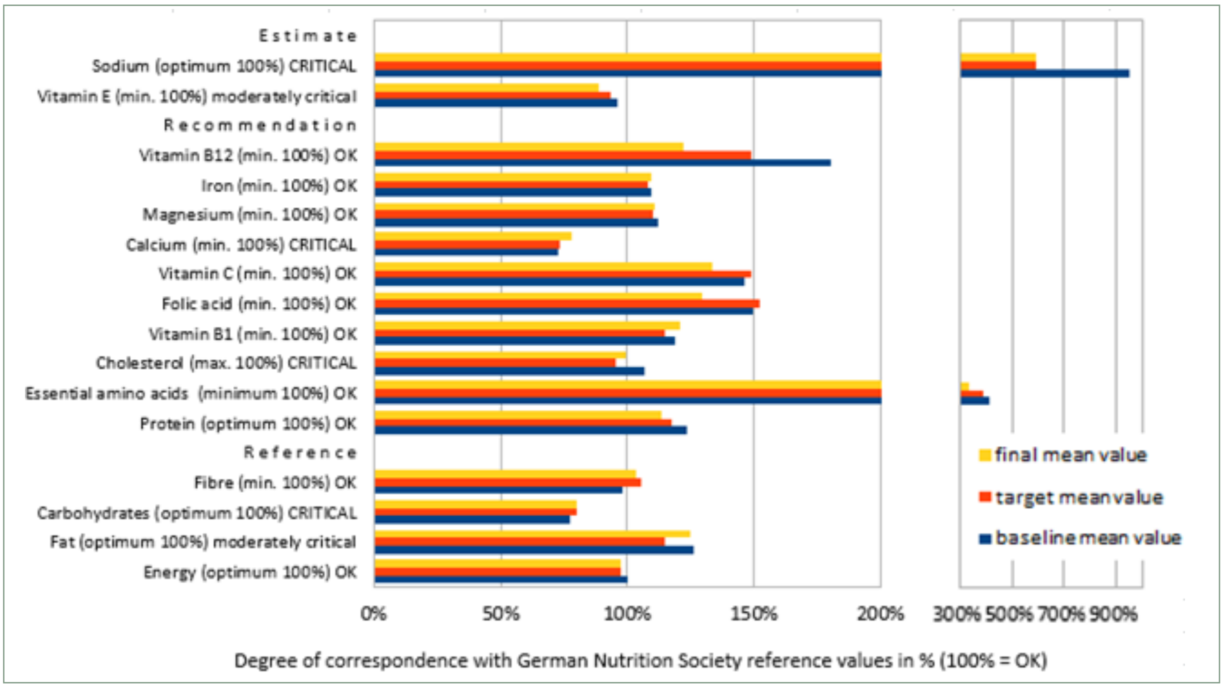

Figure 1: **Nutrient-specific analysis of the entire food supply in the survey periods (n = 411) based on the DGE reference values and comparison of the recipes: baseline survey (baseline mean value) vs. optimisation potential (target mean value) vs. revised recipes (final mean value)**
OK = deviation of less than 5% from the reference value/range
moderately critical = deviation of 5–15% from reference value/range
CRITICAL = deviation of more than 15% from the reference value/range

For the entire range of dishes, the baseline assessment (◆ Figure 2) determined a range of environmental impacts from 13 Eco-points (baked potatoes with an herbal dip; HP: 6.8) to 353 Eco-Points (Lasagne Napoli with salad and fruit; HP 10.0) per portion. After implementation of the optimisation recommendations (◆ Figure 3), the recipe with the highest environmental impact (lamb curry with coconut and lemon rice; HP: 8.2) had 286 Eco-Points. Finally, the environmental impacts were reduced from an average of 93 Eco-points per portion to 84 Eco-points. In sum, by optimizing the recipes a saving of 1.2 million Eco-points was achieved in the period under review. This corresponds to a reduction of 18.5 t greenhouse gas emissions, 240.4 m^3 water and 2.2 ha of agricultural land (◆ Table 3).

Further savings in environmental burdens could be achieved in the project by reducing food losses and wastage. At the beginning of the project, an average of 114 g of food per portion was disposed of in the eight participating facilities. With an average portion size of roughly 500 g, this corresponds to 22.8%. The project partner UAW developed specific measures to reduce the food waste for each kitchen. After implementing these measures, the participating enterprises were able to reduce food waste by an average of 15.9%. One kitchen even achieved a waste reduction of 29.3%, mainly due to less overproduction and less plate return. The high water footprint of food waste results from the fact that the share of water-intensive vegetables and salad in the total waste is above average (◆ Appendix Figure 3), and thus a disproportionately high amount of water can be saved.

Extrapolated to twelve months of catering, in total with recipe optimisation and waste avoidance a total reduction of 16.8 million Eco-points was achieved. This corresponds to a saving of 281.5 t greenhouse gas emissions, 6.0 million litres of water and 29.2 ha of agricultural land (◆ Table 3).

Discussion

In the project “Eating in Hesse – On the culinary path to sustainability”, two central issues of community catering were addressed in combination: “resource-saving and nutritionally balanced recipes” and the “reduction of food waste”. In comparison to other projects and initiatives [25–29] the following innovative aspects of this project can be underlined:

- Calculation of savings potentials from both recipe optimisation and waste avoidance
- Application of the method of ecological scarcity [13] in a German context
- Identification of corresponding savings potentials in prisons

Within the scope of the project, critical recipes were identified and recipe-specific optimization recommendations were formulated following the results of the baseline assessment (status survey) (Online supplement “Sample recipes”). However, although recommendations

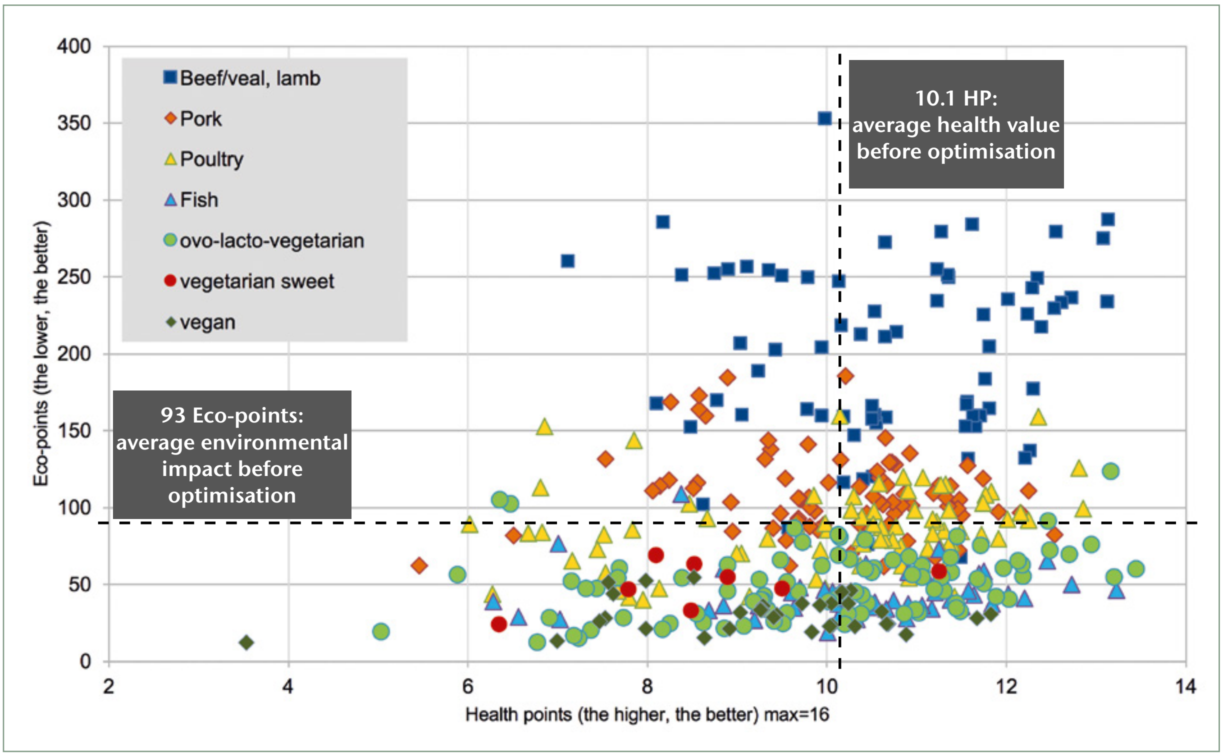

Figure 2: **Eco-points (Environmental impacts) and health quality of all recipes in the baseline analysis (first investigation period: II. quarter 2017)**

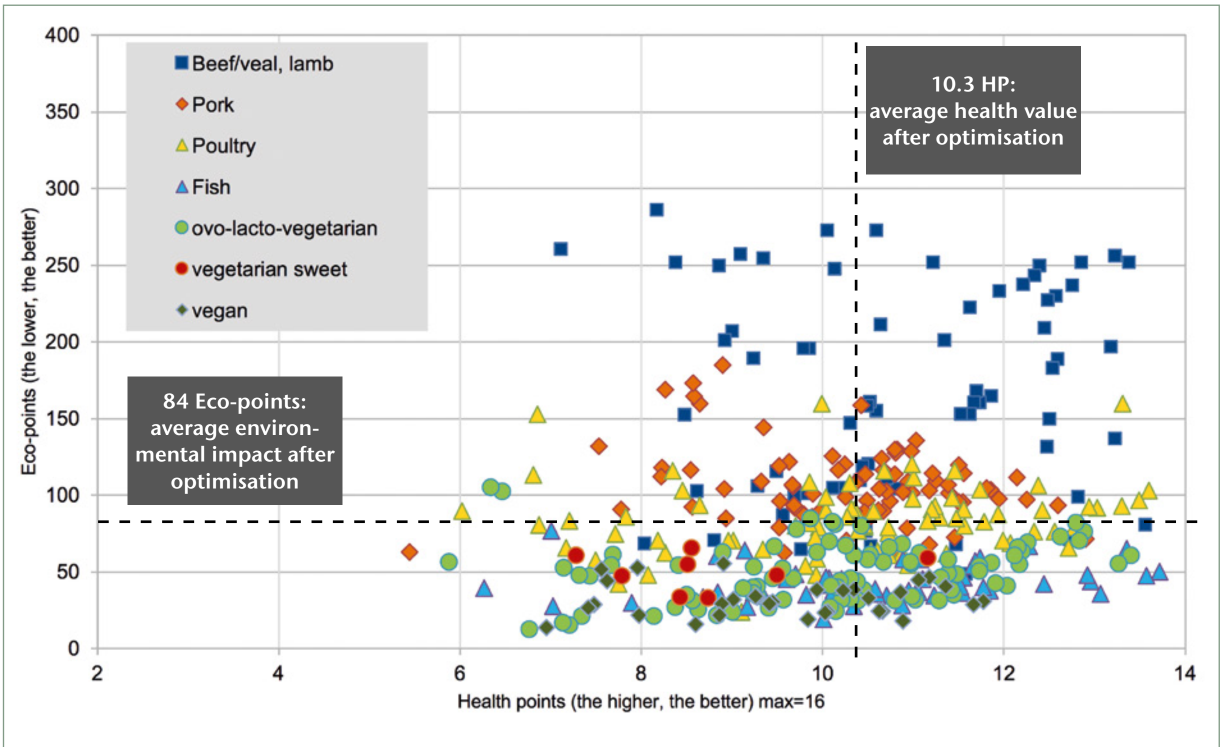

Figure 3: **Eco-points (Environmental impacts) and health quality of all recipes after implementation the optimisation recommendations in the second period under investigation (II. quarter 2018)**

were elaborated for 128 recipes, only 55% of these (70 of 128) were fully or partially implemented.

In the course of interviews conducted with decision-makers during the project, various reasons were given for this. One frequently cited reason was that in large enterprises recipe changes cannot be made directly on site, but only centrally at headquarters. Modifications adapted to the menu characteristics in

Total		Health points	Environmental impact points (Eco-points)	Greenhouse gas emissions in kg CO_2e	Water (blue) use in L	Land use in m^2
		The higher, the better, max. = 16	The lower, the better			
Total supply during the four-week investigation period (Ø)[a]						
Optimisation of recipes						
Baseline	82,770	10.12	8,194,936	130,944	2,614,268	126,725
Final state	82,770	10.34	7,019,741	112,461	2,373,860	105,216
Savings			**1,175,194**	**18,482**	**240,409**	**21,509**
Waste avoidance						
Baseline			704,001	15,829	826,863	9,043
Final state			482,879	10,854	567,149	6,203
Savings			**221,122**	**4,976**	**259,714**	**2,841**
Extrapolation of the savings to 12 months of catering per year						
... from recipe optimisation			14,102,332	**221,790**	**2,884,903**	**258,112**
... from waste avoidance			2,653,464	59,710	3,116,569	34,088
Total of recipe optimisation and waste avoidance			**16,755,796**	**281,500**	**6,001,472**	**292,200**

Table 3: **Realised savings of environmental impacts after implementing the recipe and waste optimisation**
[a] Taking into account the number of portions produced in the kitchens

addition to variants with less meat were implemented only hesitantly in some company catering facilities. One reason for this was that customers "expected a certain amount of meat in the dish" [14]. However, acceptance studies in kitchens have shown that customers tolerate meat portions that are 15–20% smaller; especially if the components are presented in an appropriate culinary manner [see also 18].

In addition to reduced portions of dairy products, the adaption of the meat components in particular offers enormous ecological potential. As has been shown in other studies, the production of animal products causes much higher environmental damage than the production of plant-based products [19–22]. Above all, dishes with meat from ruminants (beef, lamb) and dairy products have the highest environmental impact. Only in the case of water use dishes with rice and nuts achieve the highest values [10]. Concerning water use it has to be remembered that, in accordance with ISO 14046 (2014), only "blue" water was included in the water accounting [16, 23]. This comprises the water that is used via channels and pipelines for watering the animals, for irrigation in greenhouses and in open fields, for cleaning and food preparation in the food industry an in the kitchens, etc. "Green" water (direct precipitation) and "grey" water (waste water) are not included in the method.

A further limitation of the life cycle assessment conducted is that the environmental impacts from overfishing of pelagic and demersal fish species were not included. For this reason, the recipes using fish from deep-sea fishing achieved better results in the ecological assessment than fish from aquaculture, in which the environmental impacts of the production of animal feed were included.

Due to practical reasons, the exact composition of food waste could not be determined within the scope of the project. For this reason, a standard composition of food waste was used to calculate the environmental impacts. The standard composition is based on 269 individual measurements conducted in company catering and was provided by UAW (online supplement ◆ Figure 3). In order to be able to determine the environmental impacts of food waste even more precisely, it would be important for future projects to use analytical instruments that more specifically determine the food components in the waste.

Moreover, it was originally planned to carry out an economic cost analysis for each facility to show the extent to which the health improvements and ecological savings are economically viable. Unfortunately, however, a product-specific listing of the purchase prices of all components in the management systems of the participating partners was only possible in some cases. For this reason, it was not possible to conduct a systematic analysis of the change in revenues and costs.

Conclusion

The project "Eating in Hesse – On the culinary path to sustainability" has shown the opportunities, but also the challenges, associated with changes in recipe design and the management of food losses. In different settings of the out-of-home market it was demonstrated that small but targeted measures can help to improve the nutritional and ecological quality of the dishes on offer. Although not all optimisation recommendations were implemented in the participating facilities, the recommendations that were easy to implement were independently transferred to other recipes. With regard to the reduction of food waste and losses, it was shown how powerful targeted measures are. Crucial for the success in both issues "resource-saving and balanced diet" and the "reduction of food waste" is the strong sensibilsation and involvement of employees.

Conflict of Interest
The project was supported financially and in terms of selection of the participating facilities by the Hessian Ministry for the Environment, Climate Protection, Agriculture and Consumer Protection and by the *Deutsche Bundesstiftung Umwelt* (DBU) (project number: 33288/01).
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