



Portioning meat and vegetables in four different out of home settings: A win-win for guests, chefs and the planet

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ARTICLE INFO

Keywords:

Vegetables
Meat
Portion size
Real-life intervention study
Environmental impact
Healthy diet
Restaurant
Plant-forward diet

ABSTRACT

Individuals increasingly consume their meals away from home. This article describes a series of studies that examined the effects of meals with reduced amounts of meat and increased amounts of vegetables on food consumption, waste and guest satisfaction in four real-life restaurant settings in the Netherlands: an a-la-carte restaurant, six company canteens, a self-service restaurant, and a buffet restaurant, including nearly 1500 participants in total. The four studies in these four different out of home settings consistently showed that adapting portion sizes of meat and vegetables was effective to reduce meat consumption and increase vegetable consumption, while maintaining high guest satisfaction. Guest satisfaction even increased when vegetables were presented and prepared in a more attractive and tasty way. Thus, adapting portion sizes of meat and vegetables provides a viable strategy to stimulate healthy and environmentally sustainable consumption patterns in out of home settings.

1. Introduction

Current western food consumption patterns are characterized with high consumption of animal foods, i.e. especially red and processed meat, excess calories and low consumption of vegetables have all been related to obesity and non-communicable diseases such as diabetes type 2 and cardiovascular diseases (Abete, Romaguera, Vieira, & Lopez de Munain, 2014; Malik, Li, Tobias, Pan, & Hu, 2016; Pan et al., 2011; Song et al., 2016). These diets are also not environmentally sustainable, due to their high demand of natural resources and negative impact on the environment (Behrens et al., 2017; Garnett, 2014; Reisch, Eberle, & Lorek, 2013; Willett et al., 2019). There is broad agreement that the most important dietary shift that benefits both public health and the environment is a transition of Western meat-centred diets towards more plant-based diets (Aiking, 2011; Aleksandrowicz et al., 2016; MacDiarmid et al., 2012; Pimentel & Pimentel, 2003; Stehfest et al., 2009; Van Dooren, Marinussen, Blonk, Aiking, & Vellinga, 2014). This dietary shift is increasingly being acknowledged by various scientific committees (Willett et al., 2019), national health authorities (Van Loo, Hoefkens, & Verbeke, 2017) and environmental authorities around the

world (ADEME, 2018; Alarcon & Gerritsen, 2018; Garnett, 2014; Gonzalez Fischer & Garnett, 2016). These authorities explicitly recommend limiting the consumption of (red/non-ruminant) meat and increasing the consumption of mainly plant-based foods, for both health and environmental reasons.

To realize this dietary shift, both individual choices and food environments need to change. Individuals increasingly consume their meals out of home, for example in canteens at work, in food outlets on-the-go, or in restaurants. According to a recent review by Bianchi, Garnett, Dorsel, Aveyard, and Jebb (2018), the characteristics of settings where people acquire or consume food exert a powerful influence on eating behaviour. Eating out of home has been associated with high calorie intake (Robinson, Jones, Whitelock, Mead, & Haynes, 2018; Scourboutakos & L'Abbé, 2012), lower vegetable consumption (Todd, Mancino, & Lin, 2010) as well as with larger portions of meat (Seburg, Crane, & Sherwood, 2017). Out of home settings could therefore play an important role to facilitate healthy and sustainable dietary choices for people (for an overview see Kraak, Englund, Misyak, & Serrano, 2017 and Lorenz & Langen, 2018).

One way, in which out of home settings can contribute to healthier

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<https://doi.org/10.1016/j.appet.2019.104539>

Received 18 July 2019; Received in revised form 25 October 2019; Accepted 23 November 2019

Available online 25 November 2019

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Fig. 1. Presentation of the dish 'country boar' in control period (left) versus intervention period (right).

and more sustainable meals is by modifying portion sizes (Hollands et al., 2015). Portion sizes have shown to be important drivers of calorie intake in restaurants (Scourboutakos & L'Abbé, 2012). A systematic review of experimental studies that restructured food choice environments, showed that downsizing of meat portions reduced meat consumption (Bianchi et al., 2018). Similarly, previous studies found that increasing portion sizes of vegetables resulted in increased consumption of vegetables (Miller et al., 2015; Rolls, Roe, & Meengs, 2010; Van Kleef, Bruggers, & de Vet, 2015). Recently, Reinders, Huitink, Dijkstra, Maaskant, and Heijnen (2017) showed in a real-life restaurant setting that after increasing vegetable portions in combination with reducing portion sizes of meat, participants not only consumed more vegetables, but also remained satisfied with their restaurant visit and main dish. Still, chefs may be reluctant to reduce the amount of meat because they are concerned that meals will be less valued and demanded by their guests (Gase, Dunning, Kuo, Simon, & Fielding, 2014; Rijs, 2014). Moreover, they may hesitate to serve more vegetables, worrying that this may result in increased preparation time and more waste (Glanz et al., 2007). There is also a perceived lack of skills and training on how to serve more healthy dishes among chefs (Obbagy, Condrasky, Roe, Sharp, & Rolls, 2011). To reassure chefs and provide better guidance on how to provide more sustainable and healthy offerings with less meat and more vegetables, it is important to replicate and extend the findings of Reinders et al. (2017).

Therefore, a series of studies was conducted that examined the effects of modified meals with a reduced amount of meat and an increased amount of vegetables on food consumption, waste and guest satisfaction in different real-life restaurant settings in the Netherlands. We compared consumption and satisfaction before and after the changes in food offerings among separate samples of restaurant guests.

2. Study overview

Study 1 investigated the effects of modifying meat and vegetable portion sizes of main dishes in an a-la-carte restaurant. Study 2 was carried out in company canteens and focused on sandwiches. It built on the first study by paying more attention to the taste and presentation of the modified sandwiches, in addition to changing the amount of meat and vegetable fillings. Study 3, conducted in a self-service restaurant, further elaborated on the effects of enhanced taste and presentation of vegetables in combination with modified portion sizes. Additionally, it examined guests' preference for the 'regular' portion size dish, or the dish with more vegetables and less meat, by letting guests actively choose between the two options. Finally, study 4 investigated the effect of consumers' choices in the context of a buffet restaurant in which the offerings on the buffet were adjusted (i.e. less meat, more vegetables).

In this context, guests could freely choose which dishes, or combinations of dishes they wanted to eat, and how much of it they wanted. For all studies, data are presented as medians and interquartile range (shown as the first quartile (25th percentile) and third quartile (75th percentile), Q1 and Q3, respectively) as most data were ordinal data that were not normally distributed (Stevens, 1946). Accordingly, data were tested using non-parametric methods including Mann-Whitney U tests. Data were analysed using SPSS version 24.0 and a p-value of < 0.05 was considered statistically significant. More detailed descriptions of the study designs can be found in the Supplementary Materials. The Medical Ethics Review Committee of VU University Medical Center, the Netherlands, reviewed the study and confirmed that the Dutch Medical Research Involving Human Subjects Act does not apply to this study.

3. Study 1: adapting portion sizes in an a-la carte French cuisine restaurant

3.1. Method

Study 1 was conducted in a privately-owned, middle sized (ca. 120 seats), French cuisine a-la carte restaurant. We compared observations of the intervention with a control period. During the control period, portion sizes were as usual. During the intervention period, portion sizes of six main meat/fish dishes were reduced by 8–16%, depending on the dish. On average, meat/fish portions were reduced by 12%, from 154 g in the control period to 135 g during the intervention period. Vegetable portions increased on average by 31%, from 117 g in the control period to 153 g during the intervention period. See Fig. 1 for an example picture of presentation of a dish in the control period versus the intervention period.

Both during control and intervention period, when guests had finished their main meal and the waiter/waitress collected their plates, the remaining amount of vegetables, meat/fish and starchy components, as well as the leftovers from side dishes (salad, fries), were weighed separately to calculate waste and consumption per plate from the average serving size of the component. Guests were asked to complete a questionnaire to rate their satisfaction with their restaurant visit, with the meal, with the meal presentation, and with the taste on a 5-point Likert scale ranging from 1 = not at all satisfied/attractive to 5 = very satisfied/attractive. Furthermore, guests were asked to evaluate the amount of meat/fish and vegetables ranging from with 1 = too little to 5 = too much. Throughout the study, guests were not made aware of any changes in portion sizes.

Table 1

Median consumption and waste (in grams) of meat/fish and vegetables per person during control and intervention period.

	Control			Intervention			<i>p</i>
	<i>Mdn</i>	Q1	Q3	<i>Mdn</i>	Q1	Q3	
Consumption meat/fish							
Study 1: à-la-carte restaurant	146	140	153	127	123	137	< 0.01
Study 2: work canteens ^a	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Study 3: self-service restaurant	159	159	175	140	140	161	< 0.01
Study 4: buffet restaurant ^b	277	247	335	265	226	283	n.a.
Consumption vegetables							
Study 1: à-la-carte restaurant	109	63	117	124	98	153	< 0.01
Study 2: work canteens ^a	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Study 3: self-service restaurant	60	60	115	120	116	158	< 0.01
Study 4: buffet restaurant ^b	75	72	111	159	150	185	n.a.
Waste meat/fish							
Study 1: à-la-carte restaurant	0	0	10	0	0	0	0.05
Study 2: work canteens ^a	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Study 3: self-service restaurant	0	0	0	0	0	0	0.86
Study 4: buffet restaurant ^b	18.3	13.3	36.3	19.4	11.6	20.0	n.a.
Waste vegetables							
Study 1: à-la-carte restaurant	0	0	19	10	0	54.5	< 0.01
Study 2: work canteens ^a	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Study 3: self-service restaurant	0.0	0.0	2.5	0.0	0.0	5.3	0.51
Study 4: buffet restaurant ^b	14.1	5.4	20.8	31.9	19.8	39.7	n.a.

Notes: Data in this table is presented as medians (*Mdn*) and interquartile range (Q1 and Q3); *p* indicates the p-value; n.a. indicates 'not applicable', which means that data for this aspect was not available.

^a Consumption and waste were not measured in grams for Study 2. Respondents had to indicate in the questionnaire what percentage of the sandwich they had eaten.

^b Data are based on total food consumption and waste of all guests. Because no individual data on consumption and waste were collected, means instead of medians were reported (total consumption/number of guests per evening) and no statistical tests were possible.

3.2. Results

Consumption data of 337 diners were collected, of whom 185 diners also completed the questionnaire of 23 questions. The average age of the respondents was 47.7 ± 15.8 years and 52% were men. Two thirds of respondents visited the restaurant for the first time and 77% had a high-level education.

The median amount of consumed vegetables was significantly higher with 14% ($p < 0.001$), from 109 g in the control period to 124 g in the intervention period. Simultaneously, the median amount of wasted vegetables significantly increased from 0 g to 10 g ($p < 0.01$). The meat/fish consumption was significantly lower with 13% ($p < 0.001$) from 146 g to 127 g, with no difference in the amount of meat/fish wasted (Table 1).

There was no significant intervention effect on guest's satisfaction with the restaurant visit and overall meal satisfaction, though the latter tended to be somewhat lower during the intervention period as compared to control period. In both conditions, most guests indicated that they were "satisfied" or "very satisfied" with their meal. Also, evaluation of the presentation of the meal was not affected by the intervention (Table 2).

Additionally, there was no significant difference in the medians of participants' evaluation of the amount of meat/fish ($Mdn_{\text{control}} = 3.0$

Table 2

Median guest satisfaction during control and intervention period^a.

	Control			Intervention			<i>p</i>
	<i>Mdn</i>	Q1	Q3	<i>Mdn</i>	Q1	Q3	
Satisfaction restaurant visit							
Study 1: à-la-carte restaurant	4.0	4.0	5.0	4.0	4.0	5.0	0.89
Study 2: work canteens	4.0	4.0	5.0	4.0	4.0	5.0	0.31
Study 3: self-service restaurant	4.0	4.0	4.0	4.0	4.0	4.0	0.46
Study 4: buffet restaurant	4.3	3.6	4.3	4.3	3.6	5.0	0.07
Satisfaction overall meal							
Study 1: à-la-carte restaurant	4.0	4.0	5.0	4.0	4.0	5.0	0.09
Study 2: work canteens	4.0	4.0	5.0	4.0	4.0	5.0	0.28
Study 3: self-service restaurant	4.0	3.0	4.0	4.0	3.0	4.0	0.44
Study 4: buffet restaurant	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Satisfaction meal presentation							
Study 1: à-la-carte restaurant	4.0	4.0	4.0	4.0	4.0	4.0	0.18
Study 2: work canteens	4.0	4.0	5.0	4.0	4.0	5.0	0.27
Study 3: self-service restaurant ^b	3.0	3.0	4.0	4.0	4.0	4.0	< 0.01
Study 4: buffet restaurant	3.6	2.9	4.3	4.3	3.6	4.3	< 0.05

Notes: Data in this table is presented as medians (*Mdn*) and interquartile range (Q1 and Q3); *p* indicates the p-value; n.a. indicates 'not applicable', which means that data for this aspect was not available.

^a Satisfaction was originally measured on a 5-, 7- or 100-point scale. For the analysis, all measures were converted to a 5-point scale with 1 = not at all satisfied/attractive and 5 = very satisfied/attractive.

^b Only presentation of vegetables, not whole meal.

and $Mdn_{\text{intervention}} = 3.0$, with 1 = too little and 5 = too much) and vegetables between the control and intervention period ($Mdn_{\text{control}} = 3.0$ and $Mdn_{\text{intervention}} = 3.0$). Most guests, in both the control and intervention period, evaluated the amount of meat/fish and vegetables as "just right". However, the taste of vegetables was appreciated significantly less during the intervention period, while for meat/fish, appreciation of taste did not differ between control and intervention period (Fig. 2).

3.3. Conclusion

While vegetables consumption increased, and meat/fish consumption decreased, we did not detect a significant effect of adjusted serving sizes on guest's satisfaction with the restaurant visit and overall meal satisfaction, though the latter tended to be lower during the intervention period as compared to control. A number of observations stand out. First, the finding that guests were less satisfied with the taste of vegetables might suggest that people became more critical when greater portions of vegetables were served. This implies that portion size of meat was too low relatively to vegetable size, taking into account that the preparation and presentation of vegetables was not improved. To further investigate whether a tasty preparation of vegetables becomes more important by increased portion sizes, in the following studies more attention was paid to better preparation and taste of vegetables as part of the meal. Secondly, most visitors were not regular visitors, which raises the question whether adjusting portion sizes of meat/fish and vegetables is also acceptable to people who frequently visit a specific restaurant and are familiar with the food offers of a certain food outlet. Finally, this intervention was tested in a specific settings (à-la carte restaurant). As eating experiences may differ in different settings, the replicability of the findings should be tested in a different food context. Therefore, Study 2 tested the effects of modifying portion sizes of vegetables and meat on lunch sandwiches in company canteens with regular visitors.

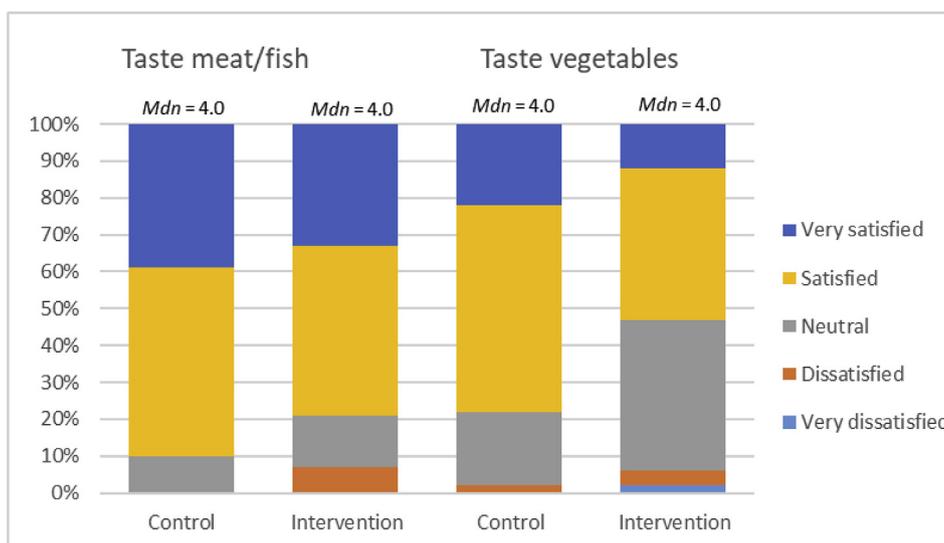


Fig. 2. Distribution of guest satisfaction ratings (in percentages) for taste of meat/fish and taste of vegetables in control and intervention period, Study 1 (n = 181). Note: *Mdn* = median.

4. Study 2: adapting recipes of luxury sandwiches in company canteens

4.1. Method

Study 2 was carried out in six company canteens operated by one company caterer at different locations in the Netherlands. The company canteens served a diverse clientele of office and factory workers from multinationals and a governmental organization. Study 2 consisted of a control and intervention period of 1 day at each location. During the control period, the standard recipes of (luxury) sandwiches, a common consumed food for lunch in the Netherlands, were maintained. During the intervention period, the recipes of six luxury sandwiches were adapted to contain less meat or fish and more vegetables. Depending on the type of sandwich, portions of meat/fish were reduced by 20–50%, with an average reduction of 34%, i.e. from 75 g to 50 g. Vegetable content on average more than tripled (+237%), i.e. increasing from 18 g to 60 g. Besides adaptations in the proportion of meat/fish and vegetables, the ingredients and preparation of the sandwiches were adjusted to retain a full flavour and attractive visual appearance: more diverse vegetables were used, which were especially selected to fit well with the meat or fish topping resulting in an overall balanced taste; luxury ingredients were added; and smaller pieces of meat or fish were equally distributed over the sandwich to ensure a full taste with every bite. See Fig. 3 for an example picture.

Guests who bought one of the studied luxury sandwiches were provided a questionnaire of closed questions and were requested to rate their satisfaction with the sandwich (overall, taste, presentation, amount of meat/fish and vegetables), indicate how much of it they had consumed, and their intention to buy the sandwich again, on a scale from 0 to 100. For ease of comparison across the four studies, satisfaction ratings were converted to a 5-point scale before analysis. Respondents remained unaware of the actual experiment (i.e. changes in portion sizes).

4.2. Results

Across the six locations, 395 respondents completed the questionnaire (control: n = 208, intervention: n = 187). Of these, 65% indicated to visit the canteen at least three times a week; 54% reported to buy the same luxury sandwich at least once a month.

In both the control and intervention period, the sandwiches were



Fig. 3. Presentation of the sandwich with salmon in intervention period (left) versus control period (right).

generally consumed in full (median 100%; IQR 5%), resulting in a 237% higher vegetable and 34% lower meat/fish consumption, with no difference in food waste (Table 1).

Similar to Study 1, there was no statistically significant difference in satisfaction with the restaurant visit, overall meal satisfaction, and satisfaction with the presentation of the meal between control and intervention period (Table 2). In both conditions, guests were equally satisfied with the taste of vegetables as well as with the taste of meat/fish. Furthermore, evaluation of the amount of vegetables significantly improved during the intervention period, while evaluation of the amount of meat/fish remained the same (see Fig. 4). During the control period 70% of the participants indicated that they would buy the sandwich again; during the intervention this was 75%.

4.3. Conclusion

Studies 1 and 2 demonstrated that consumption can be shifted from animal-based towards plant-forward meals by adjusting the amounts of meat and vegetables. By paying more attention to the preparation of the sandwiches in the intervention, we found that satisfaction with the adjusted sandwiches remained high and the specific satisfaction with the amount of vegetables even increased. This shows that even among regular customers, a reduction in animal-based products does not necessarily lead to disapproval when guests are not informed about these

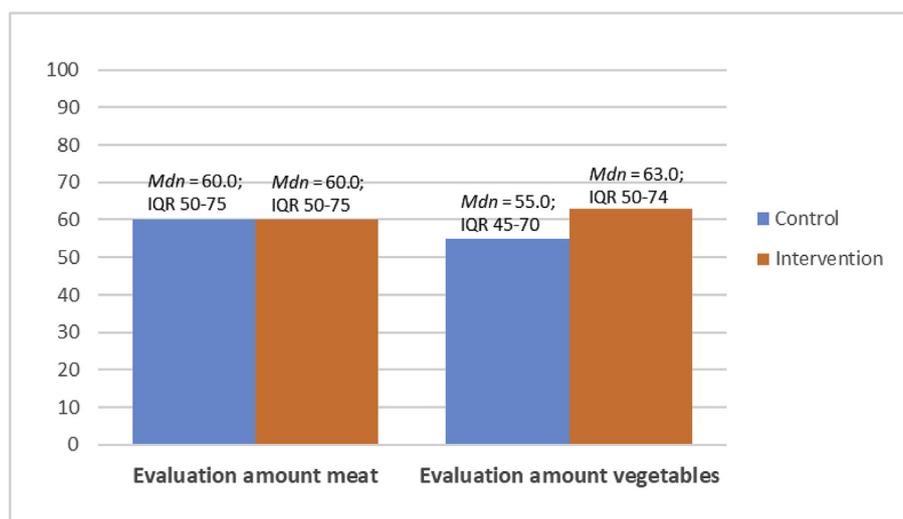


Fig. 4. Evaluation of amount of meat and vegetables in control and intervention period for Study 2 (n = 391). Note: Evaluation was on a scale from 0 (Too little) to 100 (Too much); Mdn = median; IQR = interquartile range.

changes.

Study 3 was designed to check the robustness of these findings in another setting and to test whether guests would accept adjusted portion sizes when they are informed about the changes. To study conscious preference for a sustainable menu change, we provided guests the option to actively choose between a regular meal and a meal with adjusted portion sizes.

5. Study 3: re-designed hot dishes in a self-service restaurant

5.1. Method

Study 3 was carried out in a company-owned self-service restaurant, located in a railway station. The restaurant had a contemporary Italian market style and used a counter concept where guests could order, pick up, and eat their meals. This study consisted of three parts: 1) a control period, during which regular meals were served, followed by 2) an intervention period, during which adjusted meals were served, and 3) an active-choice period, during which guests could make an informed choice between the regular or adjusted version of meals. All periods lasted for four weekdays (Tuesday-Friday).

Adjusted meals on average contained 14% less meat/fish, i.e. 145 g as compared to 168 g in regular meals. The salad garnish of regular meals was transformed into a full quality side salad, by doubling the portion size from on average 60 g–120 g and using a greater variety of colourful vegetables and luxury ingredients to improve taste and appearance. See Fig. 5 for a presentation example of a dish in the control period versus the intervention period. In one meal, i.e. chicken stew, part of the meat was also replaced by hot vegetables to maintain a full chunky appearance. Re-engineered meals contained on average 113% more vegetables than regular meals. During the control and intervention period, food consumption and waste were measured by serving standard portion sizes and by weighing of leftovers. When guests had (nearly) finished their meal, they were asked to complete a questionnaire of 22 questions and rate their satisfaction with the meal (overall, taste, amount and presentation) on a 5-point Likert scale ranging from 1 = not at all satisfied/too little to 5 = very satisfied/too much.

While in the control and intervention period, respondents remained unaware of changes in portion size, during the third part of the study (i.e. the active choice period), guests were prompted whether they “wanted the dish with extra vegetables and a bit less meat or a dish with the regular portion sizes”. To ensure that cashiers asked the question in the



Fig. 5. Presentation of the steak dish in control period (top) versus intervention period (bottom).

correct way, i.e. mentioning the re-engineered version first, and highlighting the higher content of vegetables first, rather than the reduced amount of meat, the exact phrasing of the question was printed and placed on the counter next to the cash register. The phrase was also provided to ensure that all guests received exactly the same request, as asking whether they wanted a more sustainable or healthier dish may prompt them in a different direction. Sales numbers of the regular and adjusted versions of the four dishes were recorded; food consumption and satisfaction were not assessed during the active choice period. Guests were unaware that their choice was being monitored.

5.2. Results

Consumption data were available for 479 guests, of whom 347 also completed a questionnaire. Of the respondents, 54% had visited the restaurant before. Compared with the control period, the median amount of consumed vegetables was significantly higher with 99% ($p < 0.001$) from 60 to 120 g. The meat/fish consumption was significantly lower with 12% ($p < 0.001$) from 159 to 140 g. Waste of meat/fish and vegetables did not significantly differ between control and intervention period (see Table 1).

Results showed that there was no significant difference in guests' satisfaction with the restaurant visit or overall meal satisfaction between control and intervention period. However, guests were significantly more satisfied with the taste, presentation and amount of

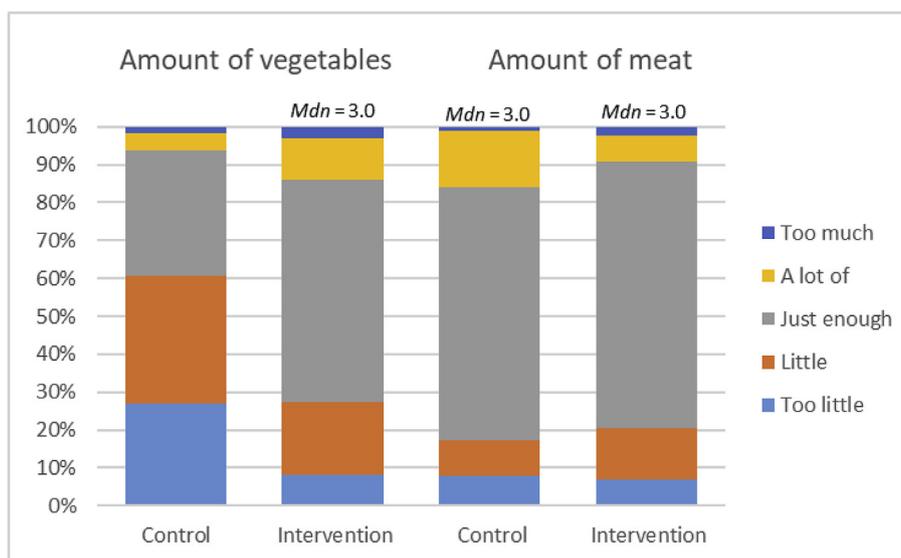


Fig. 6. Distribution of guest ratings (in percentage) of amount of vegetables and meat in control and intervention period, Study 3 (n = 347). Note: *Mdn* = median.

vegetables in the intervention period as compared to the control period (Table 2, Fig. 6). While in the control period, 60% of guests rated the amount of vegetables as “(too) little”, in the intervention period, the majority of guests evaluated the amount of vegetables as “just enough”. Satisfaction with the amount of meat/fish was not affected by the intervention.

In the third part of the study in which guests could actively choose between a regular and an adjusted version, of the 308 guests, 35% actively choose for a dish containing more vegetables and less meat. Major differences in choice behaviour were found between the type of dishes; guests who ordered salmon most often chose the modified version (48%), followed by those ordering steak (38%) and chicken (33%). Of the guests who ordered a hamburger, only 20% chose the version with more vegetables and less meat.

5.3. Conclusion

Study 3 showed that in a self-service setting providing less meat/fish, but more and a higher variety of vegetables to improve taste and appearance resulted in a shift in consumption, while guest satisfaction remained the same or even improved. Besides, the fact that about one third of guests actively chose for the option of more vegetables and less meat after prompting, indicates there is acceptance and demand for more plant-based meals out of home. Study 4 examined whether this demand can also be tapped into without a conscious prompt by the cashier. Therefore, we turned to a buffet setting and investigated whether consumption of vegetables and meat changed when offerings in a buffet were changed and guests were able to choose for themselves which food they put on their plates.

6. Study 4: buffet engineering in an “all you can eat”-buffet

6.1. Method

Study 4 was carried out in a buffet restaurant of a large hospitality chain that is known for large portion sizes of meat and visited by guests of all social-economic levels. The restaurant's dinner buffet offers a range of hot and cold dishes, including starters, soups, cold meat and fish items, cheese, hot meat dishes and vegetables, a live cooking area, where meat and fish are grilled on the spot, a salad bar, and desserts. Study 4 consisted of a control and intervention period of three days each. During the control period, the usual offer of the dinner buffet, was

maintained. During the intervention period, three hot meat dishes were replaced by hot vegetarian dishes (i.e. vegetable lasagne, vegetable curry, falafel), and in one meat dish, half of the meat was replaced by vegetables. The newly introduced vegetarian dishes were carefully chosen because they were thought to be familiar and accessible to the general population. Too fancy or unusual vegetarian dishes were avoided, as they might deter people. Deliberately, the new dishes were not promoted as “vegetarian dishes”. Instead, to merge them naturally into the buffet offer, they were presented as “world cuisine dishes” along with the adjusted meat dish (i.e. babi pangang). Also, the regular offer of prepared salads was completely renewed by introducing fresh, self-prepared salads of high quality. The new salads were carefully composed of ingredients that fit well together on taste and provide colour; special ingredients (e.g. bulgur, sweet potato, fresh herbs) and preparation methods (e.g. grilled, coarse-cut vegetables) were used for a luxury appeal. Fig. 7 provides a pictorial example of the presentation of the salad bar in the control period versus the intervention period. In total, two of the salads and four of the warm dishes contained meat in the control period, during the intervention none of the salads contained meat and only one of the warm dishes contained meat though 50% of the meat was replaced with the equal amount of mixed vegetables.

Total food consumption and waste per evening from the overall buffet was measured. Only consumption and waste of mains and side dishes were measured, hence, excluding the desserts, soups, bread, amuses and sushi. On each study day, all food, including the amount of food that had to be replenished during the evening, was weighted before it was served at the buffet. Also, all food that remained on the buffet or on guests' plates and had to be thrown away, was weighted. Total food consumption and waste per evening was divided by the number of guests present, to estimate the average per person. For the adjusted hot dishes and the salad buffet, we also assessed the total number of servings taken (per evening) and the average serving size (i.e. number of serving spoons), by observing and counting guests scooping up behaviour. When guests had finished their main course, they were asked to complete a questionnaire of 21 questions with several satisfaction ratings ranging from 1 = not at all satisfied to 7 = very satisfied, which were converted to a 5-point scale before analysis for ease of comparison across the four studies. Guests remained unaware of the actual experiment (i.e. change in buffet offer).



Fig. 7. Presentation of the salad bar in control period (top) versus intervention period (bottom).

6.2. Results

Overall, food consumption and scooping up behaviour of 1312 guests was measured, of whom 542 guests also completed the questionnaires. Of the respondents, 68% had visited the restaurant before.

Compared to the control period, the average amount of vegetables consumed per person during the intervention period was 113% higher; average meat consumption was 4% lower. The amount of vegetables wasted was twice as high, while waste of meat remained similar (Table 1). Most waste came from what remained on the buffet, rather than from leftovers on guests' plates.

No significant differences were found in overall satisfaction with the restaurant visit between control and intervention period (Table 2). In both conditions, most guests (82% in the control period and 85% in the intervention period) indicated that they were "satisfied" or "very satisfied" with their visit. Testing differences between the medians revealed that during the intervention period, guests were significantly more satisfied with the presentation of the buffet (Table 2) and with the amount of vegetable options ($Mdn_{control} = 4.3$ (IQR 2.1) and $Mdn_{intervention} = 4.3$ (IQR 2.1), with 1 = very unsatisfied and 5 = very satisfied, $p < 0.05$). There was no significant difference in participants' evaluation of the assortment of meat/fish ($Mdn_{control} = 4.3$ (IQR 0.7) and $Mdn_{intervention} = 4.3$ (IQR 0.7).

6.3. Conclusion

Study 4 showed that in a buffet setting, where guests could freely choose their foods, increasing the number of vegetarian options and renewing the salad buffet, led to an increase in vegetable consumption and a reduction in meat consumption, while satisfaction with the amount of vegetable options increased.

7. Discussion

7.1. Discussion of the results

This series of experiments consistently showed that increasing portions of vegetables and reducing portions of meat or fish was effective to reduce meat consumption and increase vegetable consumption, while maintaining high guest satisfaction. This is in line with previous research (Reinders et al., 2017). In addition, the studies showed that when more attention was paid to the preparation and presentation of vegetables, satisfaction with the amount and taste of vegetables and with the presentation of the overall meal even increased. Even if guests were in control of what they scooped up (i.e. in the case of a buffet), the adjusted offer positively influenced their dietary consumption and satisfaction. Enhancing vegetable consumption by serving larger portions is in line with previous literature, which repeatedly found that portion size affects food consumption (Steenhuis & Poelman, 2017). Several underlying mechanisms have been acknowledged (Herman, Polivy, Pliner, & Vartanian, 2015). One of these mechanisms includes the tendency to clear one's plate ("plate clearing"), although consumers will not always finish all of a meal served and differences between consumers can be observed (Robinson et al., 2018; Sheen, Hardman, & Robinson, 2018). Similarly, decreasing meat consumption through serving smaller portions, is also in line with previous literature: Freedman and Brochado (2010) found that reducing the portion sizes of French fries helped to decrease average French fries' consumption in an all-you-can-eat setting. Specifically, they showed that "decreasing portion sizes of an energy-dense food is not noticed by most diners in an all-you-can-eat environment, and therefore, can make a difference in overall caloric intake" (p. 1866).

A second finding is that the absolute amount of meat and vegetable waste remained similar or slightly increased in line with the amount offered. Only in the buffet setting, vegetable waste considerably increased, which mainly came from what remained on the buffet rather than from guests' plates. However, relative to the amounts consumed, the amounts of waste for vegetables and meat were similar in intervention and control periods. This may be explained by the aforementioned "plate clearing" effect and is in line with the finding by Cohen, Richardson, Parker, Catalano, and Rimm (2014), who found that vegetable consumption increased with greater portion sizes, without increasing waste. To reduce the absolute amount of waste, especially in a buffet setting, continuous observation and recording of the amount and kind of (vegetable) dishes wasted may be a way to better adjust the amounts that are served, to match guests' preferences and appetite. To illustrate this, in our buffet study (Study 4), we noticed on the first day of the intervention, that one dish (i.e. falafel) was wasted a lot. Therefore, on the second day, chefs directly adjusted the recipe of the dish, which indeed led to increased consumption and less waste. Structural monitoring may therefore help to further decrease food waste.

Third, the results of these four studies suggest that to be consumed and appreciated, larger vegetable offerings need to be more tasty and attractive. This corroborates the finding from Abe and Akamatsu (2015) that the effects of increased standardized portion sizes can influence consumption only to a certain extent. They found that 'too large' portion sizes led to increased waste on plates if the taste was not optimal. If a restaurant improves taste and presentation of vegetables, it is possible to increase guest satisfaction. For example, Zellner, Loss, Zearfoss, and Remolina (2014) showed that people tended to like the food on their plates more when it was presented in a more attractive manner. They suggest that an attractive presentation of food can affect liking for the flavour of the food and therefore can be used to increase the acceptance of healthy foods like vegetables.

Fourth, in Study 3, we found that about one-third of the guests actively chose the modified serving with more vegetables and less meat when prompted. This is in line with earlier research that showed that a

verbal prompt could help to downsize portions. For example, in a fast-food setting, 14–33% of customers accepted the downsized option after being prompted (Schwartz, Riis, Elbel, & Ariely, 2012). Additionally, Vermeer, Steenhuis, Leeuwis, Heymans, and Seidell (2011) and Berkowitz, Marquart, Mykerezzi, Degeneffe, and Reicks (2016) analysed the effect of openly offering different portion sized meals or starters at the point of food ordering and showed that a reasonable share of guests were willing to choose a smaller portion without financial rewards. Lorenz and Langen (2018) argue that verbal prompts could help consumers to choose the healthier alternative by implying a consumption norm or activating one's self-control. Moreover, our findings fit the trend that an increasing number of people are willing and trying to reduce their meat consumption (Kateman, 2017). Interestingly, our study found major differences in choice behaviour depending on the type of dish ordered. Guests who ordered salmon were more likely to choose the modified option than guests who ordered a hamburger. More research is needed to investigate product- and person-specific characteristics that may play a role in how people react to prompts regarding vegetable and meat portion sizes.

Finally, consumption of vegetables also increased in a buffet setting in which guests were free to choose which dish they scooped on their plates and how much of it (Study 4). Increasing the number of vegetarian and vegetable rich choice options led to increased consumption of vegetables and slightly reduced consumption of meat. The results of this study imply that also modifying the proportions of meat and vegetable options in buffets can stimulate more healthy and sustainable consumption behaviour. Lassen, Hansen, and Trolle (2007) investigated how food consumption of guests in worksite canteens differed between buffet style serving systems compared to à-la-carte systems and found that guests in buffet-style canteens showed higher consumption of fruits and vegetables. They suggested that buffet-style serving systems may lead to increased consumption because they “encourage people to combine different options”. Other studies also showed that providing more choice could help to stimulate consumption (Burns & Rothman, 2015). For example, Parizel, Labouré, Marsset-Baglieri, Fromentin, and Sulmont-Rossé (2017) found that providing more choice increased vegetable liking and vegetable consumption.

7.2. Strengths and limitations

A major strength of the current research is that all four studies were conducted in everyday settings indicating real-life robustness and feasibility. Adaptations in menu offerings were co-developed and agreed together with the staff of the participating restaurants, to ensure that interventions were practically feasible and economically viable, as well as to create commitment and ownership amongst staff to carry out the changes in a responsible way. Therefore, adapting portion sizes in menu offerings is not only an effective but also a viable tool that can be integrated in every-day kitchen practice. Nevertheless, future research may investigate whether kitchen staff can maintain this practice over a long time, and what may be potential barriers and motivators to maintain the changes.

Related to this, another strength of the fact that the current research was conducted in everyday settings, is the external validity of the evidence. The different types of food service settings, serving various clientele in different contexts, together with the overall large sample size of nearly 1500 participants across the four studies, suggest that modifying portion sizes or proportions of choice options can be effective and feasible in many settings. Whether these effects may differ in specific out of home settings, for instance those with a clear focus on convenience (e.g. fast food restaurant, snack bar, ready-to-eat meals) or health (e.g. hospital restaurants) remains to be elucidated.

A limitation of all studies described in this research was the lack of a simultaneous control group, however results were compared with a control period. Therefore, temporal changes (e.g. special occasions and/or menu changes) may have influenced consumption.

from the returned questionnaires showed that subjects in the control and intervention groups were relatively similar with regard to age and gender.¹ However, we cannot rule out selection biases, e.g. people with a more outspoken opinion, or those who were particularly (dis)satisfied with their restaurant visit may have been more likely to complete the survey. Nonetheless, having a parallel control group would have caused additional pressure and logistical difficulties for the kitchen and serving staff, and thereby may have had a negative impact on the quality of meals.

Study design and questionnaires were not only adjusted to the specific situation and interests of the restaurants, but also improved for each subsequent study as the learnings of previous studies were used as input to design the following study. Therefore, the questionnaires and items asked were slightly different per study, which impedes a direct comparison between the studies, for some of the outcomes.

Finally, we were sometimes faced by challenges to measure the consumption and waste. As Study 2 was a take-a-way product, it was not possible to collect and weigh the waste. Instead, we had to rely on the self-reported estimation of the guests on the wasted amount. In the self-service restaurant (Study 3), it was common that guests discarded their trash themselves. If researchers or staff were not quick enough to collect the plates, we could not collect the consumption or waste data of that person whilst their questionnaire data was included. In the buffet setting (Study 4), it happened a few times that the serving staff cleared the plates before the waste was assessed; this will have caused minor underestimation of waste and overestimation of the amounts consumed.

7.3. Practical implications and conclusions

This research showed that reducing meat consumption and increasing vegetable consumption in out of home settings is possible by modifying portion sizes proportion of meat and vegetable dishes on offer, and by paying more attention to the preparation and presentation of vegetables. It remains to be investigated what would be an optimal ratio of meat and vegetables to maximize guest satisfaction, environmental impact and health. In our four studies we observed that a 12–34% average decrease in the amount of meat and 31–237% average increase in vegetables did not alter guest satisfaction. Nevertheless, it is important to tailor the optimal amounts of meat and vegetables according to the type of dish that is served.

In our studies, the adjusted portion sizes still did not reach recommended levels for meat and vegetable consumption (e.g. max.70 g meat per day and 250 g of vegetables per day), but they are a step in the right direction. Other means to reduce meat and increase vegetable consumption out of home include the introduction of new plant-forward dishes, in which meat is not the centre-piece of the meal but rather used as a condiment (The Culinary Institute of America, 2016). Blended burgers, i.e. burgers in which part of the meat is replaced by mushrooms or other vegetables is another example of how to shift consumption from meat towards more plants (The Culinary Institute of America, 2016). For example, Myrdal Miller et al. (2014) showed that in beef taco blends, in which 50 percent of meat was replaced by mushrooms, enhanced its overall flavour. Nevertheless, consumers' eventual acceptance of blending plant-based ingredients into meat products depends on consumers' assessment of the taste, health, sustainability, cost, and novelty of these plant-based products (Lang, 2020).

In addition to introducing plant-forward dishes, using attractive, indulgent language to describe vegetable dishes, e.g. relating to the flavour, look and feel or origin of the ingredients, has been shown to

¹ Note that in Study 2 about 76% of the participants were men. A possible reason for this skewed gender distribution might be that some company canteen locations were at companies with a lot of male employees (e.g. steel and chemical industry).

increase vegetable consumption in various out of home settings (Turnwald & Crum, 2019; Turnwald, Bolez, & Crum, 2017).

Besides influencing immediate food consumption of diners, chefs can also play an important role in driving the overall transition towards more plant-based diets. By inspiring their peers, guests, and the wider (online) audience with tasty and exciting vegetable dishes and plant-forward menus, they can have a positive impact on people's attitude towards plant-forward eating and people's overall eating pattern, both at home and out of home. For example, "The Chefs' Manifesto", a chef-led initiative, calls on chefs around the world to make changes in their kitchens and recipes for a more sustainable food system. Another example of a global initiative, which targets chefs as champions to advance sustainable, plant-forward eating is the "Plant-Forward Global 50" (a global list of 50 chefs and restaurants recognized by the Culinary Institute of America (CIA) and the EAT Foundation).

Ultimately, serving more vegetables and less meat in restaurants can reduce the environmental impact of meals, as the production of vegetables requires less water and causes less greenhouse gas emissions than the production of meat. Since meat has about a 2 to 9 times higher CO₂-footprint than vegetables (Clune, Crossin, & Verghese, 2017), the amount of CO₂ saved by serving less meat, outweighs the amount of CO₂ associated with the additionally served (and sometimes wasted) vegetables. Additionally, adjusting portions of meat and vegetables generally leads to lower costs for the restaurant/food outlet, as vegetables are generally cheaper than meat. Nevertheless, further research is needed to assess the exact environmental impact and the costs related to it.

In conclusion, the studies in four different out of home settings consistently showed that adapting portion sizes in menu offerings is effective to reduce meat consumption and increase vegetable consumption, while maintaining high guest satisfaction. Guest satisfaction may even increase when vegetables are presented and prepared in a more attractive and tasty way.

Declaration of competing interest

The studies were carried out independently in 2017 and 2018 by Wageningen University & Research, Louis Bolk Institute and Greendish. Mrs. Lilou van Lieshout is an employee of Greendish, Mrs. Nicole Neufingerl is an employee of Unilever Nutrition Research, Mr. Joris Heijnen is employee and owner of Greendish. The opinions expressed herein and the conclusions of this publication are those of the authors and do not necessarily represent the views of their companies.

Author contributions

MR wrote the manuscript and contributed to the conceptualization and design of the studies. LL coordinated the design of the studies and was responsible for the execution of the experiments. GP carried out the data analyses and helped to write the manuscript. NN contributed to the conceptualization and design of the studies, contributed to the literature review and helped to write the manuscript. EB contributed to the design of the studies and critically revised the manuscript. MBF carried out the data analyses and critically revised the manuscript. Finally, JH provided the idea for the study and critically revised the manuscript. All authors read and approved the final version of the manuscript.

Acknowledgements

This research has been performed as part of a public-private partnership Food, Value & Impact, funded by the Dutch Topsectors Agri & Food and Tuinbouw & Uitgangsmaterialen. We would like to thank Marieke Meeusen, Erik van Bommel and Heleen Bronsveld for project management and Lisa van der Spijk, Amber Heijnen, Gijs van Bokkem, Renseke Borgerhoff, Liz Driessen, Rosjalie Jansen, Jos Schreij, Carlijn Kappers and Jeanne Steverink for helping with the execution of the

fieldwork and desk research activities. Furthermore, we would like to thank the managers, chefs, and participants in all the restaurants that participated in the studies reported in this article.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.appet.2019.104539>.

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