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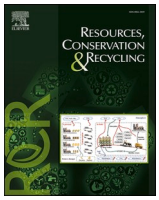

Full length article

Use-up day and flexible recipes: Reducing household food waste by helping families prepare food they already have

A. Cooper [a,1], R. Lion [b,*,1], O.E. Rodriguez-Sierra [a,1], P. Jeffrey [c,1], D. Thomson [a,1], K. Peters [a,1], L. Christopher [a,1], M.J.H. Zhu [a,1], L. Wistrand [d,1], P. van der Werf [e,f,1], E. van Herpen [g,1]

[a] BEworks, 946 Queen St W Toronto, ON, M6J 1G8, Canada
[b] Unilever Foods Innovation Centre, Wageningen, Bronland 14, WH, Wageningen, 6708, The Netherlands
[c] Marketing Mums, 54 Arbrook Ln, Esher, KT10 9EE, United Kingdom
[d] WRAP, 2nd Floor, Blenheim Court, 19 George Street, Banbury, OX16 5BH, United Kingdom
[e] Department of Geography and Environment, Human Environments Analysis Laboratory, Western University, 2333 Social Science Centre, 1151 Richmond St, London, ON, N6G 2V4, Canada
[f] Ivey Business School of Western University, 1255 Western Rd, London, ON, N6G 0N1, Canada
[g] Department of Marking and Consumer Behaviour, Wageningen University, Hollandseweg 1, KN, Wageningen, 6706, The Netherlands

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ABSTRACT

In two 5-week randomized-controlled field studies, Canadian and US households were invited to make one meal per week from food that might otherwise be discarded, using flexible recipes. In the first study (Canada), tools to increase the salience of unused food (storage basket, clips to tag, or whiteboard) were also explored. A second study (US) examined a shorter program and the addition of follow-up reminders. Food waste was assessed with a self-reported food waste measure. Intervention groups reduced their food waste significantly versus baseline by 33% (Canada) and 46% (US) and versus control by 27% (Canada) and 33% (US). The salience tools (study 1) or duration (study 2) had no impact. Eight weeks after the intervention food saving continued although the intervention conditions no longer differed significantly from control. In the US, change in Perceived Behavioral Control partially mediated the impact of the intervention on food waste reduction.

1. Introduction

With an estimated 931 million tonnes of food wasted every year, of which 60% is wasted in households, there are clear environmental, monetary, and societal benefits for households to reduce food waste (UNEP, 2021). Total food waste accounts for 8% of global greenhouse gas emissions, has an estimated worth of US$750 billion (FAO, 2013) and could have provided energy and nutrients to those in need (Chen et al., 2020).

Although our understanding of the determinants of household food waste has improved over the past decade (Principato et al., 2021; Reisch et al., 2021; Roe et al., 2020), reviews indicate there are few well-designed studies assessing the effectiveness of behavioral interventions aimed at reducing waste in households (Nisa et al., 2019; Reynolds et al., 2019; Roodhuyzen et al., 2017; Stöckli et al., 2018). The current research aims to help fill this gap by developing an intervention using the Motivation-Ability-Opportunity framework and assessing its effectiveness in reducing household food waste.

Wasting food is the unintended outcome of a complex set of food management behaviors, ranging from meal planning and grocery shopping through to how foods are stored, prepared, consumed, and disposed of (Principato et al., 2021; van Geffen et al., 2020b). In order to create a focused behavior change program, choices have to be made with respect to the target behavior (Schultz, 2014; Wilson et al., 2015) and food waste behaviors were therefore categorized as prevention or recovery behaviors. Prevention behaviors focus on avoiding a surplus of food reaching the household or on ensuring that food does not spoil (e.g., making a shopping list, correct storage), whilst recovery behaviors focus on using all the food that has entered the household (e.g., using up food before it spoils). Adopting prevention behaviors can be challenging

* Corresponding author.
E-mail address: rene.lion@unilever.com (R. Lion).

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for several reasons. First, food waste is not very salient during meal planning or shopping. Second, planning meals takes time and deliberate effort and may feel inflexible (Hebrok and Boks, 2017; Quested et al., 2013). Third, people may not feel like preparing what they had planned because they are too tired, had less time than expected, or had to adjust their schedules (Stöckli et al., 2018; van Geffen et al., 2020a). In fact, avoidable food waste mostly consists of food that has been brought into the home but was not (or only partly) used (Scalvedi and Rossi, 2021; van Geffen et al., 2017), indicating that recovery behaviors are highly relevant. However, interventions encouraging households to recover food from being wasted have not yet received systematic study. The present study aims to fill this research gap and focuses on two key recovery behaviors: (1) identifying foods that are at risk of being thrown away and (2) using these foods in a meal. Most if not all other recovery behaviors, such as the correct use of date labels or correct portioning of food are conditional on these two behaviors. The intervention was developed using the Motivation-Ability-Opportunity Behavior model (Ölander and Thøgersen, 1995), which was developed to address environmental challenges and has been applied in food waste research before (e.g., Soma et al., 2020; van Geffen et al., 2020a). It categorizes determinants into three classes: Motivation, Abilities, and Opportunities.

1.1. Determinants of food waste

Generally, people feel food waste is morally wrong and a waste of money (Parizeau et al., 2015; Quested et al., 2013; Stancu et al., 2016; van der Werf et al., 2021; Visschers et al., 2016), yet people are often not aware of how much they waste (Abeliotis et al., 2014; Quested et al., 2011). Furthermore, the economic consequences of wasting food may not always be high enough (van Geffen et al., 2020a, 2020b; Visschers et al., 2016) and the environmental consequences not salient enough to motivate action (Graham-Rowe et al., 2015; Neff et al., 2015; Stancu et al., 2016; van Geffen et al., 2017). Uncertainty about food safety or the desire to be a good provider for the family can also hinder the adoption of waste reduction behaviors (Hebrok and Boks, 2017; van Geffen et al., 2020a; Visschers et al., 2016). An additional challenge is that pro-environmental goals are relatively removed from a person in both time and place and competing motivations that involve immediate gratification, such as to eat fresh and healthy food, are likely to be prioritized (Trope and Liberman, 2010; van Geffen et al., 2020b).

In addition to these motivational determinants, prior research has indicated that Perceived Behavioral Control (PBC) or the perceived ability to tackle food waste has been associated with lower food waste levels (Aschemann-Witzel et al., 2015; van der Werf et al., 2019, 2021; Visschers et al., 2016). Thus, people need to know how to plan their meals or need to know what they can do with food that was not (completely) used in a recipe.

Furthermore, people often forget what food they have, suggesting a barrier could be a lack of salient prompts or reminders that food is about to expire. They also often lack the time and energy to decide what to cook (BeWorks, 2020; Hebrok and Boks, 2017; van Geffen et al., 2020a), suggesting there is an opportunity to create situational variables or facilitating conditions that make it easier to perform behaviors that help reduce food waste.

1.2. Intervention development

As mentioned, the intervention focused on two recovery behaviors: (1) identifying foods that are at risk of being thrown away and (2) using these foods in a meal. Intervention materials were created based on the Motivation-Ability-Opportunity framework and linked to Behavior Change Techniques (Michie et al., 2013; Ölander and Thøgersen, 1995), see Table 1.

An impactful intervention should tie into existing strong motivations. Thus, rather than viewing the good provider identity (Stöckli et al., 2018; Visschers et al., 2016) as a competing motivation that needs to be overcome, it was reframed into being a good parent or host by being resourceful with food that is available. This was introduced to participants as the Bonus Meal Mission: by participating in the program, participants would be able to make quick and delicious meals with food they already had – a "Bonus Meal" – (an immediate benefit) with the additional benefit of reducing food waste and thus saving money (Hebrok and Boks, 2017; van der Werf et al., 2021).

This motivational message was complemented with concrete and clear instructions about what to do, to prevent it from backfiring (Birau and Faure, 2018; Ruiter et al., 2001). A heuristic approach was used to help people concretize the desired actions as people often rely on mental shortcuts or heuristics to facilitate their decision-making processes when they are stressed or tired (Chaiken and Ledgerwood, 2012; Kruglanski, 1996; Wichary et al., 2016). The intervention therefore included a heuristic – "the 3 + 1 approach" – enabling people to make meals that could be easily adapted to food that is available. The 3 + 1 approach explains how bonus meals can be made by taking a base (often a kitchen staple such as rice or potatoes), vegetables/fruit, and a protein source for the meal, and adding herbs or condiments as a "magic touch" (the +1 element). The flexible recipes provide concrete examples of this approach.

Opportunity was addressed in two ways. First, to encourage follow-

Table 1
Description of how the intervention elements addressed motivation, opportunity and ability.

MOA framework	Main factors impacting the behavior	Program element that addresses this	Behavior Change Technique
Motivation	Conflicting motives (e.g., being a good provider)	Bonus Meal Mission: Food waste reduction presented as a way to be resourceful and obtain an additional meal from food that is available (information booklet)	Information about social and environmental consequences
	The motive of saving money has shown success in prior intervention study	Information booklet "The average Canadian household ends up spending $1100 of hard-earned cash on food that they don't eat."	Material incentive
	The motive of not wanting to waste food	Information booklet: "save food from being wasted"; "pack more nutrition for your family"	Information about social and environmental consequences
Ability	Increased skills and knowledge. People often rely on mental shortcuts or heuristics to facilitate decision-making	3 + 1 approach and flexible recipes	Instructions on how to perform the behavior
Opportunity	Planning a specific time to perform a given behavior helps turning intentions into action	Setting a use-up day	Goal setting/ Action Planning
	Increasing the salience of food	Collect basket Clips/Tracker Whiteboard	Prompts / cues Restructuring the physical environment
	Addressing lack of time & energy	3 + 1 approach and flexible recipes	Regulation/ Conserving mental resources

through on the desired behaviors, we asked participants to select a specific day of the week ("Use-up Day") to make a meal with food they had available, as planning a specific time to perform a given behavior helps to turn intentions into action (Bieleke et al., 2020; Zandstra et al., 2010). Second, we assessed tools to increase the salience of food that was at risk of being discarded. Different ways of increasing food salience were tested, for both inside and outside of the fridge as described in the methods section. We separately tested the effects of tangible tools because we wanted to assess the additional effect these would have in addressing food waste. Not only is this theoretically relevant, but also practically, as the cost and effort involved in distributing these tools affects the scalability of the intervention. It is therefore important to assess their added value.

The main hypotheses of our field study were:

H1: Consumers who received an intervention program would reduce their household food waste during the treatment period relative to consumers who did not receive an intervention program.
H2: The addition of tools to increase food salience would lead to a greater reduction in food waste relative to the intervention program without salience tools.

2. Study 1- testing the intervention program and salience tools

2.1. Method

2.1.1. Participants

Families with children were recruited (through market research panel Delvinia), as they have the highest absolute levels of food waste per household (van der Werf et al., 2020; van Geffen et al., 2017; WasteMinz, 2018). Participants were eligible if 1) the household had at least one child aged 3 to 18, and 2) the participant was responsible for at least half of the household's food preparation and shopping. They were compensated on completion of each touchpoint with their choice of loyalty rewards (in total approximately CAD $120 or US $90). A representative sample of 1205 English-speaking households in Canada was randomly assigned to either the control condition or one of the four treatment conditions. There were no significant differences between conditions in any of the demographics (see Appendix A, Table A1).

To keep the period of food waste reporting consistent, participants were given 48 h to complete each weekly survey. If they did not complete a survey within that period, they were removed from further participation. By week 5 of the study, 75% of participants remained (N = 909, Appendix B, Table B1). A Chi-square analysis found no significant difference in attrition rates between any of the conditions (p = .22). A follow-up survey 8 weeks later was completed by 71% of the sample that finished all five weeks of the study.

2.1.2. Experiment design

The study employed a 5-week, randomized controlled trial (RCT) repeated-measures design. Following a baseline measurement on self-reported food waste, participants in the four treatment conditions received behavioral interventions for the remaining four weeks. All treatment conditions were provided with "The Bonus Meal Mission", and three conditions also received one of three salience interventions. The control group did not receive any materials and only filled out the weekly Food Management Survey. Participants filled out a questionnaire including the self-reported food waste measure every week (see Appendix C, Table C1 for an overview of the study design).

2.1.3. Materials and procedure

The interventions are part of a behavior change program led by Hellmann's (Lion et al., 2018; Nicholson et al., 2014) and emphasized the most wasted food categories: fruits, vegetables, bread and grains (FAO, 2013; van der Werf et al., 2018, 2021). Participants selected a day of the week to make a Bonus Meal. A heuristic (the "3 + 1 approach") encouraged flexible and creative thinking by breaking down a meal into three building blocks, where ingredients could easily be substituted (see Fig. 1 for an explanation of the 3 + 1 approach). A set of 12 flexible recipes were provided as examples (see Supplement 1 for three examples). Following the introduction of the mission in week 1, the subsequent weeks had themes: week 2 focused on "the magic touch", week 3 focused on including fruit, and week 4 focused on making meals with the whole family. Participants in the Salience conditions also received one of three interventions for increasing food salience: a yellow plastic basket in which participants could collect food they did not want to forget to eat ("Collect"), a magnetic dry erase board where participants could track food that they wanted to remember to eat ("Track"), or clips that could be attached to food they wanted to remember to eat ("Tag"; Appendix D provides images of the salience interventions).

The program materials were administered online using Qualtrics. Approximately 10–14 days following recruitment, a package was delivered to the participants, containing a booklet with information about the program, the recovery behaviors, 3 flexible recipes per week, and weekly worksheets where participants could indicate what they made on their Use-Up Day and any notes or reflections they had. Participants in the Salience conditions also received the appropriate salience tool (see Supplement 2 for an overview of the full program).

2.1.4. Measures

All participants filled out a weekly Food Management Survey (FMS). Three categories of questions were included: 1) avoidable household food waste, 2) broader household food management behaviors and attitudes, and 3) engagement in the Bonus Meal Mission (treatment conditions only). Households' weekly food waste was assessed by a subset of the van Herpen et al. (2019b) food waste scale. Participants first indicated which of nine food categories they had disposed of that week (fresh vegetables and salads, non-fresh vegetables (jar/can/frozen), fresh fruit, non-fresh fruit (jar/can/frozen), potatoes, pasta, rice, beans, bread). For each selected food category, they then estimated how much they had disposed of in serving units that varied by food category (e.g., serving spoons, pieces, slices). These were converted to grams of food waste with the conversion formula outlined in van Herpen et al. (2019b). In addition, five questions assessed participants' Perceived Behavioral Control (PBC) around food waste (e.g., "I have the feeling I can't do anything about the food wasted in my household") (van der Werf et al., 2021; Visschers et al., 2016). We expected the interventions to increase Perceived Behavioral Control and wanted to explore change in PBC as a mediator of food waste reduction. We also included a measure for general Food & Cooking skills (Lavelle et al., 2017). PBC and Food & Cooking Skills were assessed at baseline and at the end of the intervention. Measures of participants' attitudes and perceptions of the program assessed whether the target behaviors were perceived to be easy and engaging and were asked after the intervention (see Appendix C, Table C1 for an overview and Supplement 3 for the full post-intervention Food Management Survey).

2.1.5. Statistical analyses

The grams per food category were summed for each household into a total food waste amount in grams per week. Data was analyzed using R (R Core Team, 2021). A linear mixed effects model[2] assessed the impact of Treatment (Treatment vs. Control) and Time (5 weekly timepoints plus follow-up) using the *lme4* package (Bates et al., 2015). A random

[2] The model reported includes all participants in the study at each timepoint. We also ran the model including only those participants who remained until week 5 of the study, and there was no change in the main or interaction effects of the overall model. The residuals showed normal distributions, with the exception of food waste data which showed heteroscadicity: as food waste increased, so did the variance. However, this dampens the effect rather than inflates it.

Fig. 1. Explanation of the 3 + 1 approach.

effect for participant accounted for the repeated measures of food waste. Age, number of children, income bracket, and PBC were included as co-variates. For ease of interpretation, main effects of Treatment and Time were assessed in an ANOVA table based on the linear-mixed effects model results, using the *lmerTest* package (Kuznetsova et al., 2017) with type-III sums of squares; denominator degrees of freedom was estimated using Satterthwaite's method. Linear regression models were used as post-hoc tests to further shed light on differences between the groups at individual timepoints. Results for linear regression models were similarly converted to ANOVA tables where applicable. For the mediation analyses, we assessed whether a change in food waste reduction as a consequence of the intervention was (partially) mediated by a change in PBC. This was done with the *mediation* package in R (Tingley et al., 2014), which models the direct and indirect effects of the intervention on PBC and food waste via quasi-Bayesian approximation. For the mediation analyses, change scores were calculated for Food waste and PBC by subtracting the respective scores in week 5 from week 1. Simulation for the model was run 1000 times.

2.2. Results

2.2.1. Program engagement & perception

The number of participants who reported making a Bonus Meal was consistent over the course of the study, ranging from 64% to 68%. The proportion of participants using their salience intervention (if applicable) increased from week 2 to the remainder of the study, with 48% using their tools in week 2, 73% in week 3, 71% in week 4, and 70% in week 5. Participants reported that the Mission did not require a lot of effort (M = 5.0) and was enjoyable (M = 5.6). At the end of the intervention, Treatment participants considered themselves to be more resourceful (M = 5.1) and more confident (M = 4.9). They also indicated that the 3 + 1 approach and the accompanying flexible recipes made it easier for them to see meal options (M = 4.7) and incorporate fruits and vegetables into their meals (M = 4.9).

2.2.2. Food waste

At baseline, a one-way ANOVA indicated that average food waste did not differ across groups, F (4, 1095) = 0.30, p = .878 (Appendix E, Table E1). The linear mixed effects models showed a main effect of Treatment, F (1, 1141) = 11.10, p = .001, and a main effect of Time, F (1, 4466) = 25.37, p < .001. Crucially, there was a significant Treatment by Time interaction, F (5, 4466) = 3.95, p = .001. The average grams of household food waste per week by condition is depicted in Fig. 2.

Post-hoc linear mixed models showed significant reductions in food waste in the treatment conditions relative to the control condition at all timepoints during the treatment period (weeks 2–5), indicating a significant impact of the interventions on household food waste (see Appendix F, Table F1). Treatment households reduced their food waste by 33.4% relative to their baseline levels, while controls reduced their food waste by 14.4% relative to their baseline level.[3] Moreover, during the treatment period, we found that treatment participants reduced their

[3] Percent change from baseline was calculated by dividing the average difference in grams from baseline for the treatment conditions (i.e., average grams in food waste across treatment conditions at baseline – average grams in food waste across treatment conditions for the entire treatment period) by the average food waste in grams at baseline for the treatment conditions. The same calculation was performed for the control condition.

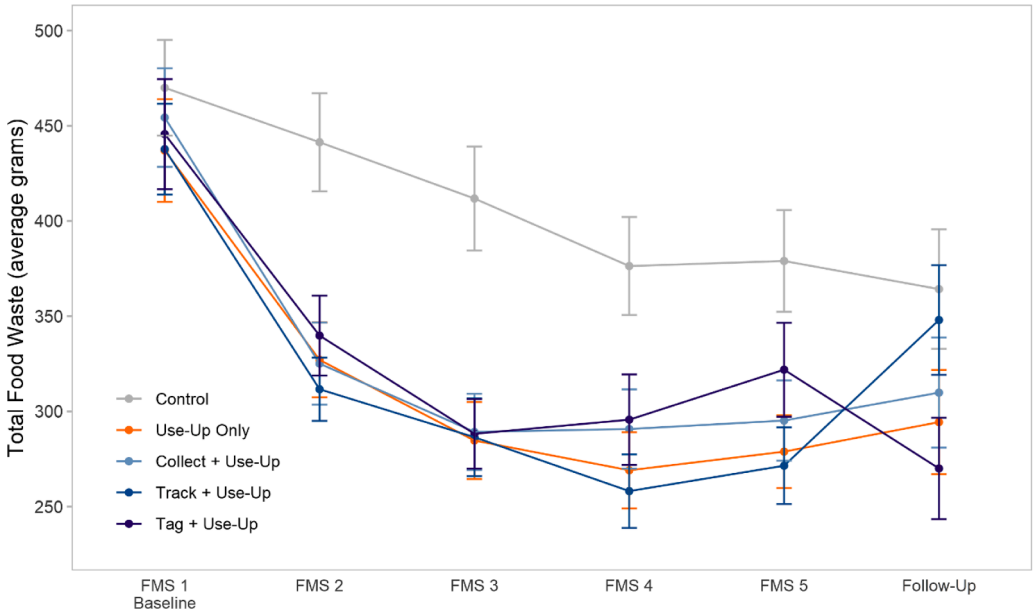

Fig. 2. Total self-reported household food waste over time (baseline to follow-up) in Canada (Study 1).

food waste on average by 26.5% relative to controls.[4] At eight weeks following the end of the treatment period, the difference from control was no longer significant.

A linear regression model assessed the relative reduction in food waste of each treatment condition compared to control at each timepoint in the study. All treatment conditions had significantly lower self-reported food waste than control at each time point ($p < .05$, Appendix G, Table G1) other than the Tag + Use-Up treatment condition at week 4 ($p = .051$) and week 5 of the study ($p = .126$). Consistent with the linear mixed model results, at the follow-up time point, food waste no longer differed significantly from control in the treatment conditions. A one-way ANOVA (excluding the control condition) conducted at each timepoint and controlling for covariates, revealed that no treatment condition differed significantly from any other treatment condition at any given timepoint in the study ($p > .241$ at all timepoints). The salience interventions did not have an additional impact on food waste.

Perceived behavioral control (PBC) was a significant predictor of total self-reported food waste in the mixed effects model, with greater PBC showing a significant negative relationship with self-reported food waste ($b = -80.2$, $p < .001$), consistent with previous reports (van der Werf et al., 2020; Visschers et al., 2016). Food & Cooking skills and Age were also a significant predictors of food waste (p's < 0.006), with higher scores on both associated with greater total self-reported food waste. PBC and Food & Cooking skills correlated moderately ($r = 0.30$, $p < .001$). For a full break down of the ANOVA table, see Appendix H, Table H1. A linear mixed-effects regression examining the change in participants' self-reported PBC as a function of the interventions did not yield a significant interaction effect: change in PBC was not larger in the intervention group relative to the control group $F(1, 1063) = 0.9$, $p = .34$ (Appendix I, Table I1). We therefore did not pursue any mediation analyses.

[4] Percent change from control was calculated by dividing the average difference in grams during the treatment period between control and treatment conditions (i.e., average grams in food waste for control during the treatment period – average grams in food waste across treatment conditions during the treatment period) by the average food waste in grams for the control condition during the treatment period.

2.2.3. Discussion

Selecting a day of the week and helping families make a meal with the food they already have significantly reduced self-reported food waste, supporting Hypothesis 1. The salience tools did not lead to significantly greater reduction in food waste relative to the use-up interventions alone, disconfirming Hypothesis 2. Perhaps encouraging people to have a Use-Up day, where they collect available food, sufficiently raised the salience of such food. The findings also indicated that the main reduction in food waste had occurred by three weeks, and that although food waste levels remained lower at follow-up than at baseline, the impact of the program started to diminish.

3. Study 2- Replication and testing a shorter program

3.1. Introduction

In a second study, we sought to replicate and strengthen the findings of Study 1 with a different group of participants - in this case in the US. Additional research questions investigated the impact of 1) program duration, 2) hardcopy vs online materials, and 3) program maintenance. As the main impact in Study 1 occurred in the first three weeks, a shorter 3-week intervention was compared to the full 5-week program, which would require less effort for both intervention implementers and participants. We also compared the physical booklet with a downloadable PDF, which would lower implementation costs. Finally, to strengthen the long-term impact of the program, we assessed whether adding a monthly reminder in the weeks following the end of the program would help maintain the impact of the intervention.

3.2. Method

3.2.1. Participants

The same eligibility criteria were applied as in Study 1. Participants were recruited through a market research panel (Prodege) and randomly assigned to either the control condition or one of three intervention conditions. For the completion of each touchpoint in the study, participants received loyalty reward points (totaling the equivalent of approximately $60 USD). A representative sample of 1047 households in the US enrolled in the study. There was a significant difference between the conditions for Income ($p < .05$; see Appendix A, Table A2 for detailed demographics). By week 5 of the study, 46% of the participants

remained (see Appendix B, Table B2 for attrition rates).

3.2.2. Design

The study used a RCT repeated-measure design. In the three treatment conditions, participants received the behavioral intervention, which was re-branded "Fridge Night Mission". In two of the intervention conditions, participants received the same 5-week program as in Study 1, either both online and in print (5-week Online + Physical condition), or only online (5-week Online Only). In the "3-week Online + Physical" condition, participants received the first three weeks of the program, which were identical to first three weeks of the 5-week Online + Physical condition. In the fourth and fifth weeks, they were sent a reminder email encouraging them to keep up with their Fridge Nights. They were re-contacted in week 5 to complete a final survey. The participants in the control condition did not receive any intervention materials and completed only the food management surveys.

At the end of the treatment program, participants in the two 5-week conditions were randomly assigned to either receive a monthly reminder e-mail which included a digital copy of the mission booklet encouraging them to keep up with their Fridge Nights or they received no reminders at all (See Appendix C, Table C2 for an overview of the experimental design).

3.2.3. Materials, measures, procedure and statistical analyses

Materials, procedures, measures and statistical analyses were similar to Study 1. The only change to the materials was that "Bonus Meal Mission" had been replaced with "Fridge Night Mission" (all materials are available on request). Furthermore, the food waste measure was extended with four categories - cheese, eggs, meat and fish - to assess whether food waste reduction would extend beyond the most wasted fruits, vegetables, and breads/grains that the intervention focused on.

3.2.4. Results

Engagement with the program was high. Eighty percent of the participants reported completing a Fridge Night each week, and 73% reported using the 3 + 1 approach to make their meal. Additionally, the majority (83%) also reported that they tried to use-up their food in meals outside of Fridge Night. Like in Canada, US participants indicated using up food on Use-Up day was easy ($M = 5.1$) and that participating in the program was enjoyable ($M = 6.0$). They also felt more resourceful ($M = 5.7$), more confident ($M = 5.2$), found it easier to see more meal options ($M = 5.4$) and incorporate fruits, vegetables and grains into meals after the program ($M = 5.2$).

The average grams of household food waste per week by condition is shown in Fig. 3. At baseline, a linear regression model indicated that average food waste did not differ significantly between the conditions, $F(3, 732) = 0.65$, $p = .59$ (see Appendix E, Table E2). The linear mixed-effects model showed main effects of Treatment, $F(1, 707.8) = 7.37$, $p = .007$, and Time, $F(5, 2518.9) = 22.18$, $p < .001$, and importantly a significant Treatment by Time interaction, $F(5, 2519.5) = 9.35$, $p < .001$.

Post-hoc linear mixed models showed that the treatment conditions differed from control relative to baseline during the treatment period (weeks 2–5) with significantly reduced food waste levels (all p's < 0.01. See Appendix F, Table F2). With a 46% reduction relative to baseline and 33% relative to control, households saved an average of 317 g of food per week from being thrown away (or 182 g versus the control group). Moreover, these waste reductions were not restricted to only fruits and vegetables (42%), and bread and grains (55%), but were also seen in other food categories, such as meat and fish (50%), cheese (44%), and eggs (56%). In the control group food waste levels reduced 8% versus baseline, but this decline was not significant, $F(1, 463) = 1.74$, $p = .14$.

A linear regression model assessed the relative reduction in food waste of each treatment condition compared to control at each timepoint in the study. All treatment conditions had significantly lower self-reported food waste than control at each time point ($p < .05$), except for the 3wk Online + Physical intervention at FMS 2 (Appendix G, Table G2). There were no differences between the intervention conditions in total food waste reduction ($p > .12$ at all timepoints), suggesting that the reduced 3-week program was as effective as the 5-week program and that sending printed booklets did not have a larger impact on food waste reduction compared to providing only online materials.

Eight weeks after the end of the treatment period, food waste levels for the treatment groups remained significantly lower than at baseline, $F(1, 855) = 34.3$, $p < .001$, but these were no longer significantly different from the control group, $F(1, 463) = 2.3$, $p = .133$. There were no significant differences in food waste at follow-up between those who received monthly reminders and those who did not, $F(1, 193) = 0.1$, $p = .720$.

Again, Perceived Behavioral Control (PBC) was a significant predictor of total self-reported food waste in the mixed effects model, with

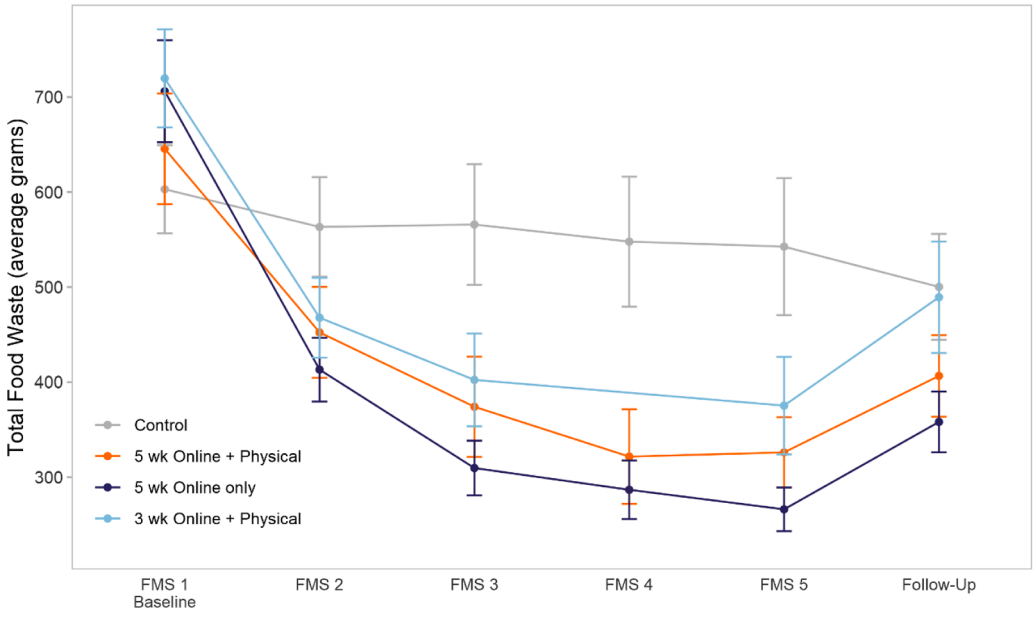

Fig. 3. Total self-reported food waste over time (baseline to follow-up) in the US (Study 2).

greater PBC showing a significant negative relationship with self-reported food waste. Food & Cooking Skills ($p = .005$) and number of children were also associated with higher self-reported waste ($p = .004$), whereas Age and Income did not (Appendix H, Table H2). Food & Cooking skills correlated moderately with PBC, $r = -0.22$, $p < .001$), indicating the constructs are related but not the same. A linear mixed-effects regression examined the change in participants' self-reported PBC from the start of the program to the end as a function of the interventions. Intervention groups saw a significantly greater increase in their PBC relative to the control group, $F\ (1, 538.2) = 14.11$, $p < .001$ (Appendix I, Table I2). Moreover, the difference scores for PBC correlated with the difference scores for food waste reduction, $r = 0.26$, $p < .01$. A subsequent mediation analysis using the difference scores found that the effect of treatment on food waste reduction was partially mediated via a change in PBC. The average indirect effect of this mediation was significant, $b = -45.0$, $p = .002$, as was the average direct effect, $b = -271.5$, $p < .001$.

4. General discussion

The two field studies show that a program featuring a Use-Up day and flexible recipes to make a meal with food that is at risk of being discarded helps reduce food waste, with reduction rates of 33% in Canada and 46% in the US. This compares favorably to previous findings, which ranged from 13% to 31% decreases in food waste (Quested et al., 2011; Sainsbury, 2018; van der Werf et al., 2021). By replicating the findings across the two studies, we demonstrate the robustness of the intervention. The self-reports indicate that our 3 + 1 approach enabled participants to see more meal options and made it easier for them to integrate vegetables and fruits into their meals. In the US, we found that the impact of the intervention was partly mediated by an increase in people's perceived ability to reduce food waste, providing further support for the finding that PBC plays an important role in tackling household food waste and that the intervention with the 3 + 1 approach improved participants ability to manage their food waste. Thus, in line with recommendations from prior research (Schultz, 2014; Stöckli et al., 2018), our intervention goes beyond providing information about the importance of reducing food waste by including a goal-setting element (selection of a Use-Up day) and a concrete tool to support this (the 3 + 1 approach). Our study focused on households with children, as these have the highest absolute food waste levels. However, other household compositions also have significant amounts of food waste related to leftovers (van Geffen et al., 2017), suggesting that our intervention would be relevant for other groups, provided that the tone of voice and the missions are adapted to these target groups.

Relative to their baseline, participants maintained lower food waste levels in the eight weeks following the end of the treatment, although the food waste levels no longer differed significantly from controls. This might be due to reduced statistical power given the lower number of participants in the 8-week follow-up: most participants reported to continue using the flexible recipes and the 3 + 1 approach, and 52% had at least five Fridge Nights during the eight weeks following the end of the program. Nevertheless, food waste levels were rising at the end of the 8-week follow-up period in both countries and monthly reminders appeared insufficient to prevent this. To the best of our knowledge, only one recently published study has examined the long-term effects of household food waste interventions (Everitt et al., 2022). Using curb-side waste analysis, they showed that food waste reduction in the intervention groups was maintained three years after the intervention, although also not significantly different from control. Research in other domains of behavior change have found that intervention effects are often not maintained after the intervention (Lemmens et al., 2008; Nisa et al., 2019; Wemyss et al., 2019). Perhaps the treatment period was not long enough to establish the target behaviors within participants' routines, given that meta-analyses have found that interventions are more likely to be maintained if they are conducted over a longer period and include follow-up prompts (Fjeldsoe et al., 2011). Future research could consider testing longer treatment period durations to assess whether this helps maintenance– although this may negatively impact participant engagement. Alternatively, prompts and reminders can be explored further. These contribute to the effectiveness of behavior change interventions, but the conditions under which these are most effective are not yet clear (Fjeldsoe et al., 2011; Fry and Neff, 2009; Howlett et al., 2019). Perhaps weekly (rather than monthly) reminders or prompts to set a Fridge Night are necessary to maintain the reduced food waste levels.

Interestingly, control participants reduced their waste from their baseline – significantly in study 1 (14%), but not so in study 2 (8%). As participants were asked to pay attention to how they managed their food throughout the week (e.g., what they purchased and disposed of, where they shopped) for the FMS, this may have increased awareness of their food management and prompted food waste reduction behaviors (Wilding et al., 2016). Indeed, research in domains such as healthy eating and physical activity have demonstrated that self-monitoring can be an effective behavior change tool (Michie et al., 2009). Future research could investigate this by recruiting a new control group for each weekly FMS, thus establishing a new food waste baseline for each week.

We used self-reports to measure food waste although this underestimates the amount of absolute food waste (van der Werf et al., 2020; van Herpen et al., 2019a) and could be influenced by social desirability bias. However, as we were primarily interested in obtaining relative rather than absolute food waste amounts to compare the efficacy of different interventions and aimed for a geographically representative sample of households across Canada (study 1) and the US (study 2), food waste composition analysis would not be feasible. We tried to mitigate social desirability bias by embedding the food waste questions within a larger survey about food management more generally, amongst questions regarding shopping, planning, and cooking behaviors, avoiding 'food waste reduction' language and by framing the information as food management aimed at improving people's ability to make quick and delicious meals. The issue of self-report also holds true for the desired behaviors, such as preparing meals using the flexible recipes to make a bonus meal. As is the case with all self-report studies, we can only assume that most respondents are truthful in their responses. Although care was taken to ensure the renumeration was in line with the effort required, it is possible that this may lead to behavioral reactivity. This should also have happened in the control group which received the same incentives, and our results show that the intervention materials had an additional effect, thus suggesting that if such behavioral reactivity occurred, it was not responsible for the full effect.

The study did not include measures of the determinants, especially concerning motivation and opportunity, as this might have led to behavioral reactivity and would have added further to the respondent burden. However, the post-intervention evaluation questionnaires suggest that the intervention did impact motivation in the desired direction. Future research could consider employing both self-report and curbside food waste measurements within the same study, including one group for which only curbside food waste is measured to reduce the chances of behavioral reactivity. Furthermore, collecting images of the bonus meals can help establish whether the desired behaviors were actually performed. Such a study may also shed more light on why the impact of the intervention was higher in the US versus Canada. One possible explanation is that because self-reported waste levels were substantially higher in the US (around 220 g higher) there was more room for improvement.

Both studies provide some insights about which elements of the intervention were most impactful. The salience tools and the hardcopies of the flexible recipes did not have an added impact on food waste levels. This is important to know, as this affects the scalability of the program. It seems that selecting a Use-Up day combined with the flexible recipes – and possibly the self-monitoring through the food waste self-report

questionnaire – is sufficient to make people aware of food that is at risk of being discarded.

5. Conclusions

The current studies are the first to assess the impact of an intervention focusing exclusively on recovery behaviors. They showed that helping participants 1) set a Use-Up day and 2) make a meal with food that would otherwise be discarded can significantly reduce food waste. These behaviors were supported by a motivational message focusing on being resourceful and a flexible approach to make meals. The fact that two key behaviors accompanied by the flexible meal preparation approach were able to help families reduce food waste is encouraging and is a first step towards further scaling up food waste reduction efforts. Furthermore, the finding that physical materials were not required for the impact suggest that scaling up of the program can be done cost-effectively through digital channels. Our results also have policy implications in that food waste campaigns should not only focus on prevention, but also on recovery behaviors, as these can have a significant contribution to food waste reduction: increasing people's ability to deal with changing plans and unexpected events enables them to flexibly manage food in their everyday lives.

Patents and intellectual property

There are no patents to disclose

Other activities

There are additional relationships or activities to declare. van Herpen, E., serves as expert member of the European Consumer Food Waste Forum

CRediT authorship contribution statement

A. Cooper: Conceptualization, Methodology, Investigation, Resources, Validation, Formal analysis, Data curation, Visualization, Project administration, Writing – original draft, Writing – review & editing. **R. Lion:** Conceptualization, Methodology, Formal analysis, Supervision, Writing – original draft, Writing – review & editing. **O.E. Rodriguez-Sierra:** Conceptualization, Methodology. **P. Jeffrey:** Conceptualization, Writing – review & editing. **D. Thomson:** Conceptualization, Methodology, Formal analysis, Supervision, Writing – review & editing. **K. Peters:** Supervision, Writing – review & editing. **L. Christopher:** Data curation, Formal analysis, Visualization. **M.J.H. Zhu:** Data curation, Formal analysis, Visualization. **L. Wistrand:** Conceptualization, Methodology, Writing – review & editing. **P. van der Werf:** Conceptualization, Methodology, Writing – review & editing. **E. van Herpen:** Conceptualization, Methodology, Writing – review & editing.

Declaration of Competing Interest

None

Data availability

Data will be made available on request.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.resconrec.2023.106986.

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