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Development and investigation on an effective intervention method with a "nudge" factor for reducing avoidable food waste from households

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ABSTRACT: With officers of waste management division of Tokyo districts, we developed and proposed a set of practical actions for reducing food waste at home. As citizens already know well in theory that wastage of food should be avoided, it is important to make it easy for them to take action, incorporating a factor of "nudge". The effectiveness of proposed intervention was tested in Maizuru City, Kyoto Prefecture. In order to accurately grasp the effects, experiment and control groups were designated; waste sorting analyses and questionnaire surveys were conducted before and after the intervention period. From the results, we could not prove the effectiveness of the intervention. Possible improvements on the methodology were discussed.

Keywords: SDG 12.3, Household food waste, Social experiment, Sorting analysis, Questionnaire survey, Japan

1. INTRODUCTION

Sustainable Development Goals target 12.3 calls for a 50% reduction of food waste happening at households, food service and retail, and the importance of reducing avoidable food waste from households have been recognised widely. However, there is not much intervention on this topic by central and local governments other than awareness raising campaigns, and it is rather difficult to observe a decline in the amount of food being wasted.

Probably this is either because the campaigns are reaching only to those who are already highly aware, or the stakeholders are aware in terms of theory, but in practice they are making little change in behaviour. In either case, it is useful to devise and implement a scheme where the possible barriers for taking action is lowered or removed, and where actors are directed to taking an action for the purpose even without a strong awareness. Such schemes are often referred to as "nudges".

2. DEVELOPMENT OF EFFECTIVE INTERVENTION

2.1 Setting of Discussion

In 2021, the Institute for research of District Mayors' association (of Tokyo) initiated a research project on the development of effective measures for behavioural change to reduce household food waste, adopting the proposal by Arakawa District council's waste department. 11 Officers from waste

departments of 6 district councils of Tokyo Metropolitan Area, as well as Okayama who acted as leader for this research project, and Watanabe who was assigned the role of sub-leader. The project was assisted by Dynax Urban Environment Research Institute with Kitasaka as principal research officer.

In total, 8 meetings were organised in fiscal year 2021, where participants shared and discussed the outcomes of deliberration at their districts on topics that were assigned prior to each meeting. In the initial stages, the background theories on food waste and nudge approaches were investigated. Following that, the members organised and conducted questionnaire surveys and waste sorting analysis to grasp the current level and situations of food waste in Tokyo Metropolitan's districts (Institute for Research, District Mayors' Association 2022).

2.1 "Nudge"

"Nudge" approaches which are sometimes also referred to as "social marketing", have been highlighted and adopted for various aims such as promoting reduction of energy consumption, and leading a healthy lifestyle. They have attracted increased interest since the award of Nobel Prize in economics by Richard Thaler in 2017. In the UK, the so-called "nudge unit" have been suggesting to the government various successful intervention measures since 2010. In the US, the National Academy of Sciences issued a report (NAS 2020) on food waste reduction, where "nudges" are introduced as promising measures. Also in the European Consumer Food Waste Forum, nudges have gained a major focus (Candeal et al 2023). In the project, various concrete examples of nudge interventions (e.g. Farr-Wharton et al 2014) were gathered and analysed, for example by classifying them into 6 major patterns.

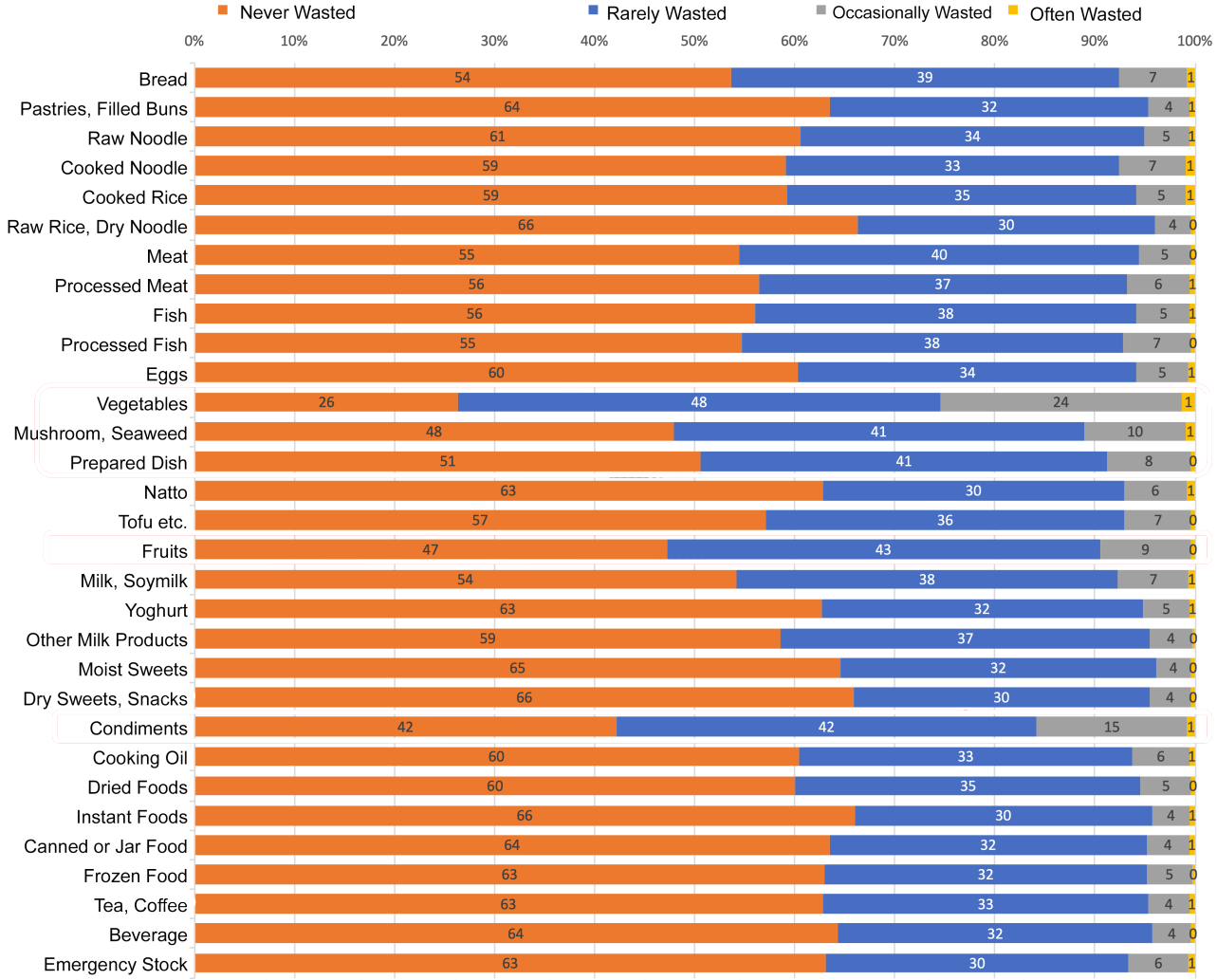

Figure 1. Frequency of various food items being wasted

2.1 Current Situation of Food Waste

As activities on grasping the current situation on food waste, a questionnaire survey and a sorting analysis of household general waste took place in June 2021. The questionnaire survey was conducted on-line to registered panels of a survey company, living within the 23 districts of Tokyo. 1563 valid responses were obtained.

In this questionnaire survey, amongst other question items, respondents were asked regarding 30 different food items the frequency of throwing away what could have been eaten (Fig. 1), the reason as to why they ended up not being eaten (Fig. 2), and the determining factor for disposing of the items. Vegetables topped the list of items that were most frequently thrown away, followed by sauces and seasonings. Not only householders found it difficult to finish many items before they had to be disposed of, but also many items were just forgotten of their existence. The item being beyond the best before date was a prevalent criteria for no longer keeping it in storage. For items without dates, they were thrown out when they were regarded as being damaged. While 90% of the respondents agreed that all food items should be eaten up and not thrown away, 33% believed that items that are past the best before date should not be eaten, and 67% was of the opinion that if food waste is being utilised (e.g. for energy or fertiliser), there is no problem with throwing away food.

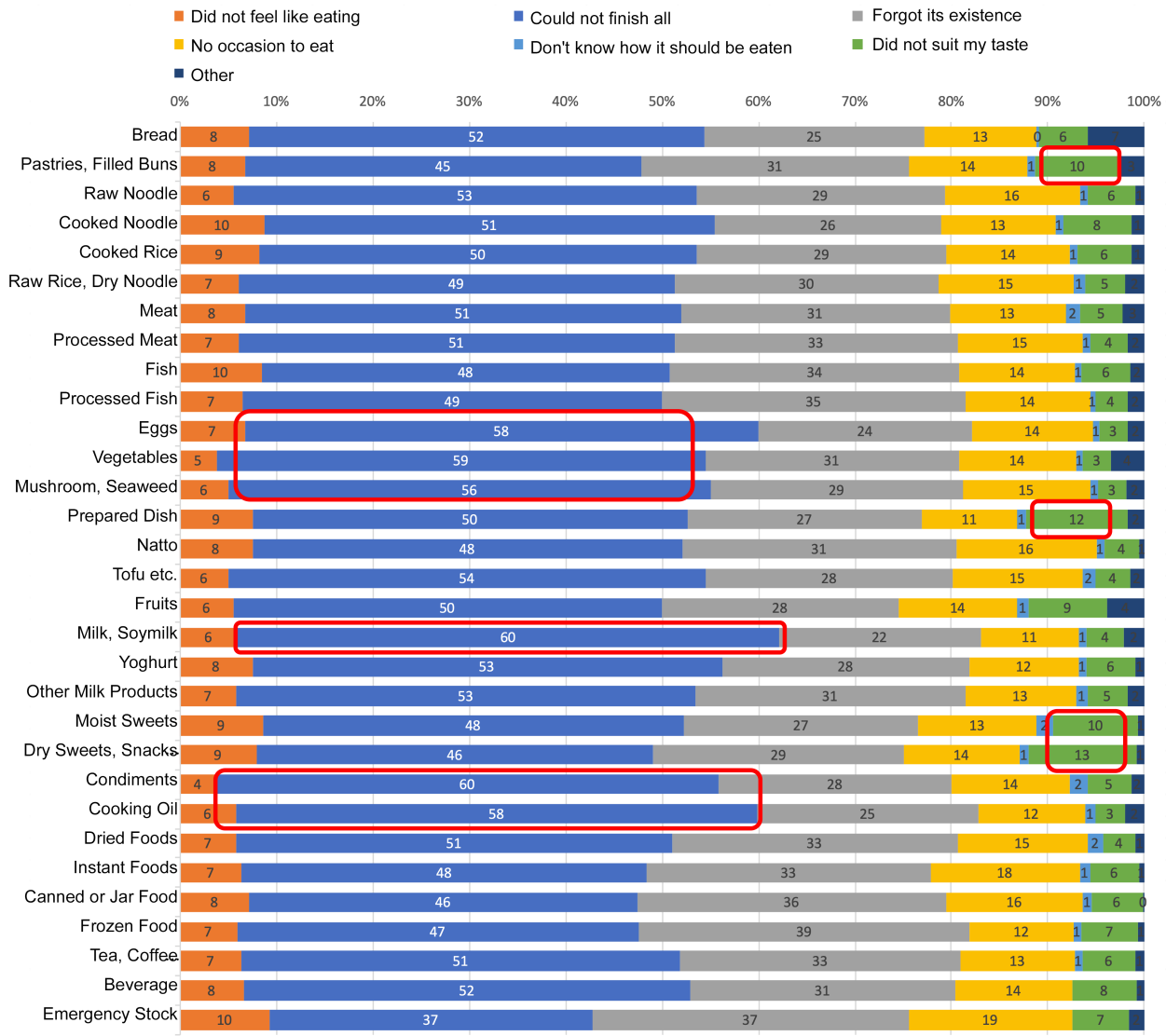

Figure 2. Reasons as to why various food items ended up not being eaten

Sorting Analysis of general household waste was conducted based on "Tokyo Method" (Okayama et al 2021). 223kg of waste sampled from Arakawa district was analysed. In line with the general characteristics of household waste in Tokyo, there was a low percentage of total food waste (avoidable and unavoidable food waste) within total disposed waste, while a higher percentage of avoidable food waste within total food waste. Dates on disposed food items were also recorded and they revealed that some consumers throw away food as soon as the best before date has passed. The sorting work was conducted by the project team members and it provided a good opportunity to put hands on and observe directly the reality of household food waste.

2.1 Proposed Interventions

Taking into account the above findings, the project members discussed effective intervention measures. As it was found out that "being forgotten in fridge" was one of the main cause of food waste, we focused on measures for food stored in the refrigerator[1]. We have trialled those involving IT technologies such as a camera installed in refrigerator and smartphone apps. Fridgecam would be useful in reminding what items are in the refrigerator, as well as avoiding duplicate purchase of an item. Smartphone app "Pekko" suggests recipes that utilise items that are registered as available in refrigerator. Another app "Limiter" sends out alerts when registered items are nearing their best before dates. These were recognised as useful to some extent, however it was noted that those that are not well versed with such technology may face difficulty with installing them, and also that some were rather cumbersome to use in a daily basis (e.g. requirement of manually registering all items purchased and used).

Hence we decided to propose "analog" measures for outside and inside the refrigerator. As for outside, we proposed magnet stickers on the fridge door indicating what food items are in stock and need to be consumed (Fig 3). Householders will stick and move the magnets as food is purchased and used. A "finished all" area was created, so that users can feel rewarded or get a sense of achievement.

For inside refrigerator measures, we discussed what kind of tools could be useful for making more visible food requiring swift consumption. Plastic trays and coloured tapes were the final proposal (Fig 4). Items that are to be consumed soon could be placed in the tray, or the tray could be used as a divider to designate an area where food requiring attention could be placed, and the area could be made more visible by coloured tapes. The coloured tapes could be cut and stuck directly to food items to draw attention. We created the tools and detailed instruction manuals for householders on these proposals, and they were revised after being tested by 20+ households.

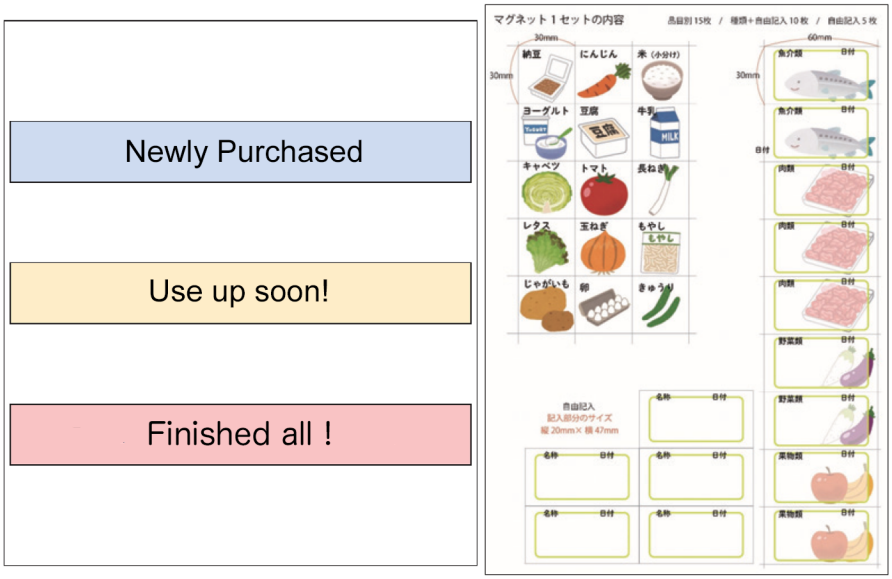

Figure 3. Magnet stickers

[1] Farr-Wharton et al (2014) tested similar interventions from the same viewpoint

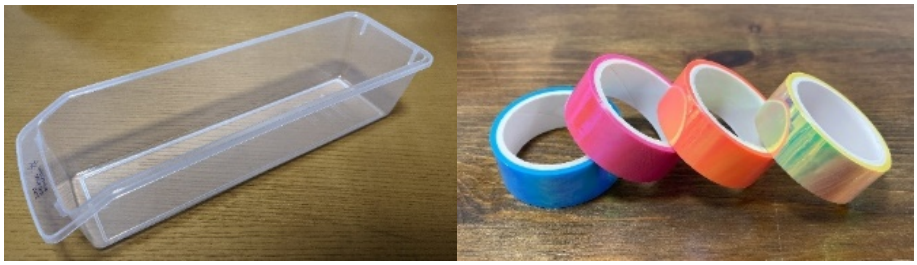

Figure 4. Plastic tray and Coloured tapes

3. SOCIAL EXPERIMENT ADOPTING THE DEVELOPED INTERVENTION

3.1 Methodology

After refining the results from the abovementioned project, these measures were implemented in Maizuru City, Kyoto Prefecture as a social experiment. In order to measure its effectiveness accurately, we have designated a control neighbourhood as well as an experiment neighbourhood, each with 200-250 households (table 1). After the pre-intervention sorting analyses of disposed household waste and questionnaire surveys at both neighbourhoods, a meeting at the experiment neighbourhood on instructions and questions on proposed measures took place to start the intervention period. Two months later, another set of sorting analyses and questionnaire surveys (post-intervention assessment) was conducted for both experiment and control neighbourhoods. Combination of observation and self-reporting (sorting analyses and questionnaire surveys), as well as pre- and post- measurements and setting experiment and control groups are also agreed as recommendable procedures in the European Consumer Food Waste Forum (Bruns and Nohlen 2023).

Table 1. Experiment and Control neighbourhoods.

Neighbourhoods	number of households	population	average age
Experiment	212	502	46
Control	210	507	47

Regarding sorting analyses, sample waste was collected from waste collection points in each neighbourhood (7 and 16 resectively) on the day of routine scheduled waste collection for burnable waste (3 days accumulation of waste), on chosen dates in September and December 2022 before and after the intervention period. All sampled waste was sorted according to the most detailed level (level 5) of Tokyo Method for the analysis of household food waste (Okayama et al 2021). The sorting categories are shown in Table 2.

Questionnaire surveys were conducted right after the sorting analyses (so as not to affect the results of the sorting analyses). The survey sheets were distributed to each household by door-to-door posting. This contained a pre-franked envelope and a QR code for the survey website, so that residents could respond either by postal service or on-line. Survey questions for pre- and post- intervention surveys at the control neighbourhood as well as pre-intervention at experiment neighbourhood were basically identical, containing questions on behaviour regarding food purchase and storage (with focus on the use of refrigerator), frequencies and attitudes towards disposing of various sorts of (potentially) edible food, as well as demographic attributes and waste collection points they usually use. The post-intervention survey at the Experiment neighbourfood additionally included questions on the use and effectiveness of items distributed to assist reduction of food waste.

As for intervention, in the Experiment neighbourhood, five tools and actions were suggested: 1) Tools for tidying items in the refrigerator, 2) Magnet stickers for managing food in the refrigerator, 3) Stickers to attract attention to the back of the refrigerator, 4) Taking photos inside the refrigerator at

regular intervals, 5) Use of smartphone apps. The following items were distributed to each household in the experiment neighbourhood by door-to-door posting: As for action 1), plastic tray and coloured tape (as in fig 4), for 2) set of magnet stickers (as in fig 3), for 3) stickers with illustration, and an instruction manual. An instruction meeting was held at a community centre in the neighbourhood, which was attended by about 30 householders. The research team as well as municipal officers explained the purpose and gave detailed instructions on suggested actions on food waste reduction and how to use the distributed items.

Table 2. Sorting Categories (Tokyo Method)

Level 1	Level 2	Level 3	Level 4	Level 5	Definition
Food waste	Avoidable food waste	A/B Unused food	A Unused ingredients	A1 Unopened ingredients	Unopened ingredients in packaging
				A2w Whole unused ingredients	Whole unused ingredients not in/no packaging
				A2wf Home-grown vegetables	Large amount of produce which is appeared to be home-grown such as with irregularities and branches
				A2p Partly used ingredients	Partly used ingredients in or without packaging
			B Unused ready-to-be-eaten food	B1 Unopened ready-to-be-eaten food	Unopened ready-to-be-eaten food in packaging including in unopened individual packages
				B2 Uneaten ready-to-be-eaten food	Whole unused ready-to-be-eaten foods without packaging, and partly unused ready-to-be-eaten foods in packaging, including foods in plastic wrap such as rice in plastic wrap However, obvious leftovers such as lunchbox remains are classified into leftovers even in packaging.
				B' Unopened drinks	Unopened drinks in packaging
		C Leftovers		C Leftover food	Ready-to-be-eaten or cooked food that appears to have been disposed after being served and partially eaten. As a principle, without packaging. However, partially eaten food left in packaging that is designed to serve as plate/bowl (food that is designed to be eaten directly from the packaging) also qualifies as leftover food.
				C' Leftover drinks	Leftover drinks in bottles or packaging
	Non-avoidable food waste	D Intentionally removed parts		De Possibly avoidable	Intentionally removed parts that are physically edible such as vegetable scraps, meat fat, fish skin, cooking oil, bread crust and kelp for soup stock. However, vegetable waste such as corn cores, which are clearly inedible and may affect the quantity, are classified into inedible parts.
				Di Inedible parts	Intentionally removed parts that are physically difficult to eat such as fruit scraps, seeds, bones, eggshells, shells, used coffee grounds and bagged soup stock. However, fruits scraps which are clearly edible and may affect its quantity such apple peels, are classified into "possibly avoidable".
		E Unclassifiable		E Unclassifiable	Very fine food waste that gets caught in kitchen sink strainers, or food waste blended with non-food waste that is difficult to sort further.

3.2 Results and Discussion

3.2.1 Waste sorting analyses

In the pre-intervention sorting analysis (Sep 2022), residents in the experiment area discharged 786.91kg of burnable (residual) waste (collection interval 3 days, 523g/person/day), while in the control area, the amount was 440.01kg (289g/p/d). Similar tendency was observed in the post-intervention analysis (Dec 2022), where the discharged amount was 773.73kg in the experiment area, and 473.26kg in the control area.

Regarding the amount of total food waste (including unavoidable food waste such as peels and bones) and avoidable food waste, in the pre-intervention experiment neighbourhood, the former was 200.47kg containing 93.94kg (47%) of the latter. In the control neighbourhood, the figures were

142.35kg, and 66.79kg (47%), respectively. Post-intervention, food waste increased in both locations. 263.97kg and 104.80kg (40%) in the experiment neighbourhood, and 167.72kg and 60.73kg (36%) in the control neighbourhood. Share of each detailed category is shown in figure 5.

The general increase in food waste is thought to be due to seasonal factors. The percentage of avoidable food waste in total waste decreased (-7%) in the experiment area, while a larger decrease (-11%) occured in the control area. From the waste sorting analyses, it was not possible to indicate the effectiveness of the intervention.

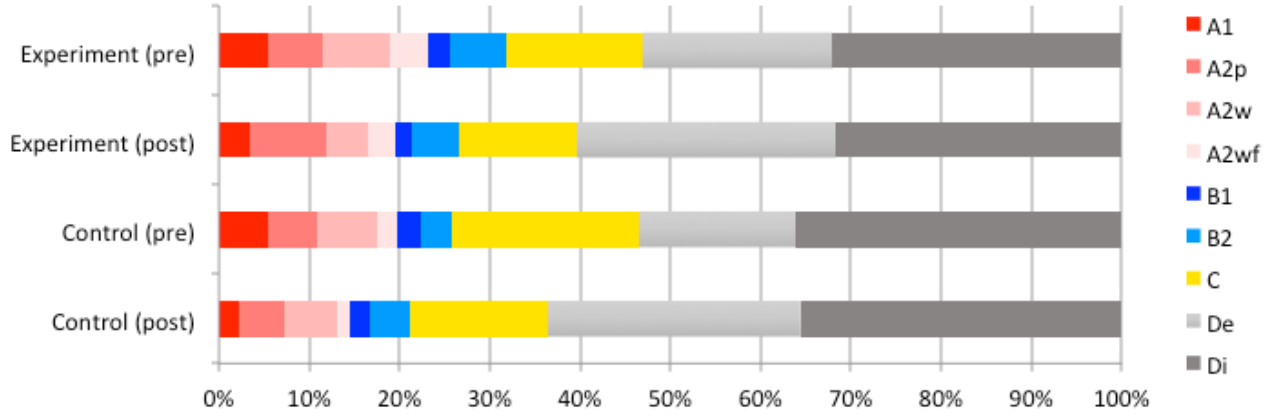

Figure 5. Results of Sorting Analyses (see table 2 for description of categories)

3.2.2 Questionnaire surveys

The number of valid responses of questionnaire surveys was 96 at the experiment neighbourhood and 100 at the control neighbourhood in the pre-intervention survey, and in post intervention, 72 and 79 respectively. Both pre- and post- intervention, in the experiment neighbourhood, the largest age group of the respondents was in the 60s, while in the control neighbourhood there were more respondents in the 30s, 40s, and 50s age group (table 3). In both neighbourhoods, 80% of respondents were female. In the experiment area, 65% of the households adopted at least one of the proposed actions. The detailed distribution of adopted actions is shown in table 4 and figure 6. Use of tools within the refrigerator was most popular.

The effect of intervention to attitude and behaviour is analysed. There were 9 questions on behaviour regarding purchase of food and use of refrigerator, and 5 questions on attitudes towards wastage of food, and 6 questions regarding frequency of food wastage. Analyses were conducted on whether there are differences between experiment and control neighbourhoods in changes before and after the intervention. Also differences between adopters and non-adopters of proposed actions were analysed. T-tests were used for responses in Likert scale, chi-squared tests otherwise.

Table 3. Age distribution of respondents

Neighbourhood	20s	30s	40s	50s	60s	70s	80s+	total
experiment	3	3	5	14	16	18	13	72
control	1	7	13	19	9	17	13	79

Table 4. Adoption of suggested actions

non-adopt	1 action	2 actions	3 actions	4 actions
34.7%	37.5%	12.5%	9.7%	5.6%

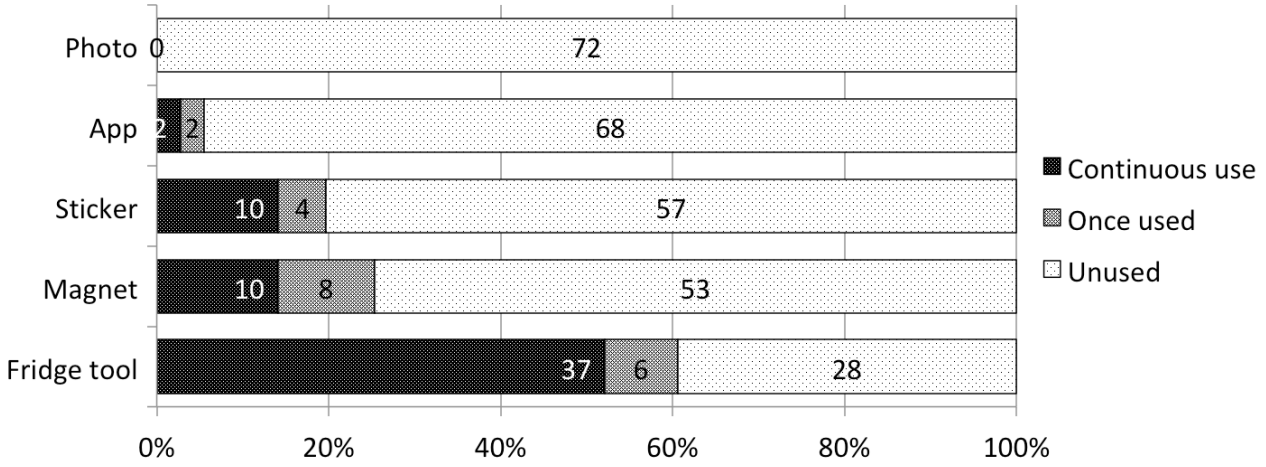

Figure 6. Adoption of each suggested action

Table 5. Chi-squared test on change of awareness (p=0.016)

Questions	less aware / no change	more aware	total
non-adopt	21	3	24
adopted >1 actions	28	19	47
total	49	22	71

Table 6. Results of t-tests (statistically significant differences)

Questions	low	high	p
Disposal Frequency: Unfinished ready to eat item	exp-post	exp-pre	0.01
Disp Freq: Unfinished prepared dish	exp-post	exp-pre	0.04
Disp Freq: Plate leftovers	ctrl-post	ctrl-pre	0.03
Disp Freq: Item that was forgotten of its existence	ctrl-post	ctrl-pre	0.01
Attitude: OK to waste if food waste is utilised (e.g. as compost)	ctrl-post	exp-post	0.04
Behaviour: Prioritised using items requiring swift consumption	non-adopt	adopt	0.03
Attitude: Items past best before date should not be eaten	non-adopt	exp-pre	0.03
Attitude: OK to waste if food waste is utilised (e.g. as compost)	non-adopt	exp-pre	0.03
Disp Freq: Unfinished ready to eat item	non-adopt	exp-pre	0.00

exp / ctrl: experiment / control neighbourhood, pre / post: before / after intervention
non-adopt: households that did not adopt the proposed actions for food waste reduction

Items with statistically significant differences are shown in tables 5 and 6. Regarding changes in awareness on food waste reduction, there was a significant increase in awareness among those that adopted the proposed actions. Regarding frequencies of food wastage, a statistically significant reduction occured in the experiment neighbourhood on unfinished ready-to-be-eaten items as well as unfinished prepared items. While in the control neighbourhood there was a siginificant reduction in wastage of plate leftovers and ingredients that were forgotten of their existence. These results are in line with the results of sorting analyses. The refrigerator tools are effective for items that showed a

reduction in the experiment area. On the other hand, the tools do not encourage family members to finish up what are on their plate. Ingredients (raw vegetable etc) tend to be kept in a different section of the refrigerator than where the tools are to be used.

However it turned out that the reductions in the experiment neighbourhood occured in households that did not adopt the suggested actions. Also the reason of food waste reduction in the control neighbourhood is unknown. Within the experiment neighbourhood, 3 out of 7 waste collection points showed more than 10% reduction of avoidable food waste in the sorting analysis, but we could not identify any notable characteristics among them.

3.2.3 Discussion

As with the sorting analysis, we were not able to show a clear result on the effect of intervention in the experiment neighbourhood. We discussed the reasons for the unclear results, and came up with the hypothesis as shown below:

1) The timing of post-intervention masurements was too late: The residents may have made more efforts on food waste reduction immediately after the introduction of actions, but three months after that, behaviour may have reverted to normal (this also raises questions on the continuity of the effect of intervention).

2) In the sorting analyses, we could observe that items such as fruits and confectionery that were received as gift were more likely to be wasted. Maizuru being relatively less urbanised, there may be stronger social capital to give and receive gifts. There is more space for growing ones own vegetable and fruits and that could contribute to increased wastage (Autumn is the harvest season, and that runs into December). Measures regarding refrigerators are not very effective for such food wastage.

3) Demographic difference between experiment and control neighbourhoods: We were puzzled with the difference in per capita waste generation between the experiment and control neighbourhoods. Table 1 shows similar average values for both neighbourhoods, but the questionnaire survey results suggested a different age distribution pattern between the two neighbourhoods. The experiment area may have a higher share of younger as well as older generations, while the population in the control neighbourhood is concentrated in the working age group. The latter tend to stay out of their home during working hours, meaning less activity and less waste at home. The largest employer in the East Maizuru area where the two neighbourhoods are located, is the Marine Self Defence Force, its employees can be away from home for months on duties on the ships. Such factors may have affected the results. We may need to be more careful in selecting neighbourhoods with similar characteristics for experiment and control groups.

4. CONCLUSIONS

In many cases, interventions on food waste reduction are conducted without accurate measurements and assessment of their effectiveness. Even for those with appropriate measurements, many of the reported successful interventions are applied to households that signed up to cooperate. We could say that there is a sampling bias - the interventions could have been effective to those who were interested in reducing food waste anyway.

However, it is important to involve the less aware households as well in order to make a notable reduction in food waste, and hence we need to assess the effectiveness of interventions applied to the whole population in a blanket way. Learning from the results reported above, we are planning another study with the same aim, with more careful selection of experiment and control areas, and shorter interval between pre- and post- intervention measurements. We will also work on refining the intervention - clearer instruction, increased interaction with residents etc.

ACKNOWLEDGEMENTS

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