Nutrition Education and Food Management Strategies to Reduce Food Waste and Strengthen Food Security

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KEYWORDS	ABSTRACT
balanced nutrition, food management, food security, food wastage, nudge theory, theory planned behavior	The issues of food waste, food management and food security are of great importance in the context of sustainable development and food security in Indonesia. Food waste contributes significantly to greenhouse gas emissions. Reducing food waste can help address climate change and its negative impacts on food security. Analyzing the effect of nutrition education and food management interventions on food waste and household food security. This study used a pre-post experimental research design using 100 respondents, namely housewives who were taken using the Stratified Random Sampling technique conducted in December 2023 - September 2024. Data were collected pre and post-intervention, where the intervention was balanced nutrition education with nudging reinforcement and food management education for 12 weeks. Hypothesis testing using T-test and Ancova. Balanced nutrition intervention with nudging reinforcement can affect reducing food waste. However, in order for the implications for food security to be better, the balanced nutrition intervention (with nudging reinforcement) must be accompanied by food management behavior (36% reduction in FW, 14% increase in food consumption quality, 3% food expenditure efficiency, and 5% increase in population food security). Balanced nutrition interventions using nudging can reduce food waste and improve food security. .

INTRODUCTION

Food waste (FW) is becoming an increasingly urgent global issue to address. According to the World Food and Agriculture Organization (FAO), about one-third of the food produced worldwide ends up as waste each year. In addition to its economic impact, FW also contributes significantly to environmental problems, such as greenhouse gas emissions and inefficient use of natural resources. According to data from the World Resources Institute (WRI), GHG emissions from food waste account for 8% of global emissions, with most of the gas emissions coming in the form of methane, which has a 25 times higher potential than carbon dioxide to increase global warming. Therefore, efforts to reduce FW are an important priority, especially through behavior-based approaches and nutrition interventions.

Conrad (2020) shared in his recent research that there is a link between consumer food waste, healthy diets, and environmental impacts, which has implications for food security and hunger. His research in the United States showed that the average consumer throws away nearly 1 kg of food every day. Therefore, nutrition professionals are urged to help steer consumers towards healthier diets and reduce food waste at the same time. This is also a key recommendation to be done in the FW reduction strategy (Bappenas 2021). Iranmanesh et al. (2022) also explained that a significant reduction in FW directly affects economic and nutritional impacts at the household level, where the household level is the highest contributor to FW. Bunditsakulchai and Liu (2021) stated that FW in households is

determined by consumer behavior from purchase to final disposal. Food management behaviors that must be improved to reduce FW are making food plans, making shopping lists, doing good storage, proper processing, and optimal food consumption (zero waste).

The Theory of Planned Behaviour (TPB) provides a strong conceptual framework for understanding the psychological factors that influence human behavior, including food management. TPB emphasizes that a person's intention to act is influenced by three main components, namely attitude towards behavior, subjective norms, and perceived behavioral control. In the context of FW management, this understanding can be used to design interventions that encourage individuals to adopt wiser food management habits.

In addition to the TPB, the nudging reinforcement approach also has great potential to change behavior without coercion. Nudging is a strategy that influences individual choices through the presentation of strategically designed options. For example, the presentation of smaller portions of food, the provision of visual information about the impact of food waste, or the rearrangement of food layout at buffets to reduce overtaking. This approach utilizes human cognitive mechanisms, such as preferences for convenience and habit, to encourage more sustainable decisions.

In an effort to integrate TPB and nudging reinforcement, nutrition and behavioral interventions can be designed to not only raise awareness about the importance of reducing FW but also form habits that support more efficient food management. Therefore, this study will intervene to change food management behavior in households by strengthening nudging in portion size so that in addition to achieving zero waste, food expenditure can also be streamlined to support the improvement of household food security.

METHODS
Research Design, Time and Place

This study uses a cross sectional study design, where all variables are measured and observed at the same time (one point in time). The research was conducted in December 2023 - September 2024. This study has received ethical approval from the Ethics Commission for Research Involving Human Subjects, Faculty of Public Health, Universitas Airlangga with Number: 208/EA/KEPK/2023.

Number and Method Subjects

The sample calculation of this study used a specific precision formula and obtained a sample of 110 households (household food managers). Sampling using the Stratified Random Sampling technique which has the following criteria: (1) Housewives aged 30-55 years, (2) Households that have 1 family card, (3) Having a refrigerator (refrigerator), (4) Doing conventional household management, (5) Willing to take part in the study until completion, and (5) In good health and able to answer questions well. However, during the intervention there was a drop out of 10% to 100 respondents at the time of final data collection (after the intervention).

Types and Methods of Data Collection

Data collection was conducted after the intervention. The stages were divided into balanced nutrition education and food management education. Material refreshers were conducted 4x throughout the intervention (1x/month), while monitoring and evaluation was conducted 1x/week to see the consistency of respondents following the directions of the education provided. The instrument used in monitoring and evaluation is a logbook that contains the date and time of monitoring, the name of the head of the family being monitored, a checklist table accompanied by photos for the application of food management. After 12 weeks, the final measurements for food management, FW, family food security, and aspects of SDGs were conducted using questionnaires. Direct measurement of FW was conducted for 8 consecutive days using SNI 19-3964-1994 guidelines. The 12-week time period was chosen based on Schiffer and Ajzen's (1985) research on Intention, perceived control, and weight loss: An application of the theory of planned behavior which is often used in behavior change research, where the minimum time used to foster intention is 6 weeks. Then, other studies confirm Ajzen's research, where the time needed to generate intentions to adoption to behavior change is 3 months or 12 weeks (Jiarong Hu et al. 2021).

Table 1 Intervention Implementation

Intervention	How to Implement
Implementation of balanced nutrition education + *nudging*	Lecture and module media and portion control reinforcement (calendar) for all respondents
Implementation of food management education	Modules and *meal plan visualization. Meal plan visualization* is a tool to make it easier to manage planning, purchasing, and portioning

Data Processing and Analysis

This stage aims to test the hypothesis regarding the interventions carried out. Analysis of differences in each treatment group uses a dependent T-Test provided that the data has met a normal distribution. If the data is not normally distributed, then the test that can be used is the Wilcoxon test. This study uses the probability value of the Shapiro-Wilk test in measuring data normality. If at a significant level of 5% a P-value> 0.05 is obtained, the research data is normally distributed. The intended analysis is to test the difference in the implementation of TPB (objective norms, attitudes, behavioral control, and intentions) and food management (planning, purchasing, storage, processing and consumption) and before and after the intervention.

Furthermore, the ANCOVA test was conducted to see the treatment precision between groups. Hanan (2018) states that ANCOVA or Analysis of Covariance is a statistical technique that combines regression analysis and analysis of variance. This test places the pre-test or baseline score as a covariate. ANCOVA serves to increase the precision of an experiment because it regulates other uncontrolled independent influences. Thus, this test is often used to determine/see the effect of treatment on the response variable by controlling for other quantitative variables.

RESULT AND DISCUSSION
Household Characteristics

Based on **Table 2**. it is known that the average age of respondents is 38 years, which means that the average respondent is at a productive age. Productive age in Indonesia is defined as the age range between 15 to 64 years5. In population groupings, this age is considered as a group that is able to contribute economically and socially. The average number of family members is 4 people, where the respondent's household is a medium family5. This means that the average respondent is at the secondary education level. Law No. 20/2003 Article 18 states that secondary education takes the form of senior high schools (SMA), madrasah aliyah (MA), vocational high schools (SMK), and madrasah aliyah kejuruan (MAK), or other equivalent forms (Kemdikbud 2003).

One aspect of the demographic dimension is socioeconomic, which is assessed through household income and expenditure. The average total household income is below the minimum wage in Bogor City (<Rp. 4,813,988/month). Food expenditure reflects the amount of expenditure used for household consumption purposes. The data shows that the average household food expenditure is higher than the proportion of national food expenditure, which is 49.51% (BPS 2018).

According to Maxwell *et al.* (2000), the proportion of expenditure on food > 60% is categorized as high. The share (proportion) of food expenditure is one of the indicators of food security of the Indonesian population. The proportion of food expenditure will be lower as income increases. Thus, it can reflect welfare. (Calibri font, size 10, and single-line spacing).

Table 2 Respondets Characteristics

Characteristics	Mean ± SD			Min	Max
Age (years)	38,20	±	0,60	30,00	55,00
Number of family members (people)	4,51	±	1,12	2,00	8,00
Education (years)	11,09	±	0,20	5,00	16,00

Total household income (IDR/month)	3.731.186,00	±	115.471,00	400.000,00	4.800.000,00
Household expenditure (IDR/month)					
Food	1.823.855,00	±	855.491,24	208.500,00	4.600.000,00
Non-food	746.090,00	±	660.548,03	100.000,00	4.000.000,00
Total	2.569.945,00	±	1.135.183,53	642.500,00	5.753.000,00
Food expenditure (%)	72,00	±	17,00	11,00	98,00

Occupation also influences behavior externally, including the occupation of housewives and the occupation of husbands and other household members (who are already working). In the study, it was found that the husband, in this case the head of the family, was mostly a laborer (31.45%) and a private employee (29.57%), while all (100%) respondents were housewives. Occupation in the household has a significant influence on household food management behavior and the level of FW produced. Employment affects food management in the household related to time and energy, when both partners work, the time available to manage food is limited. This often leads them to opt for quick solutions such as ready meals or rely on delivery services which can increase the likelihood of food wastage (Hapsari 2022; Jamaludin & Hasan Basalamah 2023). Working couples tend to lack proper meal planning due to their busy schedules. If planning is lacking, purchased food may not be fully utilized, leading to increased FW (Jamaludin & Hasan Basalamah 2023; Nadia et al. 2023).

Theory Planned Behaviour (TPB) Implementation, Food Management Behavior, Food Waste (FW), and Household Food Security

The aspects examined in the application of the SDGs in households are attitudes, subjective norms, and behavioral control, where these three aspects will influence the behavioral intention to reduce FW in urban households. The data in **Table 3**. shows that the average score of the SDG aspects has shown quite good results for households.

Table 3 SDG implementation, food management behavior, food waste, and food security of urban households

Characteristics	Mean ± SD			Min	Max
Total Attitude (score)	40,22	±	4,59	30,00	51,00
Total Subjective Norm (score)	38,72	±	6,38	13,00	52,00
Total Behavioral Control (score)	27,51	±	3,35	1,00	4,00
Total Intention (score)	21,77	±	3,06	14,00	28,00
Food Management Behavior (score)					
Total Planning	1,14	±	0,20	0,64	1,60
Total Purchase	19,98	±	2,19	14,85	25,74
Total Storage	8,66	±	1,18	5,46	10,92
Total Processing	3,21	±	0,47	1,56	4,16
Total Consumption	11,21	±	1,41	7,75	14,50
Total PPM	44,22	±	4,04	33,11	54,24
Total FW (g/cap/day)	41,52	±	35,39	0,00	159,43
FW type (score)	85,53	±	16,05	45,00	112,00

Food Management Behavior (FMB) is still low as evidenced by a score of 44.22±4.04 (score < 94.5). The average amount of FW in households was 41.52±35.39 g/cap/day, while for the type, the average was 85.53±16.05 g/cap/day (score > 42). When viewed by type, the high score is due to the largest FW contributor, namely from the staple food group (rice), which is 55.42 ± 66.35 g / cap / day, while vegetables come second with an average FW of 28.18 ± 38.94 g / cap / day, and others amounting to 11.95 ± 20.86 g / cap / day. Other types of food include wet cakes and fried foods.

Food security is seen from the aspect of the proportion of food expenditure and the level of energy adequacy. Household food security can be seen in Table 4. The results show that based on household TKE, 50% (50) of respondent families are food insecure and 30% (30) are food vulnerable, the rest are in the category of food insufficient 14% (14) and food resilient 6% (6). The value of food insecure households is still higher than the prevalence data of food insecure population in West Java, which is 4.90% (BPS, 2023).

Table 4 Distribution of household food security

KP Category	n	%
1. Food resistant	6,00	6,00
2. Food insecurity	30,00	30,00
3. Lack of food	14,00	14,00
4. Food insecurity	50,00	50,00
Total	100,00	100,00

The results showed that the TPB implementation variables (subjective norms, behavioral control and intentions) did not change before and after the intervention (p> 0.05) in both groups. However, attitudes changed after the intervention, where there was a decrease in scores in both groups (p < 0.05). Meanwhile, the ANCOVA test results showed that the intervention did not have a significant effect on both groups in TPB (p > 0.05). In other words, the intervention did not substantially increase or change the intention to reduce FW.

Food management behavior showed that all aspects of food management (planning, purchasing, storage, processing, and consumption) improved in the GS group, while only purchasing and storage improved in the GS+PPM group. The T-test showed that the total PPM score was not significantly different in the GS group before and after the intervention (no significant change). However, in the GS + PPM group, there was a significant difference in purchasing, namely p-value (0.003) <0.05. Ancova test showed that there was a significant group effect on consumption score indicated by p-value (0.041) < 0.05. This means that the intervention can affect consumption in both groups, where the score of the balanced nutrition group is higher than the PPM group.

Table 5 Differences in TPB aspects, food management behavior, and FW pre-post intervention

Variables	GS group								GS + PPM group							
	Before			After			P-Value		Before			After			P-Value	
	Mean ± SD			Mean ± SD					Mean ± SD			Mean ± SD				
Attitude (score)	45,89	±	5,18	40,16	±	3,67	0,000*		46,46	±	5,44	40,26	±	5,38	0,000*	
Subjective Norm (score)	36,97	±	4,72	38,77	±	6,37	0,120		38,35	±	4,36	38,55	±	6,38	0,839	
Behavioral Control (score)	26,69	±	2,64	27,73	±	3,60	0,137		27,73	±	2,76	27,26	±	3,08	0,331	
Intention (score)	21,28	±	2,44	27,73	±	3,60	0,323		22,26	±	2,64	21,61	±	2,88	0,211	
Food Management Behavior (score)	43,14	±	3,68	43,74	±	3,57	0,450		43,58	±	3,42	44,56	±	4,36	0,171	
Total FW (g/cap/day)	89,15	±	66,71	50,15	±	41,61	0,000*		69,24	±	45,08	33,25	±	25,30	0,000*	
FW type (score)	69,70	±	16,39	86,38	±	15,17	0,000*		70,31	±	17,32	84,46	±	16,85	0,000*	
Attitude (score)	36,97	±	4,72	38,77	±	6,37	0,120		38,35	±	4,36	38,55	±	6,38	0,839	

*Notes: *Experienced changes after the intervention*

The number and types of FW have changed, with the number of FW decreasing and the types of FW increasing. The type of FW not only shows that the diversity of foods that cause FW has increased but also illustrates that the quality of household food has also increased. The largest FW contributing

foods after the intervention were staple foods (55.42g/cap/day), vegetables (28.18g/cap/day), and others (11.95g/cap/day). Interestingly, the type of FW after the intervention was found to be fruit (4th place), whereas before the intervention fruit was the lowest FW food. The T-test results showed that there was a significant difference between the amount and type of FW before and after the intervention ($p < 0.05$). Meanwhile, the ANCOVA test results showed that the intervention gave significant results on the number and types of FW in both groups ($p > 0.05$). This indicates that the intervention has a significant effect in reducing the number of FW and improving the quality of food consumption.

Food security also changed with the percentage of food security increasing after the intervention in the GS+PPM group by 5%. This category of food security does not qualify for a T-test, but the test can be conducted on each dimension of the proportion of food expenditure and the level of family energy consumption. Based on the T-test, it is known that there is a significant difference between the two dimensions in the GS group before and after the intervention ($p < 0.05$), but there is no significant difference in the two dimensions in the GS+PPM group ($p > 0.05$). Meanwhile, the ANCOVA test results showed that the intervention had no effect on food security in both the GS and GS+PPM groups ($p > 0.05$). In other words, the intervention did not substantially improve or change food security.

Table 6 Differences in pre-post intervention food security

Variables	GS Group		GS+PPM Group	
	Before	After	Before	After
Food Security (%)				
Food Resistant	6,00	2,00*	8,00	10,00*
Food Vulnerable	41,00	29,00*	43,00	33,00*
Lack of Food	2,00	16,00*	6,00	10,00*
Food Insecurity	51,00	53,00*	43,00	47,00*

*Notes: *Experienced changes after the intervention*

In general, the GS intervention had a higher effect on FW reduction (39% reduction in FW, 17% increase in food consumption quality, and 4% increase in food expenditure efficiency) than the nutrition intervention together with food management behavior (36% reduction in FW, 14% increase in food consumption quality, and 3% increase in food expenditure efficiency). The results of this study provided a higher reduction in FW compared to general balanced nutrition education because nudging was used as reinforcement. Nudging, as an approach that focuses on behavior change without coercion, can strengthen interventions in reducing FW through several effective mechanisms. Fajri and Shauki (2023) explained in their research that nudging encourages to make better choices without removing individual freedom. For example, by using smaller plates, manufacturers can create the impression that food portions are fuller, thus encouraging consumers to take and finish less food. In addition, research on nudging strategies is effective in the context of FW reduction. For example, experiments in school canteens have shown that offering smaller portions and increasing the proportion of vegetables on the plate can reduce the amount of food wasted (Leeuwis 2023). However, if there are to be good implications for urban household food security, additional food management behavior education (GS+PPM) is needed.

CONCLUSION

Based on these points, the general conclusion can be formulated that balanced nutrition intervention with nudging reinforcement can have an effect on reducing FW. However, in order to have better implications for food security, balanced nutrition intervention (with nudging reinforcement) is needed together with food management behavior (36% reduction in FW, 14% increase in food consumption quality, 3% food expenditure efficiency, and 5% increase in food security population). When household food waste is reduced by 5 percent, GHG emissions decrease by 2.98%, so that through the interventions carried out the estimated GHG emissions that can be reduced are around 20.86-23.24%. (Calibri font, size 10, and single-line spacing).

The conclusions section serves as the culmination of the research findings and provides a concise summary of the key outcomes and implications of the study. In this section, the researchers present their final thoughts and insights based on the analysis and interpretation of the data. It is an opportunity to address the research objectives and hypotheses and determine whether they were supported or contradicted by the findings. The conclusions should be supported by evidence from the results and discussion sections, highlighting the significance and novelty of the research outcomes. Additionally, this section may also discuss the limitations of the study and suggest potential areas for future research. The "Conclusions" section aims to tie together all the threads of the research and provide a clear and coherent summary of the main findings, ultimately contributing to the broader understanding of the research field and potentially influencing future scientific endeavors.

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