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Effectiveness of Visual Meal Plans on Knowledge and Household Food Waste: Pre-Experimental Study

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Abstract

Background: Household food waste presents a significant barrier to sustainable food security, with notable environmental, economic, and nutritional implications. This study evaluated the effectiveness of visual meal-planning education in enhancing knowledge of menu planning, influencing food purchasing behavior, and reducing household food waste in Tanah Sareal District, Bogor City.

Methods: A pre-experimental, one-group pretest–posttest design was employed with 50 housewives responsible for household food management, selected through total sampling. The intervention included an initial educational session and refresher sessions every four weeks over a 12-week period, utilizing visual meal-planning materials. Data collection involved structured questionnaires to assess knowledge and behavior, as well as direct measurement of food waste using a weighing method over eight consecutive days. Data were analyzed using descriptive statistics and the Wilcoxon Signed Rank Test.

Results: Findings indicated a significant increase in knowledge scores at the third evaluation ($p = 0.001$), reflecting improved understanding of menu planning and food purchasing. While planning and purchasing behaviors improved, the changes were not statistically significant. However, household food waste decreased significantly by 41 g/capita/day (60%) following the intervention ($p = 0.000$).

Conclusion: In summary, visual meal-planning education effectively enhances knowledge and substantially reduces household food waste, although its influence on behavior change is limited.

Keywords: Nutrition Knowledge, Menu Planning, food purchasing behavior

BACKGROUND

Unbalanced consumption patterns also lead to large amounts of food that is still fit for consumption being wasted. This problem highlights inefficiencies in the food consumption chain and a lack of awareness of food management at the individual and household levels (1). In 2020, Indonesia entered a waste emergency, according to data from the Economist Intelligence Unit (EIU), which ranked Indonesia as the second-largest food-waste producer in the world after Saudi Arabia, with 300 kg of food waste per year (2). The issue of food waste at the provincial and city levels is also significant. West Java and the city of Bogor have high food waste percentages, at 41.62% and 40% of total waste generation, respectively (3,4).

Food waste significantly affects nutritional, economic, social, and environmental dimensions in Indonesia. Hunger affects 13.5% of the population, totaling 269 million people. Economic losses due to food waste are estimated at IDR 213-551 trillion annually, while greenhouse gas emissions from food waste account for up to 7.29% of total annual emissions (2,5). The household sector is the primary source of food waste, with carbohydrates and proteins being the most frequently discarded food groups (2). Inefficient consumption behaviors, particularly in meal planning, shopping, and food waste management, are key contributors to elevated household food waste (6).

The first step to reducing food waste in households is to encourage behavioral changes in the planning and purchasing stages of food consumption, as these are critical points in the household consumption chain that significantly determine food use efficiency. Unplanned or impulsive food ingredient purchases often lead to excessive or unnecessary purchases, increasing the risk of waste. An individual may intend to shop wisely, but social pressure, time constraints, or inadequate information can hinder that intention. In line with this, explain that decisions to buy food are not always based on logical considerations, but are often influenced by habits or quick decisions made spontaneously, which are influenced by emotions and habits (7). Research also shows that good planning practices, such as compiling a shopping list based on a weekly menu and adjusting portions to family members' needs, significantly reduce food waste (8).

The public's lack of understanding of the importance of efficiency in food management is also a key factor driving food waste. When someone lacks a shopping plan tailored to their needs, this often leads to overbuying, impulsive shopping, and a mismatch between stock and consumption capacity. Research shows that low consumer knowledge is directly associated with higher household food waste rates (9,10). Low knowledge in food planning contributes to high food waste; this means that public knowledge and behavior regarding food consumption management remain a weak point that needs to be addressed through more targeted educational approaches (2).

Most previous studies on the effectiveness of various educational methods, such as face-to-face and community-based education, in increasing knowledge, changing behavior, and reducing food waste, have not been systematically compared. For example, the study evaluated only changes in knowledge and behavior after group discussions, without specifically assessing changes in behavior directly related to menu planning or household food purchasing habits (11). Meal plan education can provide the community with practical guidance on how to plan menus that suit family needs, manage food shopping to avoid excess, and use food ingredients optimally. However, meal plan education can provide the community with practical guidance on how to plan menus that suit family needs, manage food shopping to avoid excess, and use food ingredients optimally. Several studies have shown that this approach has been implemented in various contexts, including community-based interventions and household-level education programs. For instance, research demonstrated that structured meal planning and shopping routines significantly reduce household food waste (12). In addition, interventions focused on improving planning skills and consumer awareness have been implemented in European household settings and have been found to be effective in promoting more efficient food consumption behavior. However,

empirical evidence is still needed to specifically examine how effective meal-plan education is in improving knowledge and behavior related to food purchasing and planning, and in reducing food waste in the Indonesian context. Therefore, this study aims to examine the effectiveness of meal plan education on knowledge, food planning and purchasing behavior, and food waste in households in the city of Bogor.

METHODS

Study Design

A pre-experimental one-group pretest–posttest design was used to evaluate the effectiveness of visual meal plan education on knowledge, food planning and purchasing behavior, and household food waste. The research was conducted in Tanah Sareal District, Bogor City, from June to September 2024. The study population comprised households residing in the selected area, and the sample included housewives primarily responsible for household food management. Fifty respondents were recruited using a total sampling technique from the accessible population that met the eligibility criteria.

Sample/Participants

Inclusion criteria were as follows: (1) housewives aged 20–55 years responsible for daily food preparation and purchasing decisions; (2) residence in the study area for at least six months prior to the study; (3) willingness to participate throughout the intervention period, including attendance at educational sessions and completion of food waste measurement for eight consecutive days; (4) ability to understand and complete the questionnaire independently; and (5) not currently participating in other similar nutrition or food-related intervention programs. Exclusion criteria comprised respondents who were absent during intervention sessions, did not complete the food waste measurement, or withdrew from the study before completion.

Intervention

The intervention comprised a structured visual meal-planning education program, beginning with an initial educational session and followed by refresher sessions every four weeks over a 12-week period. Educational materials included visual-based tools such as weekly meal plans, portion guides, and structured shopping lists to facilitate practical understanding and application in daily household settings.

Data Collection

Data collection involved structured questionnaires to assess respondent characteristics, knowledge, and food planning and purchasing behavior before and after the intervention. Knowledge was measured using a dichotomous scale, and behavior was assessed using a Likert scale. Household food waste was measured by direct observation and weighing over eight consecutive days, following SNI 19-3964-1994.Secondary data were sourced from the principal investigator’s dissertation and demographic data from the Bogor City Statistics Agency (BPS) to complement baseline information.

Data Analysis

Descriptive statistics were used to summarize respondent characteristics and the distributions of variables. The Wilcoxon Signed Rank Test was used to assess differences between pretest and posttest measurements, as the data were not normally distributed according to the Kolmogorov–Smirnov test. Statistical significance was set at $p < 0.05$. The data obtained were processed quantitatively using Microsoft Excel and IBM SPSS version 29. The analysis was conducted in two stages. First, the respondents' characteristics and the distributions of knowledge, behavior, and food waste scores were analyzed descriptively using frequency distributions and means. Second, to assess the effectiveness of

meal plan education, a pretest-posttest difference test was conducted using the Wilcoxon Signed Rank Test because the data were not normally distributed, as indicated by the Kolmogorov-Smirnov test

Ethical Considerations

Ethical approval was obtained from the Health Research Ethics Committee, Faculty of Public Health, Universitas Airlangga (No. 208/EA/KEPK/2023). The study adhered to international ethical standards, including WHO (2011) and CIOMS (2016) guidelines. All participants provided written informed consent, and the confidentiality of respondent data was strictly maintained. Detailed data are presented in Table 1.

Table 1. Type and method of data collection

No	Data Type	Data Source	Collection Method
1	Respondent characteristics	Respondent identity questionnaire	Filling out the identity form by respondents
2	Knowledge of food planning and purchasing	Knowledge questionnaire	Questionnaires were filled out using a dichotomous scale before and after education
3	Food planning and purchasing behavior	Behavior questionnaire	Questionnaire completion using a Likert scale before and after education
4	Food Waste	Food weighing form & digital scale	Direct weighing of food waste by researchers for 8 consecutive days before and after education
5	Regional and environmental data	BPS documents, SIPSN, mapping reports from the main study	Documentation and observation study of the research area

RESULT AND DISCUSSION

Respondent Characteristics, Knowledge of Food Planning and Purchasing, and Food Waste

Table 2 provides an overview of respondents' characteristics, including age, education level, number of family members, and household income. The table also reports the median values and distributions of scores for the primary study variables: knowledge of food planning and purchasing, and food waste generation.

Table 2. characteristics of respondents, knowledge and behavior regarding planning and purchasing food and food waste

Characteristics	Mean ± SD	Category	n (%)
Age (Years)	38.00 ± 5.74	30	19 (38)
		36–40	18 (36)
		41	5 (10)
		46	6 (12)

		51–55	2 (4)
Education	10.00 ± 2.99	No schooling	1 (2)
		Elementary	5 (10)
		Junior High	16 (32)
		High School	22 (44)
		Higher Education	6 (12)
Number of Family Members (Persons)	4.00 ± 0.88	3	8 (16)
		4	18 (36)
		5	19 (38)
		6	5 (10)
Income (Rp/month)	3,563,000 ± 1,160,976	840,000 – 1,634,797	3
		1,634,798 – 2,429,595	7 (14)
		2,429,596 – 3,224,393	12 (24)
		3,224,394 – 4,019,191	8 (16)
		4,019,192 – 4,813,988	20

Note: Values are presented as mean ± standard deviation (SD) for continuous variables and frequency (n, %) for categorical variables. Age and income categories were grouped based on data distribution. Income is presented in Indonesian Rupiah (IDR) per month. Total respondents (n) = 50.

A total of 50 housewives participated in this study. The mean age of respondents was 38.00 ± 5.74 years, with the majority falling within the productive age range. Specifically, 38% of respondents were aged 30–35 years, followed by 36% aged 36–40 years. Smaller proportions were observed in the age groups of 41 years (10%), 46 years (12%), and 51–55 years (4%). These results suggest that most respondents were adults and primarily responsible for household decision-making, particularly in food management and purchasing.

The mean years of schooling among respondents was 10.00 ± 2.99 years, which corresponds approximately to the senior high school level. Nearly half of the respondents (44%) had completed high school, while 32% had completed junior high school. Smaller proportions had attained elementary education (10%), higher education (12%), or had no formal schooling (2%). This distribution indicates that most respondents possessed at least a basic to moderate level of formal education, which could affect their ability to comprehend food-related information.

The median number of household members was 4 (mean 4.00 ± 0.88), with most households consisting of either 5 (38%) or 4 (36%) members. Households with three members accounted for 16%, while those with six members accounted for 10%. These results reflect the typical household size in Indonesia and provide context for analyzing food consumption patterns and potential food waste.

The mean monthly household income was IDR 3,563,000 ± 1,160,976. The largest proportion of respondents (40%) reported a monthly income between IDR 4,019,192 and 4,813,988. Additionally, 24% earned between IDR 2,429,596 and 3,224,393, and 16% reported income between IDR 3,224,394 and 4,019,191. Lower-income categories accounted for 14% and 6% of respondents, respectively.

Changes in Knowledge of Food Planning and Purchasing and Food Waste Before and After Education

An analysis was conducted to evaluate changes in the median values and distributions (IQR) of variables related to knowledge, food planning, and purchasing behavior, as well as food waste before and after the meal plan education intervention. The difference test (Table 3) was performed using the Wilcoxon test, as the data were not normally distributed. A p-value < 0.05 was considered statistically significant.

Table 3. Analysis of Differences in Knowledge, Behavior, and Food Waste Before and After Educational Intervention

Variable	Median (IQR)	Min	Max	Δ	% Increase	P-Value
Knowledge (Score) - Before	80.00 (30.00)	10	100			
Knowledge (Score) - After (1)	80.00 (10.00)	50	100	0	0	0.077
Knowledge (Score) - After (2)	80.00 (10.00)	40	100	0	0	0.074
Knowledge (Score) - After (3)	90.00 (10.00)	60	100	10	12	0.001
Food Waste (g/capita/day) - Before	68.84 (56.19)	12.44	290.28			
Food Waste (g/capita/day) - After	27.30 (57.00)	0	105.506	41	60	0.000

Note: Data are presented as median (interquartile range, IQR), along with minimum (min) and maximum (max) values. Δ indicates the absolute difference between pre- and post-intervention measurements, while % increase represents the relative percentage change. Knowledge scores were assessed at baseline (before) and during three evaluation stages after the intervention. Statistical analysis was conducted using the Wilcoxon Signed Rank Test, with $p < 0.05$ considered statistically significant.

Table 3 presents the analysis of changes in knowledge scores and household food waste before and after the meal plan education intervention. The Wilcoxon Signed Rank Test was used to assess differences between pre- and post-intervention measurements due to non-normal data distribution.The median knowledge score prior to the intervention was 80.00 (IQR 30.00), with a range of 10–100. During the first and second evaluation stages, the median score remained at 80.00, with p-values of 0.077 and 0.074, respectively, indicating no statistically significant difference from baseline. At the third evaluation stage, the median knowledge score increased to 90.00 (IQR 10.00), a 10-point (12%) improvement that was statistically significant ($p = 0.001$). These results suggest that knowledge improvement was gradual and became significant after repeated educational exposure.

A more pronounced change was observed in household food waste. Before the intervention, the median food waste was 68.84 g/capita/day (IQR 56.19), ranging from 12.44 to 290.28 g/capita/day. After the meal plan education intervention, the median food waste decreased to 27.30 g/capita/day (IQR 57.00), with a range of 0 to 105.51 g/capita/day. This represents a reduction of 41 g/capita/day, or a 60% decrease from baseline, which was statistically significant ($p = 0.000$).

DISCUSSION

Respondent Characteristics, Food Planning Knowledge, and Food Waste

The study found that respondents had an average age of 38 years, with an age range of 30 to 53 years. This indicates that most respondents are productive adults who play a significant role in domestic

decision-making, particularly in household food consumption. These findings are consistent with the Central Statistics Agency's Population and Housing Census 2023, which reports that 70.7% of Indonesia's population is in the productive age group (15–64 years) and that the national median age is 30.2 years (13). Age is a critical factor, as adults generally have greater cognitive capacity and are responsible for food planning, management, and purchasing decisions. Previous studies argue that adult consumers are more likely to make rational food choices by considering nutritional value and price, and that increasing age positively correlates with efficiency in managing household food consumption (14,15).

Respondents in this study had an average of 10 years of education, equivalent to senior high school (SMA). Educational attainment ranged from 0 to 16 years, reflecting diversity from those who had not completed primary education to those with higher education. Compared with national data from the Population and Housing Census (Statistics Indonesia), which shows an average of 9 years of schooling, respondents in this study have a higher educational level. Higher education contributes to improved cognitive abilities, such as understanding nutritional information, making informed consumption decisions, and efficiently managing household expenses. Previous research supports the view that education is a key determinant of rational attitudes and health behaviors, including food consumption.

The median household size among respondents was 4, with a range of 3 to 6. This finding aligns with the 2024 Susenas data, which reports an average of four people per household in Indonesia. Household size is a significant factor influencing the efficiency of food consumption management and the potential for food waste. Studies indicate that households with more members tend to manage consumption more efficiently, as food is distributed among more individuals, leading to reduced waste. Therefore, households with three to six members, as observed in this study, represent an appropriate target group for educational interventions on meal planning to optimize food consumption management.

Respondents' households had a median income of IDR 3,950,000, with incomes ranging from IDR 840,000 to IDR 4,813,988. Compared to the 2024 Regional Minimum Wage (UMR) for Bogor, set at Rp. 5,126,897 by West Java Governor Decree No. 561.7/Kep.798-Kesra/2024, most respondents are classified as lower-middle income. Income is a significant factor in managing consumption and food waste. Households with limited income are generally more cautious and selective when purchasing food and tend to use available food stocks more carefully (16). However, low income does not always ensure efficient consumption, as limited access to information, education, and food management skills can lead to impulsive, unplanned purchasing, which may increase food waste (6,12).

Changes in Knowledge, Food Planning, Purchasing Behavior, and Food Waste Before and After Educational Intervention

The study's results show significant changes in knowledge, food planning and purchasing behavior, and household food waste following the meal plan education intervention. Before the education, the median knowledge score among respondents was 80, indicating that the majority already had a basic understanding of nutritional principles and the importance of meal planning. However, this understanding remained declarative and had not yet been fully internalized in daily practice. This was evident from the large number of respondents who still shopped impulsively and were unable to plan balanced menus. The theory of cognitive constructivism asserts that changes in knowledge structure require a continuous process of assimilation and accommodation (17). The evaluation was conducted in three stages, and a significant increase in knowledge was only seen in week 12, with the median score increasing to 90 ($p = 0.001$). A total of 64% of respondents showed increased understanding, as indicated by active participation in discussions and independent menu planning. The process of repeated learning proved effective in strengthening conceptual understanding (18).

The most prominent change observed was a reduction in food waste. Before the intervention, elevated food waste levels were attributed to inadequate consumption planning. Following the educational program, a significant decrease in food waste was recorded over an eight-day period, measured in accordance with SNI 19-3964-1994. Respondents demonstrated greater care in portion determination, purchase planning, and optimization of food ingredients. This improvement was consistent across all respondent groups. The effectiveness of meal plan education in reducing food waste can be interpreted through the Norm Activation Model (NAM), which suggests that heightened awareness of consequences and moral responsibility fosters pro-environmental behavior. The educational intervention activated personal norms by highlighting the social and ecological impacts of food waste, thereby promoting a commitment to improved food management. These results are consistent with previous studies emphasizing the role of meal planning in reducing household food waste (12).

Effectiveness of Visual Meal Plans on Menu Planning Knowledge, Food Purchasing, and Food Waste

A significant increase in knowledge scores following the intervention demonstrates that the Visual Meal Plan is effective in enhancing participants' understanding of menu planning, aligning food purchases with actual household needs, and recognizing the consequences of food waste. Visual-based media present information in a concrete, engaging, and accessible manner. These findings are consistent with Dual Coding Theory, which asserts that presenting information simultaneously in verbal and visual formats facilitates cognitive processing and improves memory and conceptual understanding (19). In this study, visualizations such as weekly meal plans, shopping lists, and food portion guides clarified educational messages and enabled participants to relate this information to their daily consumption practices. The results further support the assertion that visual media can enhance learning motivation and promote cognitive change (20). Previous research has also demonstrated that visual media can significantly improve knowledge scores, particularly among housewives (21).

Although scores for food planning and purchasing behavior increased, these changes did not reach statistical significance. This suggests that the observed knowledge gains have not yet fully translated into behavioral change. Behavioral change is a gradual process influenced by internal factors, such as motivation, habits, and intentions, as well as external factors, including social, economic, and cultural environments (22). According to Prochaska and DiClemente's Transtheoretical Model, behavioral change progresses through several stages: precontemplation, contemplation, action, and maintenance. The Visual Meal Plan intervention supported participants in reaching the awareness and preparation stages, although most had not yet achieved consistent action. Despite this, the trend toward positive behavioral change remains notable. Some participants have begun adopting practices such as checking food stocks before shopping, creating shopping lists based on daily menus, and monitoring meal portions. These findings indicate that visual media-based education can provide initial stimuli for new behaviors, even if significant changes are not immediately evident in the short term (23).

Meanwhile, measurements of food waste variables showed a significant decrease after the intervention. These findings indicate that the Visual Meal Plan not only raised awareness but was also implemented by respondents in their home food consumption practices. The decrease in food waste was due to better meal planning, the habit of saving leftovers, and avoiding impulsive food purchases. These results align with the Household Food Waste Prevention Framework developed by WRAP (2012), which emphasizes the importance of practical, simple, and context-specific educational interventions to reduce household food waste (24). Visual Meal Plan can also be categorized as a nudging intervention, a non-coercive strategy that guides individuals to make better decisions without direct coercion (25). Realistic weekly menu visualizations, structured shopping guides, and illustrations of proportional meal sizes are effective nudges in helping households make wiser consumption decisions. Therefore, even though they

are not verbally instructive, visual media have a strong influence on shaping new mindsets and behaviors.

Overall, the findings of this study confirm that Visual Meal Plan is an effective educational approach for increasing knowledge and reducing food waste, as well as for facilitating behavioral transition towards more planned and responsible food consumption practices at the household level.

CONCLUSION

The majority of respondents were housewives of productive age with upper secondary education, residing in families with more than four members; half of these households had incomes below the median household expenditure. Prior to the educational intervention, 46% of respondents had knowledge scores below the median value of 80, 54% demonstrated food planning and purchasing behaviors below the median score of 73, and 50% generated food waste exceeding 62 grams per capita per day. Following meal plan education, knowledge scores increased significantly ($p=0.001$). Additionally, average food waste decreased by 41 grams per capita per day, a statistically significant reduction ($p=0.000$), indicating the effectiveness of the educational intervention in promoting more efficient consumption practices. Meal plan education was effective in increasing knowledge and reducing household food waste.

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AUTHOR'S CONTRIBUTION STATEMENT

ERA: Conceptualization, data collection, formal analysis, investigation, writing – original draft preparation. PDS Conceptualization, methodology, supervision, writing – review and editing.

CONFLICT OF INTEREST

The author declares that there is no conflict of interest in the writing of this article.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

The authors used ChatGPT and DeepL to improve language quality, clarity, and readability of the manuscript. The authors take full responsibility for the content of this article.

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