

# Nutrient loss due to food waste in urban households: insights from Bogor City, Indonesia

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**Abstract.** Background: Food waste (FW) has become a pressing global issue, contributing significantly to nutrient loss and significantly achieving sustainable healthy diets. Urban households, in urban particular, are among the primary contributors to this problem. Objective: This study aims to analyze nutrient loss resulting from food waste in households. Methods: A cross-sectional study was conducted to measure food waste (FW) over eight days using the SNI 19-3964-1994 method. Stratified random sampling was employed to select 110 households, targeting housewives aged 30-55 years who manage household food and own a refrigerator. Data were analyzed using IBM SPSS version 22.0, Microsoft Excel 2019, and the Wasted Daily Diets (WDD) method. The nutritional content of food waste was assessed using the 2017 Indonesian Food Composition Table, encompassing energy, macronutrients, fiber, iron, and vitamins A and C. Results: The average food waste amounted to 78.38 g per capita per day, resulting in nutrient losses of 122.71 kcal of energy along with seven other nutrients. Conclusions: Annually, 28.23 kg of food per capita is wasted. If recovered, this amount could provide sufficient energy and nutrients to sustain one person for eight days. This study highlights the urgent need to raise public awareness about reducing food waste and promoting sustainable, healthy diets. Initiatives such as food sharing can help prevent waste while addressing nutritional issues, including iron deficiencies.

## 1 Introduction

Efforts to achieve a healthy and sustainable food future necessitate balancing nutritional needs, food costs, and environmental sustainability [1]. Despite these goals, global food waste (FW) has risen significantly, now totaling 1.3 billion tonnes annually, with urban areas generating more waste than rural regions [2,3]. Indonesia ranks among the top five countries with the highest levels of food waste (FW) globally, producing 20.93 million tonnes annually—an amount capable of feeding over 30% of the Indonesian population [4]. West

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Java, the most populous province in Indonesia, records a notable FW rate, with the city of Bogor contributing 40% [5].

Urban communities, characterized by higher incomes, often exhibit greater purchasing power, which is frequently associated with increased food waste [6]. In urban areas, food waste is particularly prevalent among food groups such as vegetables and fruits, which are commonly discarded [7]. This pattern reflects an unbalanced diet and contributes to inadequate micronutrient intake, potentially leading to nutrient deficiencies, obesity, and non-communicable diseases [8]. Furthermore, households account for 61% of food waste [4], largely due to poor food management practices. Mothers, as primary household meal managers, play a pivotal role in this context. The age of the household manager is a significant factor, with mothers aged 30 and above generally considered more experienced in managing household food [9].

Food waste (FW) often includes items that remain consumable but are discarded for various reasons, commonly referred to as leftovers. These foods, still rich in nutrients and suitable for consumption, are frequently treated as waste, despite the persistent global challenge of addressing nutritional deficiencies. This underscores a critical gap and presents emerging issues that require effective solutions. The United Nations (UN), through its Sustainable Development Goals, mandates that all countries reduce food waste at the consumption level by 2030 [10]. Food waste is closely linked to nutrient loss [11], posing a significant barrier to achieving sustainable diets.

Nutrient loss in food waste (FW) refers to the nutrients contained in discarded food that are lost due to non-consumption. The degree of nutrient loss is influenced by the diversity of discarded food items and the failure to effectively utilize the nutrients they provide. Investigating food waste (FW) is essential for identifying and quantifying nutrient loss at the household level. Such analysis enables a detailed assessment of the implications of nutrient loss and its sustainability by calculating the nutritional content of leftovers. This approach can uncover the true value of wasted food, offering critical insights for developing policies to reduce food waste and enhance public awareness. This study examines the estimated nutrient loss in household food waste, aiming to promote efficient food consumption, address nutritional gaps, and foster sustainable dietary practices.

## **2 Materials and methods**

This study employs a cross-sectional design conducted in 2024 in the Tanah Sereal Sub-district, Bogor City, using a purposive sampling method. Bogor City, characterized by rapid population growth, is the third largest waste producer in Indonesia [5,12]. Additionally, the Stratified Random Sampling (SRS) method was used to select 110 households based on income. The study focused on housewives aged 30 to 55 who own a refrigerator and manage household food. The mothers who participated as respondents in the study exhibit characteristics reflective of the broader population, making them representative of the Tanah Sereal community in Bogor City.

Food waste (FW) was measured using the SNI 19-3964-1994 method, which evaluates municipal solid waste and its composition [13]. Trained enumerators directly weighed FW from each food group over eight consecutive days, with measurements conducted each morning. Food groups were categorized based on a modified Household Dietary Diversity Score (HDDS) to assess household dietary diversity [3]. The 12th food group, beverages, was separated into its own category, resulting in a total of 13 food groups. The nutrient content measured included energy, protein, fat, carbohydrates, fiber, iron, and vitamins A and C, based on the 2017 Indonesian Food Composition Table.

Data processing was conducted using IBM SPSS version 22.0 and Microsoft Excel 2019, employing the Wasted Daily Diets (WDD) calculation method. The WDD was determined

based on the lowest nutrient values of the examined nutrients (energy and the other seven nutrients), reflecting the amount of nutrient loss in discarded food. This loss was quantified as the nutrients that could fulfil a healthy diet (energy and the other seven nutrients) for multiple people over one day, or the nutrients that could provide energy and the other seven nutrients for one person over several days [16,19]. The WDD calculation analyzed the nutrient content of food waste to determine the amount sufficient to meet the 2019 Recommended Dietary Allowance (RDA) for adult men aged 30–49 years. The age group was selected because their nutritional needs are generally more stable and represent the upper limit of requirements compared to other demographic groups, such as women or individuals in older or younger age brackets. Meeting the nutritional threshold for this group is likely to fulfill the needs of other groups as well. This age group is often used as a reference for policy-making, as it represents the productive adult population. The WDD results were based on the lowest WND (wasted nutrient days) value, calculated by dividing the annual per capita nutrient content of food waste by the recommended nutrient adequacy levels [15,16]. Wasted Nutrient Days (WND) are determined by dividing the total annual per capita nutrient loss from food waste (in kilograms) by the recommended dietary allowances for each measured nutrient, including energy and seven additional nutrients [16]. This study was approved by the Health Research Ethics Committee of the Faculty of Public Health, Airlangga University, under reference number 208/EA/KEPK/2023.

### 3 Results and discussion

Based on eight days of food waste measurements from 110 households, collected each morning, an average of 78.38 g per capita per day (28.23 kg per capita per year) was recorded. The analyzed food waste consisted of 13 food groups from the Household Dietary Diversity Score (HDDS), encompassing edible food, leftovers, by-products, raw ingredients, and expired items. The disposal of this food resulted in the loss of 122.71 kcal of energy, 4.05 g of protein, 6.42 g of fat, 13.24 g of carbohydrates, 0.74 g of fiber, 1.22 mg of iron, 21.32 mcg of vitamin A, and 6.77 mg of vitamin C. These findings highlight that the discarded food contains valuable nutrients and could potentially contribute to meeting dietary requirements.

**Table 1.** Food groups to the average loss of energy and macronutrients from household FW

Food groups	Energy		Protein		Fat		Carbohydrate	
	kcal	%	g	%	g	%	g	%
Cereals	38.4	31.4	1.00	25.0	0.51	8.2	7.94	60.1
Tubers	1.23	0.9	0.04	1.3	0.19	3.0	1.06	7.5
Meat and meat products	6.14	5.4	0.52	12.6	0.45	6.9	0.00	0.3
Fish and seafood and others	1.23	1.3	0.16	4.0	0.06	0.5	0.13	1.0
Eggs	1.23	0.8	0.08	2.0	0.06	1.0	0.00	0.1
Milk and milk products	17.18	13.9	0.72	18.3	0.96	14.6	1.32	9.6
Legumes, nuts, and seeds	8.59	6.9	0.72	17.6	0.32	4.9	0.53	3.9
Vegetables	4.91	3.8	0.28	6.9	0.06	1.2	0.93	6.5
Fruits	3.68	3.4	0.04	0.9	0.06	1.2	0.79	6.4
Oils and fats	35.59	28.5	0.40	9.9	3.73	58.0	0.13	0.8

Food groups	Energy		Protein		Fat		Carbohydrate	
	kcal	%	g	%	g	%	g	%
Sugar and sweeteners	2.45	1.9	0.00	0.2	0.00	0.4	0.26	2.3
Spices and condiments	1.23	0.9	0.04	0,2	0.00	0.1	0.00	0.4
Beverages	1.23	0.9	0.04	1,1	0.00	0.0	0.13	1.1
Total	122.71	100	4.05	100	6.42	100	13.24	100

Cereals were the most frequently discarded food group, resulting in significant losses of energy, protein, and carbohydrates (Table 1). Additionally, over 50% of the discarded fat was attributed to the oil and fat food group. Our research findings revealed that rice was the most commonly discarded item within the cereal group, while the oil and fat group primarily consisted of leftover frying oil and high-fat products such as margarine and butter. Additional contributions to fat losses came from sources like eggs, milk, and other animal proteins. The vegetable group was the second largest contributor to food waste, and along with fruits, it significantly contributed to the loss of fiber and vitamin C (Table 2). The analysis also identified legumes and nuts, as well as milk and its derivatives, as key contributors to the loss of iron and vitamin A in food waste.

The results of this study indicate that nutrient loss arises from both the diversity of food types in food waste and the significant quantity of waste generated. A varied diet provides a range of nutrients that can meet an individual's nutritional needs. However, uneaten food, whether due to spoilage, cooking processes, or leftovers on plates, results in a loss of nutrients that could otherwise meet dietary requirements. This is supported by previous research conducted on the American population [14], which highlights the connection between food waste and nutrient loss. Their findings revealed a significant relationship between food waste and the quality of the studied foods. The food groups with the highest waste percentage were fruits and vegetables, while dairy, meat, and certain grains had the lowest. Assessing nutrient loss due to food waste can serve as a valuable tool for evaluating dietary quality in food consumption.

**Table 2.** Food groups to the average loss of fibre, minerals, and vitamins from household FW

Food groups	Fibre		Iron		Vitamin A		Vitamin C	
	g	%	mg	%	mcg	%	mg	%
Cereals	0.01	1.1	0.04	2.9	0.00	0.0	0.68	9.1
Tubers	0.00	1.1	0.10	7.9	6.40	29.7	0.00	0.0
Meat and meat products	0.01	0.7	0.03	2.4	0.43	1.9	0.00	0.0
Fish and seafood and others	0.00	0.0	0.03	2.4	0.64	2.9	0.00	2.5
Eggs	0.00	1.1	0.21	15.9	13.43	63.6	0.21	2.9
Milk and milk products	0.05	6.5	0.39	29.9	0,00	0.0	0.21	0.2
Legumes, nuts, and seeds	0.33	43.5	0.26	19.9	0.00	0.0	4.72	69.7
Vegetables	0.14	17.9	0.06	4.9	0.00	0.0	0.96	14.1
Fruits	0.00	0	0.01	0.9	0.00	0.4	0.00	0.1
Oils and fats	0.01	1.4	0.00	0.9	0.00	0.0	0.00	0.1
Sugar and sweeteners	0.01	1.4	0.00	0.9	0.00	0.0	0.00	1.0

Food groups	Fibre		Iron		Vitamin A		Vitamin C	
	g	%	mg	%	mcg	%	mg	%
Spices and condiments	0.01	1.4	0.00	3.9	0.00	0.0	0.00	0.1
Beverages	0.18	23.9	0.09	7.2	0.43	1.5	0.00	0.2
Total	0.74	100	1.22	100	21.32	100	6.77	100

Meanwhile, our research analyzed nutrient loss by estimating the WDD (wasted daily diet) value. The calculation revealed that if food were successfully saved, it could fulfill between 2.1% and 14.4% of daily energy requirements, as well as the macro and micronutrient needs studied. Specifically, the total food waste generated per person in Tanah Sereal District, Bogor City, over the course of a year could provide enough energy and nutrients to sustain one individual for eight days. This suggests that 28.23 kg of food waste per capita per year could meet the energy and nutrient needs of eight people in a single day (Table 3). The calculation of nutrient loss from food waste in this study highlights the need for public awareness to reduce food waste generation, enabling the effective utilization of the nutrients contained within it to meet nutritional adequacy.

**Table 3.** Nutrient loss contained in household FW as % of Recommended Dietary Allowance (RDA) levels and Wasted Daily Diet

Nutrients	Wasted amount	SD <sup>1</sup>	Total nutrients (cap/year)	RDA <sup>2</sup>	%RDA	WND <sup>3</sup>	WDD <sup>4</sup>
Energy (kcal)	122.71	105	44174.91	2550	4.8	17.32	7.60 = 8
Protein (g)	4.05	4	1442.51	65	6.2	22.19	
Fat (g)	6.42	8.3	2312.74	70	9.2	33.04	
CHO (g)	13.24	12	4766.27	415	3.2	11.48	
Fiber (g)	0.74	1	273.62	36	2.1	7.60	
Iron (mg)	1.22	2.5	465.82	9	14.4	51.76	
Vit.A (mcg)	21.32	34	7676.30	650	3.3	11.81	
Vit.C (mg)	6.77	9	2462.82	90	7.6	27.36	

<sup>1</sup>Standard deviation of the mean number of nutrients

<sup>2</sup>Nutritional adequacy of adult men aged 30-49 years based on the 2019 RDA

<sup>3</sup>Wasted Nutrient Day (WND)

<sup>4</sup>Wasted Daily Day (WDD)

This study reports lower food wastage and nutrient loss compared to previous research. For example, one study found a food waste level of 29 kg per capita per year, leading to the loss of 144 kcal of energy, 4.4 g of protein, 1.1 g of fiber, 67 mcg of vitamin A, and 1.1 mg of iron [17]. Furthermore, a study conducted in the UK documented 85 kg of food waste per capita per year, resulting in the loss of 326 kcal of energy, 10.9 g of protein, 3.4 g of fiber, and 1.8 mg of iron [15]. Various studies reveal differing amounts and distributions of food waste, with cereals and vegetables consistently identified as the primary contributors to household waste.

The calculation of nutrient loss in food waste in this study emphasizes the need for public awareness to reduce food waste, enabling the effective utilization of its nutrients to meet the community's nutritional needs. Several studies have shown that food waste, which is often discarded, occurs at all stages of the food supply chain, with the consumption stage being the largest contributor. This situation hampers the achievement of sustainable, healthy diets that the global community aspires to. It is crucial for individuals to adopt responsible behaviors and attitudes toward food. Food waste is a multifaceted issue, intertwining social, economic, and environmental challenges, all of which affect sustainability. Moreover, the issue of food

waste, recognized globally, is addressed within the targets of the Sustainable Development Goals (SDGs), which aim to reduce its occurrence [18].

This study has several limitations that should be considered. One of the primary limitations is the potential variability in food waste patterns, which may be influenced by different income groups. While this study was conducted in an urban area, the income levels of households vary significantly, which is also linked to differences in purchasing and consumption habits. This affects both the quantity and types of food discarded, as well as the waste patterns observed within each group. Additionally, behaviors and knowledge related to household food management contribute to the variability in food waste patterns. Awareness of the importance of reducing food waste and managing food more efficiently varies significantly among households. Communities that are more aware of the importance of shopping planning are better able to manage household food according to their needs, helping to save family budgets. This approach also promotes more sustainable food provision within the family.

Based on the findings, awareness of effective household food management is relatively low, making food waste a persistent issue in many households. There is a clear need for counselling and training, especially for mothers, who play a central role in managing household food. This training should focus on areas such as shopping planning, food storage, food preparation and utilization, meal planning, and understanding family portion sizes. Furthermore, campaigns that emphasize the importance of reducing food waste and link it to the achievement of sustainable, healthy diets are essential for the community. One simple suggestion is to promote food sharing as a practical solution to address food waste.

## 4 Conclusion

Discarding 78.38 g of food per person per day results in a loss of 122.71 kcal of energy, 4.05 g of protein, 6.42 g of fat, 13.24 g of carbohydrates, 0.74 g of fiber, 1.22 mg of iron, 21.32 mcg of vitamin A, and 6.77 mg of vitamin C. If saved over the course of a year, this amount could meet an individual's nutritional needs for 8 days. Government policies aimed at reducing food waste are crucial, particularly for the local government of Bogor City.

Starting with the reduction of household food waste, the Bogor City Government can engage mothers—who are the primary food managers in households—through posyandu (integrated health posts). Posyandu can serve as a platform for periodic training and counselling on family food management, as it provides an accessible way to reach mothers and families. Additionally, public awareness campaigns on the importance of reducing food waste to achieve sustainable healthy diets are essential. Through food sharing, we can prevent waste and support those in need, particularly in addressing iron deficiencies. It is hoped that this practice will become a positive habit in utilizing food to meet nutritional needs. Further research could delve deeper into the relationship between food waste and socio-economic factors, as well as examine the impact of family food management training on reducing household food waste.

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