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Retail Food Waste and Estimated Nutrient Losses in Urban Areas of Dar es Salaam, Tanzania

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Abstract

Food waste is a global problem with social, nutritional and environmental implications affecting the sustainability of the food chain. In Tanzania, food waste coexists with food and nutrition insecurity, however, its extent and its nutritional impact remain unclear. This study sought to quantify food waste from selected fresh produce in Dar es Salaam's retail markets and estimate the associated nutrient losses per-vendor per day. Data was collected from three districts namely: Kinondoni, Ubungo and Temeke. A total of 108 fresh food vendors collected their daily food waste of pre-selected fresh food produce items namely bananas, tomatoes, potatoes, carrots, cabbage and amaranth for seven days. These waste samples were measured daily on a weighing scale and recorded. Measurement of 108 samples daily for 7 days resulted in a total of 756 sample recordings obtained. Data in mean kilograms of waste was then calculated using standardized conversion factors to nutrient compositions using Tanzania food composition tables to estimate nutrient losses embedded in wasted fresh food. The data was further presented as recommended intakes for additional context. Of the selected foods, bananas produced the highest amount of waste with a daily mean of 13.9 kg ± 13.1 (SD) per-vendor, tomatoes produced a daily mean of 10.1kg ± 6.9 (SD); potatoes 8.5kg ± 6.3 (SD); cabbage 4 kg ± 3.0 (SD); carrots 3.4 kg ± 1.6 (SD), while amaranth was the least wasted with a daily mean of 0.2kg ± 1.0 (SD) wasted. Food wasted at the retail level of the Dar es Salaam food supply contained 3,643 Kcal, 93.4 g protein, 147 g dietary fiber, 6,429 µg vitamin A, 1,371 µg folate, 66.3 mg iron and 20,936 mg potassium per-vendor per day indicating notable nutritional losses embedded in food wasted at the retail level of the Dar es Salaam food supply.

Keywords: *Food Vendors; Food Waste; Nutrient Loss; Retail*

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Introduction

Food waste is a global problem with social, nutritional and environmental implications significantly affecting the sustainability of the food chain (Cicatiello *et al.*, 2017; Abiad and Meho, 2018; Ishangulyyev *et al.*, 2019). The Food and Agricultural Organization (FAO) reported that global food production must increase by 60% by 2050 in order to meet the demands of the growing world population (FAO, 2014). However, more than one third of the food produced today is lost or wasted. Approximately 14% of the world's food is lost annually between harvest and the retail market (FAO, 2019). Additionally, an estimated 17% of food is wasted at the retail and consumer levels (UNEP, 2021). This adds up to approximately 31% of all food produced being wasted, signifying a gross misuse of global food resources.

The growing concerns about hunger, environmental preservation and the economy have increased public awareness to food waste (Buzby and Hyman, 2012). Consequently, growing attention to food waste has been reflected in the Sustainable Development Goals (SDGs). SDG target 12.3 calls for halving per-capita global food waste at the retail and consumer levels and reducing food loss along production and supply chains by 2030, SDG goal 2 calls for an end to hunger, achieving food security and improved nutrition, and the promotion of sustainable agriculture (UN, 2015).

Meanwhile, malnutrition remains a significant public health issue throughout the developing world, particularly in Southern Asia and Sub-Saharan Africa (FAO *et al.,* 2022). In the developing world, food waste is synonymous with food and nutrition insecurity since there are significant nutritional losses embedded in food waste, and foods with a higher nutritional profile, such as fruits and vegetables, tend to be the most wasted (Parfitt *et al.,* 2010). Reducing food loss and waste is widely recognized as a crucial means to reduce production costs and enhance efficiency of the food system, improve food and nutrition security, and contribute towards environmental sustainability (Lipinski *et al.,* 2018). Furthermore, by reducing food waste, more food would potentially be available thus alleviating the burden of hunger.

Various studies have highlighted the nutritional consequences of food waste, as evidenced by research conducted by Lipinski *et al.,* (2018), Cooper *et al.,* (2018), Chen *et al.,* (2020), and Brennan and Browne (2021). However, it is noteworthy that a majority of these investigations have predominantly focused on developed countries. In contrast, the available body of research reporting on the levels of food waste in developing countries remains relatively limited. In Tanzania evidence indicates that food waste exists alongside food and nutrition insecurity. A comprehensive study was undertaken in the Kinondoni municipality of Dar es Salaam with the objective of evaluating both the rate of per-capita household daily waste generation and the composition of waste. According to the findings, an overwhelming majority, specifically 74.1%, of the generated waste in this locale was identified as food waste (Oberlin, 2013). This observation sheds light on the significant proportion of discarded food items within the municipal waste stream. Furthermore, an assessment of food security in 16 selected districts in Tanzania between 2019 and 2020 showed that 20% out of the entire population in those districts experienced severe food insecurity (PMO, 2020).

Although the quantity of food waste generated by retailers is considerable, it represents only a minor fraction of all food wasted along the supply chain in high-income countries (Ishangulyyev *et al.,* 2019). This is one of the reasons why, up to now, retail-level food waste has not been studied in depth unlike other stages of the food chain, such as on the farm and in the household (Ventour, 2008; Cicatiello *et al.,* 2017). However, the level of retail-level food waste is of higher significance for assessment in low- and middle-income countries because the proportion of food wasted at the retail level is perceived to be considerably higher compared to that of high-income countries due to challenges faced by low- and middle-income countries in transport and storage infrastructure and technologies for fresh food produce (Gustavsson *et al.,* 2011; Lipinski *et al.,* 2018).

It is important to assess the burden contributed by retail-level food waste to nutrition, in order to formulate strategies that can be adopted toward systematic reduction and recovery of wasted food, particularly at the retail level of urban food systems in Tanzania. An estimate of the nutrient content of discarded foods, provides quantification for a comprehensive set of nutrients lost at the retail level of the food supply chain. This study aimed to determine the quantities of food waste of bananas, tomatoes, potatoes, carrots, amaranth and cabbages generated by retail market vendors in Dar es Salaam as well as to estimate the overall nutrient losses embedded in food waste, on a per-vendor per day basis.

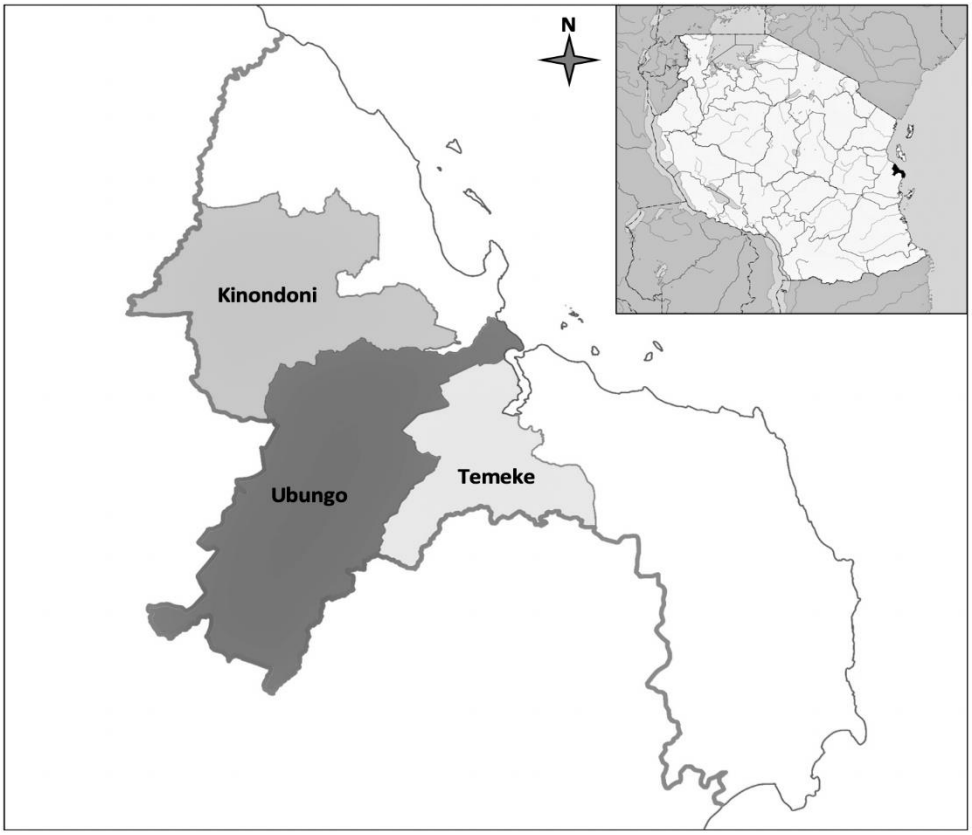
Materials and Methods

Description of the Study Area

The study was conducted in Dar es Salaam region which is the largest and most populated city in Tanzania also serving as the commercial hub in the country, with about 5.4 million residents (NBS, 2022). It is also a regionally important economic centre. The region is composed of Dar es Salaam City Council (DCC) and five district councils: Kinondoni in the north; Ilala in the centre; Ubungo and Temeke in the south; and Kigamboni in the east. Distribution of retail food market outlets in Dar es Salaam is characterized by the presence of at least one large-scale retail food market in each district, with a total of six large fruit and vegetable markets in the city (ISWA, 2017). These large-scale markets account for much of the food waste sourced from retail markets and were identified as a good reference point for quantifying food waste.

Figure 1

Map of Dar es Salaam Region and the Studied Districts



Study Population
The study population consisted of male and female retail food market vendors working in fresh food markets within the selected districts of Dar es Salaam; whereby, for the purpose of this study, retail food vendors were considered as the food waste generating entity.

Study Design
A descriptive cross-sectional study design was employed to conduct this study in March 2024.

Sampling Procedure
A multistage sampling procedure was carried out for the study. Three districts namely Ubungo, Ilala and Temeke were randomly selected for investigation. One representative large-scale fresh food market was selected in each district making a total of three fresh food markets. The selected markets were Mabibo in Ubungo district, Buguruni in Ilala district and Stereo in Temeke district, each with a vendor population of approximately 4300, 2213 and 4800 vendors respectively as reported by the market administrators during the preliminary survey of the markets. The study target sample was perishable food produce, wherein the selected food groups were fruits, vegetables and starchy roots and tubers. This is because perishable foods such as fruits and vegetables are known to be wasted in especially high rates, leading to significant losses of under-consumed nutrients (Spiker *et al.,* 2017). This choice of produce was also consistent with a study conducted by the FAO which showed these categories of foods to be among the highest contributors to food waste (FAO, 2015). Hence a total of 6 produce items were selected for assessment; namely ripe bananas, tomatoes, cabbage, amaranth, potatoes and carrots. These produce items were selected for sampling due to their wide consumption in urban Tanzania, their constant availability in retail markets throughout the year as well as their perishability. To acquire these samples vendors were recruited from the markets using a simple random selection process, whereby names were picked randomly from a pool of vendors' names resulting in the inclusion of a total of 108 selected market vendors. The recruited 108 vendors consisted of 36 vendors from each market location (Ubungo, Ilala, and Temeke) to participate in the study. Furthermore, 6 vendors were chosen for each food produce in each of the three designated markets. The demographic characteristics of all vendors were gathered through the use of a brief questionnaire.

Data Collection Tools
The study adopted a mixed methods approach by utilizing observation, sample collection and measurement as well as questionnaires to obtain primary data for the study. Special bags were used for collection of food waste; a digital weighing scale was used for measurement of food waste weights; a food waste assessment sheet was used for recording measured weights; and a questionnaire was constructed to obtain market and social-demographic characteristics of vendors producing food waste.

Piloting the Data Collection Tools
A preliminary survey of retail markets was conducted through observation before commencement of data collection. The data collection tools were all pretested to obtain the feasibility of the collection process, test the quality of questions (for questionnaires), and were modified where necessary.

Data Collection Process
Direct weighing method was adopted from the Food Loss and Waste Accounting and Reporting Standard (WRI *et al.,* 2016). Each vendor was provided with special bags and zip-ties, and were instructed to collect food waste generated by their business which was intended for disposal daily. Food waste of each selected produce item was collected from the vendors each morning, weighed on a scale and recorded in kilograms to determine net weight of food waste. The weight of the empty bag (i.e., the tare weight) was deducted from the recorded weight. This process was repeated daily for a period of 7 days for each of the 108 vendors in the selected markets bringing the total to 756 sample recordings.

Data Analysis
Mean values of food waste were calculated from the recorded weights of food for each produce per-vendor. Calculation of nutrient loss was done through conversion of food waste data in weight to nutrient content using food composition tables. For each produce selected, corresponding nutrient composition was obtained from the Tanzania Food Composition Tables (Lukmanji *et*

al., 2008) per standardized 100-gram (g) unit of food. Subsequently, the amount of each nutrient present in the recorded weight of food waste was calculated, and amounts were summed by nutrient to estimate per-vendor nutrient loss per day resulting from waste of each of the selected produce items. The nutrients considered were energy in kilocalories, protein, total fats, carbohydrates, dietary fiber, vitamin A (presented as retinol activity equivalents (RAE)), vitamin E, Vitamin C, thiamin, riboflavin, niacin, vitamin B6, folate and pantothenic acid. Nutrients such as cholesterol, vitamins D and B12 were not included due to the selected food products being plant sourced whereas these nutrients are largely animal sourced nutrients and their content in plants is negligible. Furthermore, nutrients such as vitamin K and selenium have not been presented due to their absence in the Tanzania food composition tables. It is important to note at this point that for the purpose of this study, food waste quantities were determined for whole foods, with both edible and inedible components of foods being included in reporting of the food waste. This is based on the conceptual framework for food loss and waste (FAO, 2019) which indicates that both edible and inedible components of food have both nutritional and economic value when recovered from being wasted and have therefore both been taken into account.

Comparison between nutrient loss and dietary intake was done by referring to the recommended daily nutrient intake for the general Tanzania Mainland population (MoH, 2023) and equivalent per-vendor nutrient loss, and presented in proportions of per thousand of the market food vendor population to illustrate the effect that food waste generated from a vendor population has on nutrient losses in the Dar es Salaam food supply.

Data Management and Ethical Approval

Study participants were informed of study procedures and only those who agreed to participate were recruited upon providing informed written consent. Each participant was assigned a serial number in order to reserve their personal information. Only research personnel were provided access to respondent information and sample data. Data from the Tanzania Food Composition Tables (Lukmanji *et al.*, 2008) were downloaded and compiled into spreadsheets in Microsoft Excel (Microsoft Corp) together with sample data for calculations. This research was reviewed and granted ethical approval by the review board of The National Institute for Medical Research (NIMR) and provided the ethical clearance number IMR/HQ/R.8a/Vol.IX/4272.

Results

Demographic Characteristics of the Study Population

Table 1 shows the socio-demographic characteristics of the sample population. There was a slightly higher proportion of male (56%) than female (44%) vendors. A high proportion of the vendors had attained primary education as their highest level of education (62%), and about 2 out of three (69%) were married.

Table 1

Socio-Demographic Characteristics of Vendors (n=108) Selected from the Three Markets in Dar es Salaam

Characteristic	Total	Ubungo	Ilala	Temeke
	← n (%) →			
Sex				
Male	60 (55.6)	18 (50.0)	20 (55.6)	22 (61.1)
Female	48 (44.4)	18 (50.0)	16 (44.4)	14 (38.9)
Education level				
No formal education	2 (1.9)	1 (2.8)	1 (2.8)	0 (0.0)
Primary education	67 (62.0)	23 (63.9)	26 (72.2)	18 (50.0)
Secondary education	38 (35.2)	12 (33.3)	8 (22.2)	18 (50.0)
University	1 (0.9)	0 (0.0)	1 (2.8)	0 (0.0)
Marital status				
Divorced	3 (2.8)	1 (2.8)	2 (5.6)	0 (0.0)
Married	76 (70.4)	27 (75.0)	26 (72.2)	23 (63.9)
Single	25 (23.1)	8 (22.2)	6 (16.7)	11 (30.6)
Widowed	4 (3.7)	0 (0.0)	2 (5.6)	2 (5.6)
	← Mean ± SD →			
Age (years)	37.1 ± 9.7	37.8 ± 11.5	36.7 ± 8.9	36.4 ± 8.9
Experience (years)	8.8 ± 5.7	8.9 ± 4.9	7.8 ± 5.4	10.0 ± 6.6

Quantification of Waste

Buguruni market in Ilala represented the highest quantity of food waste with a daily mean value of 7.2 kg ± 0.48 (SE) waste generated per-vendor, Stereo market in Temeke presented a mean value of 7.1 kg ± 0.68 (SE) per vendor per day, while Mabibo market in Ubungo presented the lowest amount of food waste generated with a daily mean value of 5.7 kg ± 0.29 (SE) per-vendor per day.

Figure 2 shows the amount (in kilograms) of each produce that is wasted daily per-vendor in Dar es Salaam and the constituent districts observed in the study. Food waste from bananas produced the highest amount of waste with a daily mean value of 13.9 kg ± 13.1 (SD) per-vendor, followed by tomatoes with a daily mean of 10.1 kg ± 6.9 (SD); potatoes 8.5 kg ± 6.3 (SD), cabbage 4 kg ± 3.0 (SD), carrots 3.4 kg ± 1.6 (SD), and amaranth produced the least amount of waste with a daily mean of 0.2 kg ± 1.0 (SD) wasted

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Figure 2

Daily Per-Vendor Food Waste of Selected Fresh Food Produce

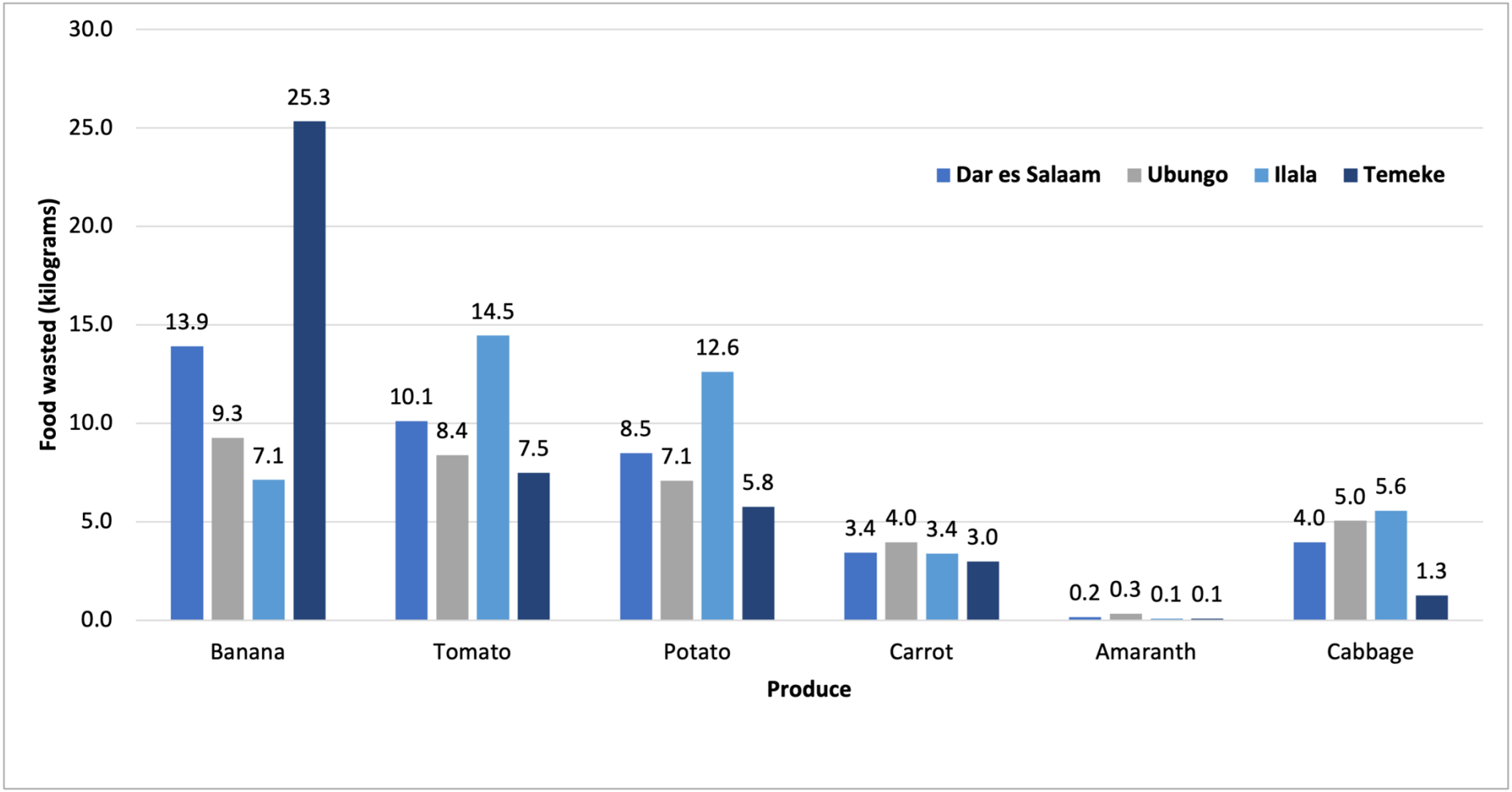

Table 2

Daily Per-Capita Nutrient Loss by Food Produce in Dar es Salaam Tanzania

Nutrient	Mean nutrient loss	Banana	Tomato	Potato	Carrot	Cabbage	Amaranth
Energy, macronutrients, and fiber							
Energy (Kcal)	3,643	12,377	2,123	4,921	1,410	988	36.6
Protein (g)	93.4	153	91.0	220	31.0	51.4	13.5
Total fat (g)	15.4	41.7	30.3	8.5	6.9	4.0	0.80
Carbohydrates (g)	876	3,170	465	1,052	330	229	13.5
Dietary fiber (g)	147	361	111	212	96.3	98.9	6.7
Vitamins							
Vitamin A (mg)	6.4	0.42	8.8	0.00	28.9	0.20	0.23
Vitamin E (μg)	7.6	13.9	0.00	0.00	24.1	7.9	0.00
Vitamin C (g)	0.97	1.2	1.9	0.97	0.20	1.5	0.07
Thiamin (mg)	3.1	0.00	10.1	0.00	3.4	4.0	0.80
Riboflavin (mg)	12.2	13.9	10.1	33.9	3.4	0.00	12.1
Niacin (mg)	47.7	97.3	60.7	84.9	34.4	7.9	1.1
Vitamin B6 (mg)	15.1	55.6	10.1	17.0	3.4	4.0	0.32
Folate (mg)	1.4	2.8	1.5	1.4	0.65	1.7	0.14
Pantothenic acid (mg)	15.1	41.7	30.3	0.00	10.3	7.9	0.16
Minerals							

Nutrient	Mean nutrient loss	Banana	Tomato	Potato	Carrot	Cabbage	Amaranth
Calcium (g)	1.1	0.70	0.51	2.5	1.1	1.6	0.15
Phosphorus (g)	1.8	3.1	2.4	3.2	1.2	1.0	0.08
Magnesium (g)	1.3	3.8	1.1	2.0	0.41	0.47	0.09
Potassium (g)	20.9	49.8	22.5	35.0	11.0	6.7	0.6
Sodium (g)	0.83	0.14	0.91	0.85	2.4	0.71	0.01
Iron (mg)	66.3	41.7	50.6	271	10.3	19.8	3.7
Zinc (mg)	14.6	27.8	10.1	33.9	6.9	7.9	1.0
Copper (mg)	9.7	13.9	10.1	33.9	0.00	0.00	0.32
Manganese (mg)	18.6	41.7	10.1	50.9	3.4	4.0	1.4

Nutrient Loss

Wasted food at the retail level markets contained 3,643 Kcal, 93.4 g protein, 15.4 g total fat, 876 g carbohydrates, 147 g dietary fiber, 6.4 mg vitamin A, 1.1 g calcium and 20.9 g potassium per-capita per day (Table 2). Fruits were found to contribute most to losses of nutrients such as energy, carbohydrates, dietary fiber as well as folate while, starchy roots were identified to contribute most to losses of protein, vitamin A, calcium and iron. Vegetables did not produce notable contributions compared to the other food groups due to their minimal waste in comparison to the other food groups (Table 3).

Table 3

Contribution of Food Groups to Daily Per Capita Nutrient Loss in the Dar es Salaam Food Supply

Nutrient	Total	Fruits	Vegetables	Starchy roots
	← n (%) →			
Energy, macronutrients, and fiber				
Energy (Kcal)	3,643	2,416 (66.3)	170 (4.7)	1,055 (29.0)
Protein (g)	93.4	40.7 (43.5)	10.8 (11.6)	41.9 (44.9)
Total fat (g)	15.4	12.0 (78.2)	0.8 (5.2)	2.6 (16.7)
Carbohydrates (g)	876	606 (69.1)	40.5 (4.6)	230 (26.3)
Dietary fiber (g)	147	78.8 (53.3)	17.6 (11.9)	51.4 (34.8)
Vitamins				
Vitamin A (mg)	6.4	1.5 (23.9)	0.07 (1.1)	4.8 (75.0)
Vitamin E (µg)	7.6	2.3 (30.3)	1.3 (17.2)	4.0 (52.5)
Vitamin C (mg)	0.97	0.52 (53.8)	0.25 (26.1)	0.20 (20.1)
Thiamin (mg)	3.1	1.7 (55.3)	0.79 (25.9)	0.57 (28.8)
Riboflavin (mg)	12.2	4.0 (32.7)	2.0 (16.4)	6.2 (50.9)
Niacin (mg)	47.7	26.3 (55.2)	1.5 (3.2)	19.9 (41.7)
Vitamin B6 (mg)	15.1	11.0 (72.7)	0.7 (4.7)	3.4 (22.6)
Folate (mg)	1.4	0.7 (52.2)	0.31 (22.3)	0.35 (25.5)
Pantothenic acid (mg)	15.1	12.0 (79.7)	1.3 (8.9)	1.7 (11.4)
Minerals				
Calcium (g)	1.1	0.20 (18.1)	0.29 (26.2)	0.06 (55.6)
Phosphorus (g)	1.8	0.91 (49.8)	0.18 (10.0)	0.74 (40.2)
Magnesium (g)	1.3	0.8 (62.5)	0.09 (7.2)	0.39 (30.3)
Potassium (g)	20.9	12.0 (57.5)	1.2 (5.8)	7.7 (36.7)
Sodium (g)	0.8	0.2 (21.0)	0.1 (14.5)	0.5 (64.5)
Iron (mg)	66.3	15.4 (23.2)	3.9 (5.9)	47.0 (70.9)
Zinc (mg)	14.6	6.3 (43.3)	1.5 (10.1)	6.8 (46.6)
Copper (mg)	9.7	4.0 (41.2)	0.1 (0.5)	5.7 (58.2)

Manganese (mg)	18.6	8.6 (46.5)	0.9 (4.8)	9.1 (48.7)

Table 4

Comparison of Daily Nutrient Losses Per 1000 Vendor Population with Recommended Intakes of Specific Nutrients for the General Tanzania Mainland Adult Healthy Population

Nutrient	Recommended intake (RDA)	Proportion of the recommended individual nutrient intake discarded per vendor as waste	Equivalent number of recommended intakes (Per 1000 vendors)
Energy (Kcal)	2,312	158%	1,575
Protein (g)	97.5	95.8%	958
Total fat (g)	55.0	27.9%	279
Carbohydrates (g)	337	260%	2,601
Dietary fibre (g)	39.2	377%	3,770
Vitamin A (mg RAE)	0.89	725%	7,249
Vitamin C (g)	0.17	566%	5,662
Folate (mg)	0.63	218%	2,182
Calcium (g)	1.1	102%	1,018
Iron (mg)	25.2	263%	2,629
Zinc (mg)	11.9	123%	1,227

NOTE: Equivalent intakes are represented in proportions of per thousand (1000) population of retail market food vendors to illustrate the effect that food waste generated from a vendor population has on nutrient losses in the food supply

Comparison of Nutrient Loss to Dietary Intake

Comparison between recommended daily nutrient intake for the general Tanzania mainland population and equivalent number of intakes of specific nutrients embedded in retail-level food waste showed that for every thousand vendor population, food waste generated was sufficient to fulfill 1,575 daily intakes for energy, 2,601 intakes for carbohydrates, 3,770 intakes for dietary fiber, 7,249 intakes for vitamin A and 1,018 intakes for calcium. Nutrients presented in Table 4 are as they have been recommended in the Food-Based Dietary Guidelines for Tanzania mainland population (MOH, 2023).

Discussion

This study aimed to determine the quantities of food waste of selected fresh food produce namely bananas, tomatoes, potatoes, carrots, amaranth and cabbages, generated by retail market vendors in Dar es Salaam as well as to estimate the overall nutrient losses embedded in food waste, on a per-capita per day basis. Findings of this study reveal that a significant amount of food is wasted in the retail-level markets of Dar es Salaam. The highest per-vendor waste was recorded in the Buguruni market located in Ilala district which was only marginally higher than the Stereo market located in Temeke. The Mabibo market located in

Ubungo district was found to generate the least amount of food waste. Among the contributing factors for this high level of waste may be as postulated by Gustavsson *et al.,* (2011) that consumers in developing countries generally purchase smaller amounts of food produce at a time, usually just enough to suffice for meals on the day of purchase. This trend would account for excess carryover stock in retail markets. This situation coupled with poor storage infrastructure observed within the markets results in spoilage of food which ultimately ends up wasted.

Following a comparison, it was observed that there was minimal fluctuation in the quantities of daily per-capita waste generated across the individual districts. However, upon a more in-depth analysis of waste pertaining to specific food produce items, it became apparent that while the quantities of per-capita waste generated by market vendors did not significantly differ between the various districts, the contribution of specific food produce to the overall food wasted in these markets did vary among the districts. This indicates that certain foods were discarded in higher proportions than others, depending on the specific market. This discrepancy is attributed to consumer preferences, market locations, or variation in prices of produce items among food markets (Cicatiello *et al.,* 2016). For example, the results indicate that waste of bananas is notably higher in Temeke district compared to the other districts. This is on account of the Mabibo market located in the Ubungo district being the preferred outlet for purchasing bananas in Dar es Salaam. Furthermore, the peripheral location of the Stereo market in Temeke district relative to the other two markets which are more centrally located in the city further contributes to cutting away at the demand for bananas from Temeke district. This results in a higher quantity of bananas being wasted in Temeke District.

Nutrient losses embedded in food waste

Analysis of the nutritional content of the wasted food produce has uncovered significant nutrient losses embedded in retail-level food waste. Energy, carbohydrates and dietary fiber account for the majority of losses of macronutrients from the selected produce items. Comparatively, the greatest burden of waste from the selected produce items is found in micronutrient losses. With vitamin A, vitamin C and folate constituting the majority of losses of vitamins and potassium, phosphorus and magnesium being subject to the highest losses of minerals found in wasted food produce, the high proportion of loss of these micronutrients is in line with a study by Chen *et al.,* (2020) which looked at trends in global nutrient losses caused by food waste of 151 countries and found the same nutrients to be lost in relatively high amounts as a result of food waste.

Utilizing recommended intakes to contextualize nutritional data is essential for a better understanding of the burden of food waste on food security (Spiker *et al.,* 2017). Upon breaking down food waste data into its nutritional components and comparing it against nutritional recommendations for the Tanzanian population the results were quite striking.

Using Vitamin A as an example, the amount of food waste produced per thousand (1000) vendor population is enough to meet the nutritional needs for vitamin A of 7,249 people. For further context the smallest market sampled in this study which was located in Ilala district has a population of 2,213 vendors meaning, by applying the trend implied by this data, that food waste generated in the market on an average day is equivalent to the nutritional requirements for vitamin A of 16,042 people. Moreover, the market located in Temeke district has a population of 4,800 vendors which is more than double that of the Buguruni market and signifies a loss equivalent to the requirements of 34,796 people for vitamin A.

Implication of nutrient losses embedded in food waste

Implications of the determined levels of nutrient losses can better be understood by referring to the nutritional situation within the Tanzania population. According to the Tanzania National Multisectoral Nutrition Action Plan (NMNAP II) of 2022 (PMO *et al.,* 2022), Vitamin A is considered to be a micronutrient of major public health concern, stating that a third of all women and children in Tanzania are vitamin A deficient, significantly raising morbidity and mortality and is also the leading cause of preventable blindness.

This coincides with the alarming levels of vitamin A that have been determined to be embedded in food waste generated by the retail markets of Dar es Salaam.

Another nutrient of concern outlined in NMNAP II is iron. Findings of this study show that food waste generated per thousand vendors is equivalent to the nutritional requirements for iron of 2,629 people. Meanwhile, according to the Tanzania Demographic and Health Survey (TDHS), 59 percent of children and 42 percent of women in Tanzania exhibit some level of anemia of which the common cause is iron deficiency (NBS, 2022). Vitamin A and Iron are mere examples of the nutritional implications of food waste generated at the retail level and how it represents a missed opportunity to improve nutrition. Other nutrients of concern which were lost in relatively high amounts were dietary fiber, vitamin C, and folate.

These findings validate that food waste coincides alongside food and nutrition insecurity in Tanzania. However, to our knowledge, data concerning nutritional implications of household waste has not yet been documented and represents a potential area for investigation. This suggests that there is a need for further in-depth study concerning food waste in both retail and consumer levels in order to grasp the full magnitude of food waste.

Attention to this matter is of utmost importance since increased production of food may ultimately result in even higher levels of food waste (Goodwin, 2023). All food that ends up in landfills represents nutrients that are lost from the food chain and contributes toward food insecurity (Chen *et al.,* 2020; Vanham *et al.,* 2015). However, efforts placed towards reducing food waste aid in ameliorating food insecurity since reducing food waste is beneficial for improving availability of nutrients currently under-consumed in Tanzania, as well as retaining more of what is already produced for consumption.

Strengths and Limitations

This study does have its limitations, notably in addressing seasonal variations in food waste and the corresponding financial losses, given the sensitivity of fresh produce to fluctuations in temperature and moisture. The data collection period from February to April also precluded the analysis of seasonal price variations. Despite these constraints, a key strength of this research lies in its precise quantification of food waste using the direct weighing method during data collection, acknowledged as the most reliable approach compared to other techniques.

Conclusions

The amount of food waste generated in retail level food markets of Dar es Salaam is substantial. Perishable produce, particularly fruits, vegetables and starchy roots and tubers are important sources of micronutrients. This makes the nutritional implications of food waste even more concerning. The quantity of micronutrient rich foods that are disposed in landfills every day are therefore counterproductive to hunger reduction efforts and must be given attention. Further investigation must be done in order to capture the full extent of the burden of food waste in Tanzania since food waste represents a missed opportunity to improve nutrition and reduce the burden on Tanzania's precious resources for a sustainable food system.

Recommendations

To tackle food waste in Dar es Salaam's retail markets and enhance nutritional security, different approaches are recommended. First, efforts should focus on reducing the spoilage waste at the market level by investing in improved storage infrastructure, such as refrigeration and properly ventilated rooms.

Better coordination between the suppliers and market vendors in demand forecasting. By implementing a system for vendors to forecast consumer demand and encouraging more collaboration between vendors and suppliers, they can better optimize for consumer preferences, quantities and reduce overstocking.

Further research is warranted to understand the issue more comprehensively. By investigating the seasonal fluctuations in food waste, it would be possible to provide more targeted interventions based on the seasonal trends.

The investigation may also extend further to the household level by interviewing the consumers

at the markets and also investigating interactions between retail and consumers, to develop recommendations on how measures for food waste reduction at the retail level should be designed to avoid increasing the risk of shifting food waste to households this will aid to understanding how retail and household waste contribute to the overall problem and obtain a more holistic view of food waste in Dar es Salaam and Tanzania at large.

Finally, an economic analysis should be done to evaluate the financial implications of the food waste. This may be followed by a cost-benefit analysis to evaluate the implications of implementing the strategies suggested to reduce the food waste. Such analysis would help the decision makers to understand the potential return on retail level investments associated with the different interventions. The more advanced approach to this recommendation is to make a full cost accounting (going beyond retail cost of the wasted food) including the entire costs of food production and external costs in order to evaluate whether measures for food waste reduction make sense economically by taking into account the entire food chain from production to consumption.

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