



Original Paper

Fruit and Vegetable Waste Characteristics and Management Practices at Pasig Mega Market in Pasig City, Philippines

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Abstract—The fruit and vegetable sector produce waste significantly, causing social, environmental, and economic loss. Thus, a study was conducted at Pasig Mega Market, Pasig City to describe the fruit and vegetable vendors' waste management practices. Vendors and government employees participated in focus group discussions and key informant interviews. Results showed an average of 100-200 kilograms of waste were collected in the market daily, with leafy vegetables, watermelon, melon, and saba as common types. Focus group discussions revealed that discounted prices for suboptimal items, quality assurance methods, adherence to First-In-First-Out principles, and marketing strategies were the vendors' efforts to reduce waste. The identified approaches in handling wastes were, giving them as animal feed, creating alternative products, and returning damaged products to suppliers. Key informant interviews disclosed that the local government and market administration practices in waste management were composting and donation as animal feed for the local zoo. Moreover, it revealed improvement in the management of implementing the ordinances. Problems encountered were focused on supplier issues, weather, market competition, and consumer preferences. Overall, their waste management reduces food waste disposed of in landfills. Recommended strategies for vendors and administration are valorizing food waste, organizing awareness and livelihood programs, and conducting regular evaluations.

Keywords—environment, food waste, fruit and vegetable, public market

I. INTRODUCTION

The continuous growth of the global population subsequently also brought an increase in the utilization of various resources. In the food sector, the total global production of primary crops grew by about 53% from 2000 to 2019, which represents 3.2 billion tons more [1]. Specifically, fruit production increased by 54% or 311 million tons, and vegetable production increased by 65% or 446 million tons [1]. These represent greater demands for food supplies to feed billions of people worldwide, and to suffice their diverse food preferences and standards. Unfortunately, the demand parallels the expanding quantity of food waste generated, thus making food waste a severe global problem. Nearly 931 million tons of food waste were collected in 2019, and 17% of global food

production ended as waste [2]. Contradictorily, we still confront world hunger today, where the hunger rate increases yearly, and many still suffer food insecurity [2]. In response, the FAO, IFAD, UNICEF, WFP, and WHO have developed key policy areas and goals to combat food insecurity [3]. It involves more remarkable improvement in the food value chain, which entails reducing food loss and food waste through a comprehensible set of policies and investments in the food system [3]. In the Philippines, the Ecological Solid Waste Management Act of 2000 was passed, which generally deals with solid waste [4]. Unfortunately, there still needs to be an existing national policy or ordinance that deals explicitly with food waste management. Moreover, only limited published local studies tackle this issue. The growing population carries along a growing amount of waste. Thus, investing in more research studies on food waste and its management will be beneficial in the Philippines.

Agriculture is one of the Philippines' most important economic sectors as it contributes about 12.3% to the growth rate of the Philippines' gross domestic product composition [5]. Furthermore, the country is a significant producer of agricultural items such as fruits and vegetables (FV) for local and export use [5]. In the food system, FV is one of the major sources of revenue since they are frequently in high demand and may be sold at a high price [6]. Hence, food waste reduction makes economic sense at the small scale, by lowering food bills and at the large scale by reducing disposal costs for restaurants, processors, and farmers [7]. It is socially important when rescued foods are handed over to emergency food providers who aim to eliminate community hunger [7]. FV has been contributing also to the long-term sustainability of the food system. Proper management of FV surplus or inedible components will keep food out of landfills, which is beneficial to the environment [7].

In the market, FV are highly perishable and have more risks of becoming food waste [8]. Thus, a study on FV waste management among public market vendors was conducted at Pasig Mega Market, Pasig City, Philippines. It is one of the biggest markets in Metro Manila and the Philippines. It will explore the practices of the vendors in minimizing and handling FV waste.

II. MATERIALS AND METHODS

A. Locale of the Study

The study was conducted at Pasig Mega Market, Pasig City, Metro Manila, one of the largest public markets in the Philippines (Fig. 1).



Fig. 1. Pasig Mega Market, Pasig City, Metro Manila

It is located at the corner of Market Avenue and Caruncho Avenue, Barangay Malinao, Pasig City. Currently, it has 3,312 vendors and stalls that are visited by 8,000 to 10,000 people every day.

B. Study Design and Participants

A descriptive research design was utilized for the research. The participants were four fruit vendors, four vegetable vendors, and three key informants who were purposively selected for the data collection, based on their length of experience and involvement in FV waste management. For confidentiality, their real names were not used instead, they were assigned codes. All FGD participants were female, and their years of experience varied from under a year to 25 years. More so, most of them work 12 hours per day for six to seven days a week. Meanwhile, the key informants were staff from the City Environment & Natural Resources Office (CENRO), the Officer-In-Charge of the Pasig Mega Market Administration, and the unit head of the Special Operation Group (SOG) at Pasig Mega Market.

C. Research Instrument

Focus group discussions and key informant interviews were used among the selected participants to answer the stated research objective. Open-ended semi-structured interview guides were prepared, which focused on determining the characteristics of FV waste, the practices done in minimizing and handling FV waste, and the problems encountered in doing so. The guide was written in Filipino for the FGD, whereas the KII interview guide was written in both English and Filipino, to promote better understanding and conversation among the participants. A survey questionnaire for the socio-demographic and work profile was prepared for the vendors too, which included age, sex, type of vendor, years of experience, and monthly income.

D. Data Collection

Two FGDs and three KIIs were conducted to collect primary data and secondary data were retrieved from documents requested from the local government office. Before the interviews, the researcher briefed each participant about the study's details, and their consent was solicited through an Informed Consent Form. A letter of intent, along with a nondisclosure agreement, was also prepared for some government employees. The FGDs and KIIs were recorded throughout and were transcribed verbatim. Afterward, the data were analyzed accordingly.

E. Data Analysis

Following transcription, the qualitative data was processed using thematic analysis, in which responses were sorted and classified according to themes. On the other hand, the retrieved secondary data were used to support the participants' answers.

F. Flowchart of Methods

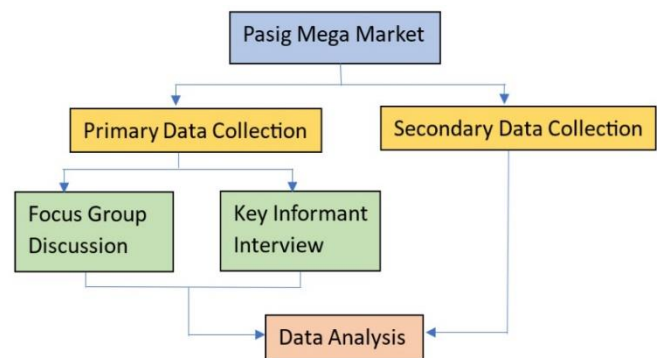


Fig. 2. Flowchart of the methodology

III. RESULTS AND DISCUSSION.

A. FV Waste Characteristics at Pasig Mega Market

Pasig Mega Market has a total of 3,312 stalls with 68 fruit wholesalers and 322 fruit retailers, as well as 68 vegetable wholesalers and 678 vegetable retailers, for a total of 1,136 FV stalls. The most common types of waste generated were overripe watermelon, melon, orange, papaya, and saba (banana). Other than leafy vegetables, three vegetable vendors reported on the FGD that radishes, carrots, and calamansi easily rotted after at least one day of selling. A large volume of waste is produced due to quality defects and over-ripeness. For instance, of 500 mangoes (10kg) initially delivered to a vendor, one-fifth becomes unsellable the following day due to the wet season and mechanical injuries during transit. Another wholesale vendor mentioned that sorting mangoes is inevitable when selling to consumers, resulting in 25 kilograms of unsold items. Similarly, discounts are given to mangoes in poor condition, where one vendor loses between PHP 100-200. A study by Lebaka et al. (2021) shows the nutritional significance of mangoes, a mango pulp contains a range of reducing sugars, amino acids, aromatic compounds, and valuable chemicals such as pectin, vitamins, anthocyanins, and polyphenols [9]. Mango processing produces peels and kernels as bio-wastes, albeit they

also have nutrient benefits. The mango kernel contains more antioxidants and polyphenols than the pulp and peel and is used for oil extraction [9]. Meanwhile, a saba vendor also stated that out of one ton, 500 kilograms of saba becomes waste in one to two weeks, equivalent to about PHP 15,000 total loss. Saba fruit is abundant in nutrients, making it an excellent food choice. It has nutritional fiber, iron, and vitamins A, B, and C [10]. In vegetables, two vendors identify that pechay baguio (napa cabbage) rots considerably faster than others. Aside from being highly perishable, it is occasionally oversupplied in the market, lowering its price and decreasing its probability of being purchased. According to one vendor's account, she accepted a discount bargain rather than lose more the next day. Usually, when pechay baguio is not immediately sold, a half-kilogram will no longer be in good condition the next day. Based on the Retail Price Range of Selected Agri-fishery Commodities at NCR Markets [11], the vendor might lose approximately PHP 15 to PHP 30 of her profit for every kilogram of pechay baguio.

In an article by Renee (2018), pechay baguio is a nutrient-dense vegetable with vitamins, minerals, and antioxidants [12]. It is exceptionally high in folic acid, providing one-third of the daily need in two cups of consumption, vitamin K for blood clotting, a good calcium source for the bones, and fiber for the digestive system [12]. The average daily collection of FV waste market-wide is 100 to 200 kilograms, as stated by a key informant. Furthermore, another key informant working as the unit head of the special operations group (SOG) provided a total number of collected wastes in the past four months of the year 2022, as seen in Fig. 3. As observed, collection in September was the greatest with 7,380 kilograms, which can be attributed to the typhoons during that season. The Ilocos region, Cagayan Valley, Cordillera Administrative Region (CAR), and Central Luzon were directly affected in which many of the suppliers are situated [13]. Meanwhile, the volume of FV wastes reduced to 5,120 kilograms in October, indicating product quality and profitability recovery.

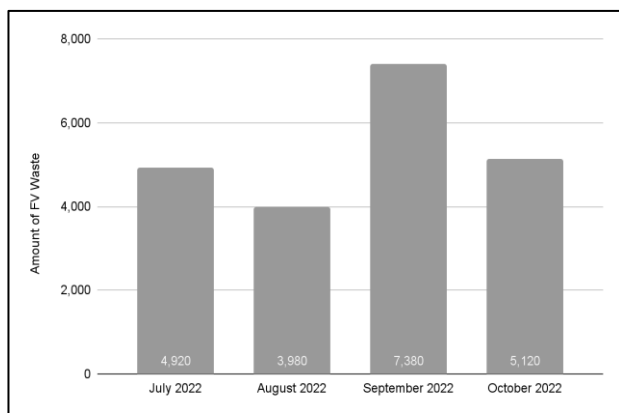


Fig. 3. Volume of FV Waste Collected in Pasig Mega Market from July to October 2022

Fruits and vegetables provide nutrients like water, fiber, proteins, lipids, minerals, and digestible carbohydrates [14], and it is highly significant in contributing to the health of the communities in the Philippines. However, they are not

maximally utilized when a large volume of waste is produced from this sector. Thus, we are missing the opportunity to address malnutrition and improve the quality of life through health and nutrition.

B. Practices of Vendors in Minimizing FV Waste

The vendors shared several practices for minimizing FV waste, focusing on maintaining their products' quality and shelf life and reducing economic loss. Five vendors shared that they perform a round of inspection and sorting to identify those of good quality from the unsellable. Breazeale (2023) explains that color darkening, bruises, cracks, cuts, punctures, abrasions, and tears encompass the results of mechanical damage¹⁵. Additionally, tearing in leafy vegetables can cause rapid dehydration, discoloration, or rot [15], which was observed by the vendors in their products. Two vendors then shared that the damaged FV was separated from the good batches to avoid further contamination. After sorting, they wiped some products with mud to remove dirt and other contaminants that may contribute to speeding spoilage. Vendors also allot time for regular cleaning to ensure a well-maintained marketplace that contributes to making a safe and pleasant experience for both consumers and vendors. In addition, two vendors care for leafy vegetables requiring hydration through the sprinkling of water to avoid wilting. Such practices are comparable to the recommendations by Erkmen & Bozoglu (2016) stating that microbial deterioration contributes to around 20% of all vegetables and fruits produced for human consumption globally [16]. They further discussed that outside elements such as air, high humidity, and high temperature enhance the possibilities of microbial development and decomposition during vegetable and fruit storage [16]. Thus, to decrease microbiological spoilage, they prescribed refrigeration, modified environment packaging, washing, freezing, drying, heat treatment, and chemical preservatives [16].

In the market, the FV vendors delay their products' deterioration through washing and drying. Limiting degradation is also critical to lessen the negative economic impact. Specifically, fruit microbial decay causes financial loss across the fruit supply chain [17]. For six vendors, having multiple suppliers was also proven helpful in providing consistent, high-quality items. Moreover, with mitigated compromise, they acquire the type and quantity of products they need at certain times. While ripening the fruits, a chemical known as ethrel and a process known as *kukulobin* are utilized in batches by one of the vendors. It allows her to regulate the volume of fruits they desire to ripen at specific periods. The practices by the FV vendors imply that the quality of FV sold is integral to their profitability because of consumers' quality standards. It is supported by FAO's report (2019), which states that the volume of FV waste is reliant on the ability of producers, exporters, and sellers to maintain the FV quality according to consumer demand [18].

The vendors also consider the selling period of FV to maximize their freshness and minimize waste. Thus, two vendors practice the "First-in, First-out" (FIFO) principle, separating the products according to the date of purchase. Other food establishments widely practice the FIFO principle to avoid

spoilage and ensure consumer safety. In addition, microbial contamination could be controlled with the efforts of food handlers, whether in processing plants, restaurants, and others [19]. The benefits of FIFO described in the article of Burton-Hughes (2022) include decreasing food waste, guaranteeing safer food storage, and satisfying consumers, which are in line with the vendors' goals in terms of the approaches they employ [20]. The four fruit vendors mentioned engaging in sound marketing strategies to cope with the market competition. From the vendors' experiences, we can observe that market competition affects FV waste by impacting product marketing. Reducing FV waste and enhancing efficiency in the supply chain is feasible when sellers find means to balance competition and sustainability in the market. On the other hand, product prices are influenced too by poor quality and high supply. Eight vendors have common sentiments that some products with minor defects are being sold at a discounted price to avert total loss. Similar reports were noted in the study of Ortiz-Gonzalo et al. (2021), where products that did not satisfy retail standards were redistributed to traditional wholesale markets [21]. Yet, there is already a loss, such as cabbage losing 44 to 66% of its wet weight, when suppliers trim the outer leaves to remove wilt [21]. In comparison to other suppliers that are less stringent with the criteria, Ortiz-Gonzalo et al. (2021) added that the trimming method used by modern retailers produces substantially more waste [21].

C. Practices of Vendors in Handling FV Waste

Aside from the daily FV collection, two vendors accounted that some consumers purchase discarded FV at a meager price to feed their animals, whereas two vendors give them free of charge. These are similar to the report of Pinotti et al. (2020), where fresh-cut leafy vegetables are a possible alternative feed item for livestock that might aid in utilizing the circular economy in animal production, hence strengthening sustainability [22]. Meanwhile, one vendor makes fermented banana vinegar from her unsold saba for personal consumption since she is unsure of its profitability. Several studies have ventured into converting FV waste into alternative productive items. Jiménez-Moreno et al. 's study (2019) utilized the bioactive chemicals in FV waste as pharmaceutical excipients and food additives or used them in pharmaceutical formulations or food matrices to create nutraceutical and functional foods [23].

Another is the literature findings of Lau et al. (2021), which indicated that agriculture by-products, mainly vegetables and fruit, could be utilized to increase and improve the nutritional content of functional foods such as biscuits, cakes, and bread [24]. For one vendor, she returns the damaged products to her supplier, which saves money and avoids food waste as the supplier takes responsibility for handling it. For others who cannot do so, they maximize their resources by keeping portions of their products and selling them as sliced fruits or mixed vegetables for meals like *Pinakbet* or *Sinigang*. In this way, they only dispose of parts of the FV that are completely inedible. Some seeds from the FV wastes were also retrieved for planting in their improvised farming area. FV wastes have an impact on several dimensions of our society. Seberini (2020)

stated that as food waste decomposes it releases hazardous methane into the environment [25]. Globally, it accounts for 7% of total greenhouse gas emissions and if appropriately treated, less damaging carbon dioxide instead of methane could be emitted into the atmosphere [25]. Food waste also wastes valuable resources and as a result becomes an economic, environmental, and socio-ethical problem [25]. To mitigate it, efforts to repurpose FV wastes help reduce costs for the vendors as they find alternative uses for products that would otherwise be discarded. Overall, proper FV waste management can assist in decreasing the environmental effects of food waste, improve sustainability, and generate economic and social advantages.

D. Problems in Minimizing and Handling of FV Waste

Two vendors recalled incidents in which they experienced dishonest negotiations and sub-optimal quality of products with some suppliers. Unfortunately, vendors could not express their complaints or concerns freely due to poor responses from suppliers. Consequently, they become responsible for minimizing or managing the food waste that might be generated from poorly delivered items and profit loss. In a study by Al-Dairi et al. (2022), they concluded that mechanical damage to agricultural produce caused by transportation and vibration results in considerable economic loss related to shortened shelf-life [26]. They recommended excellent management techniques, such as using adequate packing and including acceptable cushioning materials to reduce product damage during travel [26]. On the other hand, supplies transported from Davao are known to be mainly grown for export. Per the vendors' observation, items rejected for export are being included in the supplies delivered, resulting in a mix of sub-optimal quality items sold at the market. Consumer preference also poses a problem as it establishes perception among producers and sellers on the acceptability of products in the market. Alegbeleye et al. (2022) and Johnson et al. (2019) discussed that edible products do not guarantee marketability by consumers [17][27]. Moreover, some blemishes/flaws may be minimal during harvest and may not be perceived as inferior quality by producers but it may get exacerbated throughout the product when it reaches retail, making it less likely to be purchased by consumers.

In relation, market competition tends to put pressure on vendors to satisfy consumer demands. This might result in rejecting deformed or blemished FV and compromising quality and freshness to cut costs. Although market competition was present, a key informant said that the prices among the vendors were relatively similar. Since there were various suppliers, they could choose from, they could maintain a reasonable price for their products. Weather, on the other hand, was regarded as one of the leading causes of FV waste among vendors. The wet season increases the likelihood of diseases caused by water molds flourishing in waterlogged soils and regions with standing water for extended periods [28]. They can promote quick withering and decline of plants and fruit rotting [28]. In the study of do Nascimento Nunes (2008), it was further discussed that the development of appropriate temperature, humidity, and atmosphere practices throughout the handling and distribution of fresh FV from the field to the consumer is a

significant problem that is still far from being met [29]. The respondents also took into account the impact of the COVID-19 pandemic on FV waste. It was challenging for the vendors at the Pasig Market to continue selling since the market was inaccessible to consumers and the prices were high.

Overstocking happens due to unforeseen circumstances, such as consumer demand changes or supply chain interruptions. These changes caused the vendors to cut their prices to sell their products, despite having good quality. Although the COVID-19 pandemic is predominantly a public health issue, it affected all levels of the agricultural market chain [30]. It is linked to the constraints of the movement of people and supplies due to the required measures adopted to limit the virus' spread [31]. Thus, supplies were stuck in the market during the pandemic crisis since no channels were available to reach consumers. However, through the intervention of the local government, they provided means for supplies to reach the consumers. Programs such as Online Palengke and Mobile Palengke were implemented, providing a livelihood for other Pasigueños. Table 1 summarizes vendors' problems in minimizing and handling FV wastes, as discussed previously.

TABLE I. PROBLEMS OF FV VENDORS AT PASIG MEGA MARKET IN MINIMIZING/HANDLING FV WASTES*

ASPECTS	PROBLEMS
Issues Encountered with Suppliers	<ul style="list-style-type: none"> • Dishonest suppliers • Sub-optimal quality (supplies are rejected from export)
Market Operations	<ul style="list-style-type: none"> • Market Competition • Oversupply • Consumer Preferences
External Factors	<ul style="list-style-type: none"> • Rainy Weather (typhoon) <ul style="list-style-type: none"> ○ Pest infestation ○ Damaged products • Pandemic <ul style="list-style-type: none"> ○ Inaccessible public market ○ Higher price

*Narratives from FGD and KII

E. Efficient Market Management

In Pasig, the management of the Mega Market was entrusted to the Market Administration. It comprises 600 staff members. A key informant shared in his interview that there was a significant improvement in the functioning of the market because of better management. The city is currently re-enforcing the "*Tapat Ko, Linis Ko*" ordinance. The SOG also conducts a daily flushing operation in which the market task force cleans big hallways and shared spaces. Stall owners also comply with the permits, and health and sanitation protocols processed in the market administration office. Synchronized and active market staff members are in their respective assignments, waste collection is on time, and waste bins in every market area are

sufficient. As the market provides an adequate supply of resources, it fosters higher efficacy.

On the other hand, suppliers with permits were the only ones allowed to deliver and trade at the market. Supplier deliveries were also monitored on occasion. The Market Administration also takes initiative in FV waste management. The SOG staff collects about 100 kilograms of FV wastes at the vendors' stalls which are donated to the Pasig Rainforest Park as feed for the animals in the zoo. In the United States Environmental Protection Agency Food Recovery Hierarchy (2023), FV waste as animal feed is the third most preferred way of handling it [32]. Ideally, the prevention of FV waste is prioritized to minimize the excess food in the food chain. However, if not achieved, the primary beneficiaries of the excess edible food are community sites to feed the hungry [32]. Nonetheless, inedible food is recommended to be donated as animal feed. Doing so can reduce costs for zoo keepers and for food waste generators on disposal while limiting the environmental effect of this waste. A study by Huber-Humer et al. (n.d.) presents that the European Union follows the same hierarchy but with the exception of food waste as animal feed [33]. They eventually banned utilizing it to prioritize hygiene regulations and ensure food safety [33].

Through the City Environment and Natural Resources Office (CENRO), the city also practices composting in compliance with the ordinance. Collected food wastes were brought to the composting facilities, transformed into fertilizers, and distributed to homeowners and small-scale farmers. Augustin et al. (2020) discuss that composting and anaerobic digestion are usual food waste treatments available, and composting aids in reforestation, restoration of wetlands and other ecological habitats, and revival of terrestrial environments [34]. Good compost reduces waste issues and contributes substantially to economic and social sectors [35]. Aside from the composting drums, Pasig also owns bio machines donated by DOST and DENR.

F. Strategies to Minimize/Handle FV Waste

Vendors were directly involved in minimizing and handling FV wastes. They could explore the marketability of alternative products from overripe or slightly damaged yet edible FV. Recommendations by Augustin et al. (2020) in making use of FV as raw materials or ingredients are: creating flour for producing other forms of food or confectionaries (banana flour), purees, chips, paste or sauce, fruit jam, juice, or concentrate for preparing beverages, vinegar, and so on [34]. In a study by Abodunde and Akin-Osanaiye (2023), they found that single-cell protein from yeast using fruit waste can serve as a cheaper alternative to the conventional protein from plants and animals [36]. In another study by Das and Ray (2022), they concluded that thermally treated tomato waste fragments (skins, seeds, and pomace) possess a significant potential, and can be deemed important in the development of waste management strategy [37].

Vendors are also encouraged to attend seminars or courses to preserve the quality and safety of their products. In this way, they will learn sustainable methods or technologies to maintain the quality of their products. The market administration may also conduct a one-day seminar for vendors about the FV waste

situation in the Philippines and in the local area. It can also tackle practical ways to minimize and handle FV wastes as a vendor. Also, the administration can organize a short-course program for vendors about proper food storage, food handling, and food safety. It can also include a campaign that mainly targets the consumers, focusing on giving practical ways to help the city reduce FV waste. One example could be the consumers' perception and acceptability of FV that have minimal blemishes/flaws. Raising awareness of FV waste may encourage creativity and more inclination to come up with ideas for decreasing waste and using resources more sustainably. Thus, the administration can organize workshops or livelihood programs to teach vendors or other interested parties to make alternative products such as fermented products. In Guiuan Eastern Samar, the people created an innovation that addresses FV wastes in their public market. They transformed inedible FV wastes into fermented FV juice, which added income to them as they made the product marketable as fertilizer in backyard vegetable gardens and ornamental plants [38].

Open and responsible policy implementation ensures that the public is informed of the market's progress and encourages them to contribute input and feedback as appropriate. Hence, the administration may perform frequent evaluations through vendor surveys. The survey aims to gather vendor input on the market operations and conditions, such as their experiences with suppliers.

IV. CONCLUSION AND RECOMMENDATIONS

The study highlights the efficient practices of the vendors and local government in managing FV wastes. Their collected wastes are distributed to stakeholders who use them, thus lessening the food waste dumped in landfills. Some FV waste reduction and management strategies are also suggested for developing a more sustainable food system in the community. Specifically, vendors can explore the profitability of alternative products from unmarketable FV. Also, they should attend seminars or courses on proper food storage, safety, and handling to adapt new and sustainable methods for handling FV. For the market administration, they can organize seminars, short courses, and campaigns for vendors and consumers which raise awareness on food waste reduction and management. Moreover, they can conduct livelihood programs for vendors and other interested parties in valorizing FV waste into food or fermented products. Finally, the market administrator can conduct frequent evaluations using surveys to get vendor feedback on market operations and conditions, such as their experiences with suppliers.

LIMITATIONS

The study on waste management practices solely focuses on F&V waste. The primary data were gathered from eight vendors at the Pasig Mega Market in Pasig City who participated in a focus group discussion and three local government employees 5 directly involved in waste management who participated in the key informant interview. The data were processed and discussed through thematic analysis. The scope of the discussion was only on characterizing the F&V waste

generated, determining the practices for minimizing and handling F&V waste, discussing the problems they encounter, and recommending strategies to minimize and handle the F&V waste. Moreover, the secondary data obtained upon request of documents from the local government office were utilized to support the results from the FGD and KII.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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