ORIGINAL ARTICLE

Environmental Assessment of Catering Service Operations in Jitra, Malaysia

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ABSTRACT

Introduction: The entire human food supply system can be susceptible to food loss. Catering services is one of the major creators of substantial amounts of food waste. This causes a detrimental impact on socio economic and environmental sustainability. This study was aimed to examine the food waste and carbon footprint from catering operations which have expanded into an industry. These operations particularly expanded due to its social and economic significance in the growing town of Jitra, Kedah. **Methods:** Five catering services were selected to represent the catering operations. Food waste was categorized based on waste from preparation loss, serving loss and plate loss of the customer. The loss categories were differentiated by three colour-coded containers and were weighed in-situ. This was followed by determination of carbon footprints from the electricity and water consumption during the catering operations. Material Flow Analysis was used to visualize the material flow from the catering services' operations. **Results:** Customer plate waste contributed to the majority of the food waste, accounting for 54.47% of the waste, while preparation loss produced 45.53% of the food waste. The catering services produced roughly 11.87 $kgCO_2e$ of carbon footprint from the average electricity consumption, and had an average power usage of 108.58 kWh. Meanwhile, for the total average of water consumption, the catering services used up to 5.71 m^3 of water on a daily average, which may produce 22.71 $kgCO_2e$ of carbon footprint. **Conclusion:** : This study was not designed for a detailed examination of food waste generated by catering services, but rather on how variables that affect food waste generation and carbon footprint could be included. Therefore, this study assisted the management of catering services in identifying areas for improvement including resource management to reduce the generation of food wastes.
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INTRODUCTION

Food waste is one of the serious issues faced globally. Food systems are currently inefficient, whereby about one-third and half of all processed food is wasted before consumption (1). Food waste is described as "any waste or by-product of food production, processing, distribution and intake" (2). The hospitality and food service industries have significant potential to prevent food waste and therefore researchers have been increasingly interested in the food waste from this industry (3). Moreover, the foodservice and hospitality industry is anticipated to see substantial growth rates in many parts of the world over the coming years.

One third of the food that is generated for human consumption worldwide is misused annually, amounting to about 1.3 billion tonnes of food waste per year (4). From 2011 to 2014, the quantity of food waste had rose 7.6-fold and by 2020 is expected to increase to more than 5 million tonnes a day (5). If existing management of waste processes are left unenhanced, increasing quantities of wastes produced by the foodservice and hospitality industry would contribute to a substantial rise in the associated environmental impact. In fact, the generation of waste is occasionally regarded as the most notable impact to the environment by the hospitality industry (2). With a large percentage of waste generated from catering and restaurant operations and going into the environment, environmental impact is becoming one of the biggest problems facing the industry (6).

Various factors lead to waste generation from catering services for events, including the type of event, location, time of day, and types of food (7). Selection of catering services would also differ based on the type of catering service, the variety of food and the number of patrons. The majority of existing research on catering services focus on restaurants, hotels and in-flight catering operations. Therefore, this study was aimed to look at the environmental assessment of catering operations. In this study, catering facilities in Jitra, Kedah was selected for testing. This town is a rapidly growing town with economic and hospitality prospects and demand. Several environmental aspects were particularly investigated.

Conventional methods of food waste disposal, such as landfill disposal and illegal dumping, are not preferable as food waste can efficiently and naturally decompose. Food breaks down and releases greenhouse gases such as carbon dioxide (CO_2) and methane (CH_4) into the atmosphere (6). Proper management of wasted food is needed to minimize environmental impacts and effects on health. In determining the most effective prevention and intervention of food waste strategies in the hospitality and food services industry, it is essential to first identify the patterns and causes of food waste reduction (4). The purpose of this study is to identify the environmental assessments of day-to-day operations of restaurants, using the material flow analysis (MFA) approach. The findings may help food catering services and restaurant operations to establish methods to decrease food waste and maximize their resources (6).

MATERIALS AND METHODS

Determination of food waste from catering services

The sizes of the event were classified based on the number of guests or patrons. The smallest sized event had less than 50 guests, while less than 500 guests were the largest. The details of the catering services in this study are shown in Table 1.

The methodology used for the environmental assessment of catering operations included Phase 1 (Preparation), Phase 2 (Implementation), Phase 3 (Waste Collection) and Phase 4 (Data Analysis). The data collection plan is described in Figure 1.

A checklist was prepared to include the number of employees, the hours of operation, method of disposal of waste, the expected number of guests, electricity consumption and water consumption. For the electricity and water consumption, the reading of the meters of the facility was taken before and after operation hours.

Next, an audit of food waste generated by the five catering services were prepared. The collection of food waste data took place over seven days. There were four types of food waste to consider. These were storage losses (STOR), preparation losses (PREP), serving losses

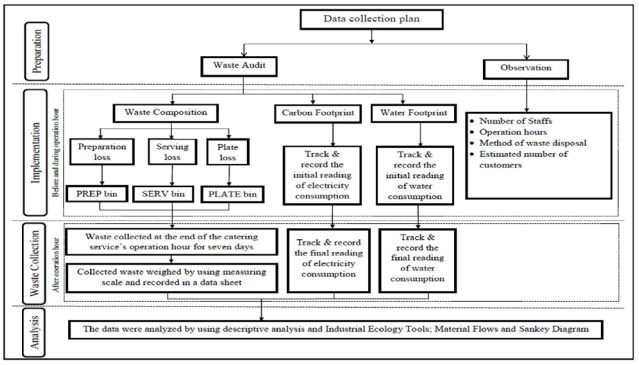

Figure 1: Methodology of Data Collection

Table I: The characteristics of catering services in this study

Catering	Event type	Event size (guests per event)
A	Small feast ('kenduri arwah' and 'tahlil')	<100
B	Wedding Ceremonies	<500
C	Birthday celebration, Small feast	<50
D	Wedding Ceremonies	<500
E	Birthday celebration, Business event (meetings)	<100

(SERV) and plate waste (PLATE) (8). In this study, only three types of losses were considered, as there were no storage loss involved.

1. Preparation losses (PREP) – Losses obtained during preparation of food and cooking (vegetable peels, spoiled food or dropped food).
2. Serving losses (SERV) – Food left from the buffet, obtained after operation hours.
3. Plate waste (PLATE) – Residue left on plates by customers, obtained after hours of operation.

Three separate bins were prepared for the catering services to dispose the food waste. These food wastes were then collected for weighing according their categories. This was carried out on-site using a weighing scale (9). Visual observation was conducted of the catering services to identify and evaluate the waste generation variables, and catering service disposal techniques. Furthermore, the final reading of electricity and water consumption was tracked and recorded.

Material Flow Analysis (MFA) was used to visualize the production of food waste. The total amount of food waste from each stage was summed up and reported as percentage of total weight.

Quantification of Carbon Footprint

Carbon footprint from electricity and water consumption produced from the catering services were calculated using formulas. A carbon footprint is described as the total quantity of greenhouse gases emitted to directly and

indirectly support human activities. Two main parameters are required to calculate carbon footprint. The first is activity data (AD), that shows the quantification of the operation. The second parameter is the emission factor (EF), to indicate the emission equivalent of CO_2 emitted by the AD unit. The emission factors used in this study are shown in Table II. The carbon footprint produced from food waste was measured using the equations by Malek & Kumarasan, 2019 (10). The equation (1) is:

Carbon footprint ($kgCO_2e$) = Activity Data (AD) * Emission Factor (EF) (1)

Table II: The emission factors used in this study

Activity Data (AD)	Type	Unit	Greenhouse Gases (GHGs)	Emission Factor
Electricity	Malaysia (Commercial Rate)	Kilowatt-hours (kWh)	Kg CO_2e	0.10919
Water	Water Supply	Cubic meters (m^3)	Kg CO_2e	0.344

RESULT

Food Waste Generation based on Different Loss Categories by Catering Operations

Table III shows the average amount of food waste generated from five catering services, according to the loss categories. The findings shows that 683.7 kg of food was thrown away by all five catering services, with an average of 97.6 kg per catering service during the time span of data collection. PREP losses resulted in 44.4 kg and PLATE losses resulted in 53.2 kg of food being wasted over the course of seven days. The plate waste showed slightly more waste than the loss of preparation. The results show different total weight of food waste between the five catering services. The highest waste generated was recorded by catering D, at 260.1 kg and the least was by catering C, at 59.5 kg.

Material Flow Analysis (MFA) on Daily Operations of Catering Services

As illustrated in Figure 2, Material Flow Analysis (MFA) on catering service operations revealed that food waste accounted for 45.53% of preparation loss and 57.47% of customers' plate waste.

Table 3: The average of food waste amount generated from the five catering services according to preparation loss and plate loss categories.

	Day/kg														Total weight (kg)		Average Total Weight (kg)	
	Day 1		Day 2		Day 3		Day 4		Day 5		Day 6		Day 7					
Loss	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2
Catering A	7.1	10.7	8.3	10.2	5.9	9.9	6.6	11.4	3.6	8.7	5.3	9.5	3.4	5.9	40.2	66.3	5.7	9.5
Catering B	5.8	8.9	10.5	7.8	20.0	15.7	30.2	18.9	12.5	16.8	9.7	12.9	7.7	9.8	96.4	90.8	13.8	13.0
Catering C	5.0	7.5	3.3	4.2	4.7	6.6	3.7	4.6	3.0	2.5	2.9	4.2	3.3	4.0	25.9	33.6	3.7	4.8
Catering D	15.8	19.2	22.4	25.4	18.7	19.4	15.5	19.8	19.2	22.8	14.1	16.8	13.5	17.5	119.2	140.9	17.0	20.1
Catering E	4.2	5.7	3.3	5.0	5.6	7.2	7.8	10.5	3.0	2.9	2.4	3.5	3.3	5.9	29.6	40.7	4.2	5.8
Total (kg)															311.3	372.4	44.4	53.2

(*Note: P1: PREP Loss, P2: PLATE Loss)

Figure 2: Material Flow Analysis (MPA) on operations of catering services

Carbon Footprint from Electricity Consumption

Figure 3 shows the carbon footprint from electricity consumption during the operation of all five catering services. According to the carbon footprint assessment, catering D was the greatest contributor to overall carbon footprint. Catering D used up to 23.86 kWh of energy and emitted up to 2.61 $kgCO_2e$, accounting for 21.99% of the overall pollution. The findings further showed that the lowest total carbon dioxide emissions was from catering E, at 2.22 $kgCO_2e$.

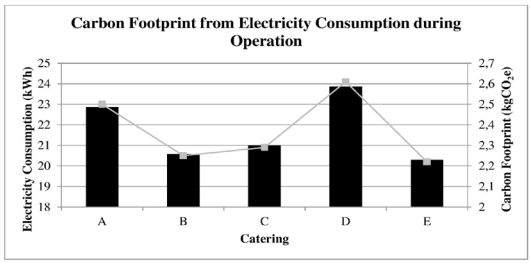

Figure 3: Carbon footprint from electrivity consumption during operation

Carbon Footprint from Water Consumption

Figure 4 shows the carbon footprint from water consumption during operation. The highest amount of average water consumption was by catering D with an average of 5.71 m^3. Catering C had the lowest water consumption, at 3.29 m^3. The main contributor to cumulative carbon emissions was catering D on the basis of the estimated carbon footprint. This catering service used up to 5.71 m^3 of water and up to 0.62 kg of CO_2e was released, representing 25.10% of the overall emissions. Furthermore, the findings show that catering C emitted a total carbon dioxide of 10.34% or 0.35 kg of CO_2e.

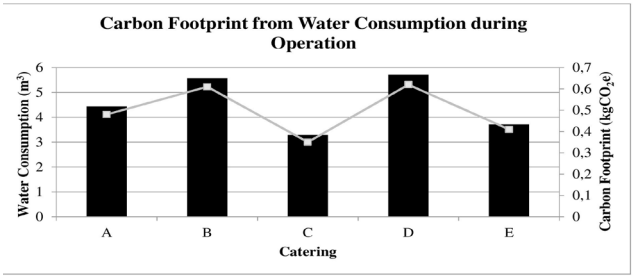

Figure 4: Carbon footprint from water consumption during operation

DISCUSSION

Food Waste Generation based on Different Loss Categories by Catering Operations

This study aimed to determine the generation of food waste caused by various loss categories by selected catering service operations. This study was conducted on-site at five catering services over seven days, whereby regular data on food waste was collected. The catering services were selected based on the type of catering service, the variety of food and size of event. It was found that the size of the event had the greatest impact on food waste generation.

According to the findings, food waste by catering services was extracted from two major loss categories: PREP loss and PLATE loss. SERV loss was not included in this study as no waste was created through this loss during the food waste audit. Remaining food was still utilized and enjoyed somewhere after the event ended. The food was either handed over to the guests, the catering employees, or the event's organizer for their consumption.

As for the difference between the total weight of waste throughout the seven days, plate wastes were slightly more than preparation waste. The results also showed a difference in total weight of food waste between the catering services. Catering D recorded the highest generation of waste, while catering C had the least. This is attributed to the size of the event. Large events generate more waste than smaller events. Small sized events are easier to plan and control. On the contrary, bigger events could have higher waste volume due to low turnout. This consequently leads to too much food being served. Significant differences were discovered between the big events, such as wedding ceremonies and the small events such as birthday celebrations.

Human factors also influence the amount of waste generated in events, as food waste is the outcome of the actions, behaviors and practices of consumers. Observations on-site revealed that guests were taking more food than they consumed. The availability of an unlimited quantity of food served at an event and with guests not required to pay for the food, are factors that encourage guests to take more than they could eat (11). After the meal, guests are left with a huge amount of uneaten food, thus best related to taking more food than one can eat.

The attitude of guests most probably affects the amount of food waste during catering services, but no evidence has been presented to support the strength of this effect (12). Conclusions could not also be made to support this effect from our study, as the particular profile or dietary patterns of the guests who visited the observed events were not gathered. Specific studies are needed to better understand the various types of events and individual

guest socio demographics when taking into account factors such as gender, age, salary, or occupation.

The current study then analyzed the Material Flow Analysis (MFA) to track the quantity of food waste generated from the various categories of food loss. A particular food goes through four main stages in the catering process. This includes storage, preparation and into cooking, serving, and consumption. Food waste can be found at any stage of this process. PLATE waste from catering services was obvious and more significant, compared to PREP waste. PLATE waste was higher compared to PREP waste.

According to Drewitt (13), PLATE loss is typically connected to customer attitude and behavior. The 'eyes bigger than the stomach' mindset takes control when a person's behavior is to take more food than what one eats, especially when the food is without a charge. This is unfortunate as there is limited possibility to control or reduce waste at the PLATE loss category, compared to food wasted through PREP loss. Waste produced during the PREP stage is typically unavoidable and not edible in regular circumstances. For example, fruit and vegetable peels, egg shells, and bones are usually generated from the PREP stage and are not suitable for use.

Before the catering process begins, a caterer uses their experience to calculate the quantity of food required based on the number of visitors and structure of guests. Experience helps a caterer to calculate the quantity of ingredients required to prepare a particular kind of food for per person (14). In addition, hosts may have the tendency to over prepare and provide decadent meals in order to impress their guests. Therefore, the ability to accurately estimate the amount of food to be prepared and the number of guests in an event, is essential to minimize waste.

During the duration of this study, no food was wasted from the serving category (SERV). It was observed that remaining food was taken by guests, workers or the hosts for later consumption. This was recognized as a good practice and one that will help to reduce food waste if practiced at all events with catering services.

Carbon Footprint from Electricity Consumption during Operations

The purpose of this preliminary study is to estimate the carbon footprint generated by the operation of catering services. One of the primary sources of carbon emissions in the provision of catering services is energy. This was obtained by the used of electricity during operating hours, as food preparation for bigger events are done using electrical kitchen appliances. This differs from commercial kitchens which most often use coal and water as energy (15).

During the food preparation process, greenhouse gases emissions are thought to be connected to the energy used to cook with an electrical appliance or to store the food in a refrigerator or freezer. Refrigerators are temperature controlled and typically run 24-hours a day (16). Kitchen areas have the highest CO_2e emissions, as majority of the cooking is done using electric-powered equipment. As the usage of surplus electricity is detrimental to the environment, its usage must be controlled to address the threat of the emissions towards pollution. It is therefore vital that energy use is well recorded and logged within the food-service industry in order to effectively manage and track carbon emissions.

Carbon Footprint from Water Consumption during Operations

Water consumption is another cause of significant carbon emissions in the provision of catering services. A large volume of water is used in the food service industry. The third-largest volume of water is used in the cooking process (17). According to studies, the most water-demanding process is food preparation (17, 18). It is inevitable to use water to wash food, utensils and clean the kitchen as well as when cooking during operation hours. Water is also used to dilute chemicals, sanitizers and detergents used to clean the items in and the kitchen facility. During the washing process, more water was consumed to remove oil (19). It is thus necessary to calculate the volume of water consumption in restaurants (20). This practice can be extended to the operations of catering services. Furthermore, water use ultimately influences operating costs and have environmental impact.

CONCLUSION

In conclusion, food waste caused by the food service industry has been identified to significantly impact the environment. In this study, we investigated the food waste generated as part of the hospitality sector. This aim of the study was met, whereby food waste generation by different loss categories (plate waste, serving, and preparation) were documented and the assessment of carbon footprint was performed.

The study revealed that catering services generate food waste based on the size of the occasions catered for. The amount of food wasted during catering were greater for big events compared to small events. The loss of customer's plate was greater compared to preparation waste and this was linked to various factors including consumers' attitude and behavior which could be further explored in future studies. Waste from the preparation step was typically inevitable due to their non-edible nature. This study was able to provide a snapshot of the variables in food waste generation from catering services. For overall carbon footprint, the average of

electricity and water usage throughout catering service operations was established. The use of energy-efficient equipment and water conservation techniques are the best approaches to reduce operating footprint.

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