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Patterns and Causes of Food Waste in the Hospitality and Food Service Sector: Food Waste Prevention Insights from Malaysia

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Abstract: Food waste has formidable detrimental impacts on food security, the environment, and the economy, which makes it a global challenge that requires urgent attention. This study investigates the patterns and causes of food waste generation in the hospitality and food service sector, with the aim of identifying the most promising food waste prevention measures. It presents a comparative analysis of five case studies from the hospitality and food service (HaFS) sector in Malaysia and uses a mixed-methods approach. This paper provides new empirical evidence to highlight the significant opportunity and scope for food waste reduction in the HaFS sector. The findings suggest that the scale of the problem is even bigger than previously thought. Nearly a third of all food was wasted in the case studies presented, and almost half of it was avoidable. Preparation waste was the largest fraction, followed by buffet leftover and then customer plate waste. Food waste represented an economic loss equal to 23% of the value of the food purchased. Causes of food waste generation included the restaurants' operating procedures and policies, and the social practices related to food consumption. Therefore, food waste prevention strategies should be twofold, tackling both the way the hospitality and food service sector outlets operate and organise themselves, and the customers' social practices related to food consumption.

Keywords: food waste; food loss; hospitality; food service sector; food waste prevention

1. Introduction

One third of food produced globally for human consumption is lost or wasted, which amounts to approximately 1.3 billion tons per year [1]. Food waste's formidable economic, environmental and social impacts have been recognised at the highest levels of global governance. The UN's sustainable development goal for responsible consumption and production urges the world to "halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses" by 2030 [2]. The FAO recently launched the 'Global initiative on food loss and waste reduction' aiming to reduce food wastage throughout the food system by facilitating collaboration, coordination, and research and by raising awareness [3].

Food waste is produced along the various stages of the food supply chain [4]. The hospitality and food service (HaFS) sector (for the definition of the HaFS sector refer to [5]) has been identified as a sector with significant potential for food waste prevention, hence food waste from this sector has recently received increased attention in research [6,7]. Recent studies are building an understanding of the drivers giving rise to food waste [8,9] offer suggestions for food waste prevention strategies targeting consumers' attitudes and behaviours [10,11] or alternative approaches drawing from social practice theory [12]. The majority of research on food waste provides evidence from developed countries such as Scandinavia and Norther Europe [6,13,14], Northern America [15], and Southern Europe [16] with only few studies providing a developed country/ emerging economy perspective [17–19]. Despite their different perspectives, methodological approaches, and contributions, all of the above studies highlight the lack of sufficient evidence on how, why, how much and what type of food is wasted in the HaFS sector, and what could be done to prevent it. This is the research gap that this study seeks to address.

Therefore, this research aims to determine the patterns and causes of food waste generation in the hospitality and food service sector, in order to identify the most promising measures for food waste prevention. This paper presents a comparative analysis of five case studies from the HaFS sector in Malaysia, providing much needed evidence from a developing country perspective [7]. The study positions itself in the interface between quantitative and qualitative research, drawing on methods from ethnography and grounded theory, complemented with concepts and tools from industrial ecology.

2. Literature Review

Food waste is a growing issue due to its environmental [1,20–23], economic [24–27] and social implications [28–30]. Food waste has high carbon, water and ecological footprint [31–33] as well as negative impacts on cropland and fertiliser use [34]. Most importantly, it is recognised that food waste reduction has an important role to play in the quest for global food security [4,35,36].

Academic research on food waste has focused on developed countries [37,38] and households [39]. The material and social contexts of food waste practices [12,40] and in particular awareness around food and waste matters [41,42], lifestyle [43], technology and innovation [13,44], food shopping, preparation and consumption behaviours [45–47] are central in understanding household food waste. Discussions on household food waste centre around waste separation behaviour, especially in highly density housing areas [48,49], waste prevention [50,51], the perspective of the consumer, namely how consumers experience aversion when they waste food [52,53], how food consumption practices influence waste generation [54,55], and the role of social media campaigns in food waste prevention [56,57].

Outside the household focus, studies have examined the scale and nature of food losses and waste in the entire food chain expressed in weight, calorific content and economic value [4,58,59]. In hospitals case studies have highlighted the scale of the food waste problem [25], shown how catering practices and public procurement impact food waste generation [60], and how reduced portion sizes, bulk meal delivery systems, improved forecasting, and provision of dining rooms can be effective food waste minimisation strategies [61,62]. Research focusing on the retail sector highlights the complex and varied causes of food waste and suggests multifaceted prevention approaches [61,62] including social media campaigns with mixed results [57]. In the food industry, studies argue that clearer communication and stronger cooperation amongst the main actors in the food supply are essential for food waste reduction, through waste avoidance and donations of edible fractions to charitable organisations [63,64]. Case studies in universities have explored food waste reduction interventions such as tray-less delivery systems [65], written messages encouraging pro-environmental behaviour [11,66] and a social media-based food sharing tool [67] with mixed results.

Finally, in the HaFS sector research has focused on quantifying and monitoring food waste [6,9,14,68], other studies suggested that food buffet services and overproduction are two of the main causes of food waste [15,69], and revealed that 'nudging' techniques can lead to food waste minimisation [11,70]. Other studies have attempted to quantify food waste and understand the processes that give rise to it in order to propose recommendations for food waste reduction [12,15,71–73]. Food

waste prevention has been recognised as the most advantageous option for addressing food waste [74], and food surplus management identified as essential in achieving prevention [75]. Food surplus management includes the redistribution to people affected by food poverty as a means of achieving food waste reduction and urban food security [76,77]. However, the role that food surplus redistribution can play towards realising sustainable food is questioned [28,78]. It is argued that food surplus donations though civil society organizations, in fact, depoliticise food issues, focus on individual personal responsibility, and fail to address structural poverty [79,80]. Most studies acknowledge the need for more holistic understanding of the problem, and call for interventions at the individual, organisational, and policy levels [8].

3. Methods

Five case studies from the hospitality and food service sector in Malaysia were selected based on access, availability, type of food service (such as buffet style, *a la carte*, combination of the two), price range, type of cuisine, type of customers, primary function (such as work place canteen, hotel restaurant, banquet facility, standalone restaurant), and size (number of meals served per day) (for more details on the case studies please refer to Table 1). The selected case studies did not aim to give a comprehensive picture of the whole HaFS sector, but instead to offer opportunities to test how these variables affect food waste generation and prevention. Food waste generation was studied from the time of purchasing raw food supplies, throughout food storage, preparation and cooking, customer consumption and finally discarding food waste. It did not include waste collection and final disposal at the landfill or other waste treatment facilities, as these stages were outside the remit and control of the HaFS operations.

Table 1. Case studies summary table.

	Description	Size (Av. No. of Meals served Per Day)	Average Meal Price (RM[1]/USD[2])	Type of Service	Type of Customer & Function
HaFS Operation 1	Banquet facility	560	RM80–250 (USD22–68)	Buffet (all you can eat) Full table service Lunch, dinner, mid-morning and mid-afternoon coffee breaks	Local families/weddings, professionals on conferences, workshops, annual dinners, promotional events
HaFS Operation 2	Chinese cuisine restaurant	210	RM60–150 (USD16–41)	*A la carte* Lunch, dinner	Local families, professionals in meetings, work colleagues
HaFS Operation 3	Malay cuisine restaurant	160	RM40–100 (USD11–28)	Buffet (all you can eat) *A la carte* Lunch, dinner	Local families, work colleagues, professionals in meetings
HaFS Operation 4	Five-star hotel restaurant	170	RM80–130 (USD22–35)	Buffet (all you can eat) *A la carte* Breakfast, lunch, dinner	Tourists, professionals in meetings, local families
HaFS Operation 5	University food court	6,440	RM5–20 (USD1–4)	Canteen buffet (pay what you eat) Breakfast, lunch, dinner	Students and university staff

[1] RM: Ringgit Malaysia; [2] USD: United States Dollar.

Mixed methods were used for data collection and analysis based on the methodological framework developed by Papargyropoulou et al. [81] (pp 328-330). Figure 1 presents the methodological framework and the following sections elaborate on the individual methods used.

Quantitative data collection methods used in the case studies aimed to identify processes and activities within the HaFS operations that give rise to food waste [82]. They were used to measure the amount of food waste generated from these processes in order to prioritise the most promising measures for waste prevention. The quantitative data collection methods comprised of a food waste audit, photographic records, and collation of financial records and inventory of food purchases. During the food waste audit, the amount and type of food waste were measured and recorded continuously throughout the day and for a sufficient length of time (continuously for one week) in order to account for daily variation [83]. The length of the waste audit exceeded the recommended 3 days duration by WRAP and the Sustainable Restaurant Association, in order to improve data reliability [5,84]. Building on previous research [84] three types of food waste were monitored. 'Preparation waste':

produced during the food preparation stage, due to overproduction, peeling, cutting, expiration, spoilage, overcooking, etc. 'Customer plate leftover waste': food discarded by customers after the food has been sold or served to them. 'Buffet leftover waste': excess food that has been prepared but has not been taken onto the customer's plate or consumed thus left on the buffet or a food storage area and later on discarded. The ingredients of the food waste were also recorded to categorise food and food waste into nine food commodity groups (Table 2) and produce detailed Sankey diagrams of Material Flow Analyses (MFA). In addition, in-situ estimates of the edible fraction of food waste were made based on visual observations, in order to understand how much of the food waste was avoidable or unavoidable (for definitions of avoidable and unavoidable food waste refer to [5].
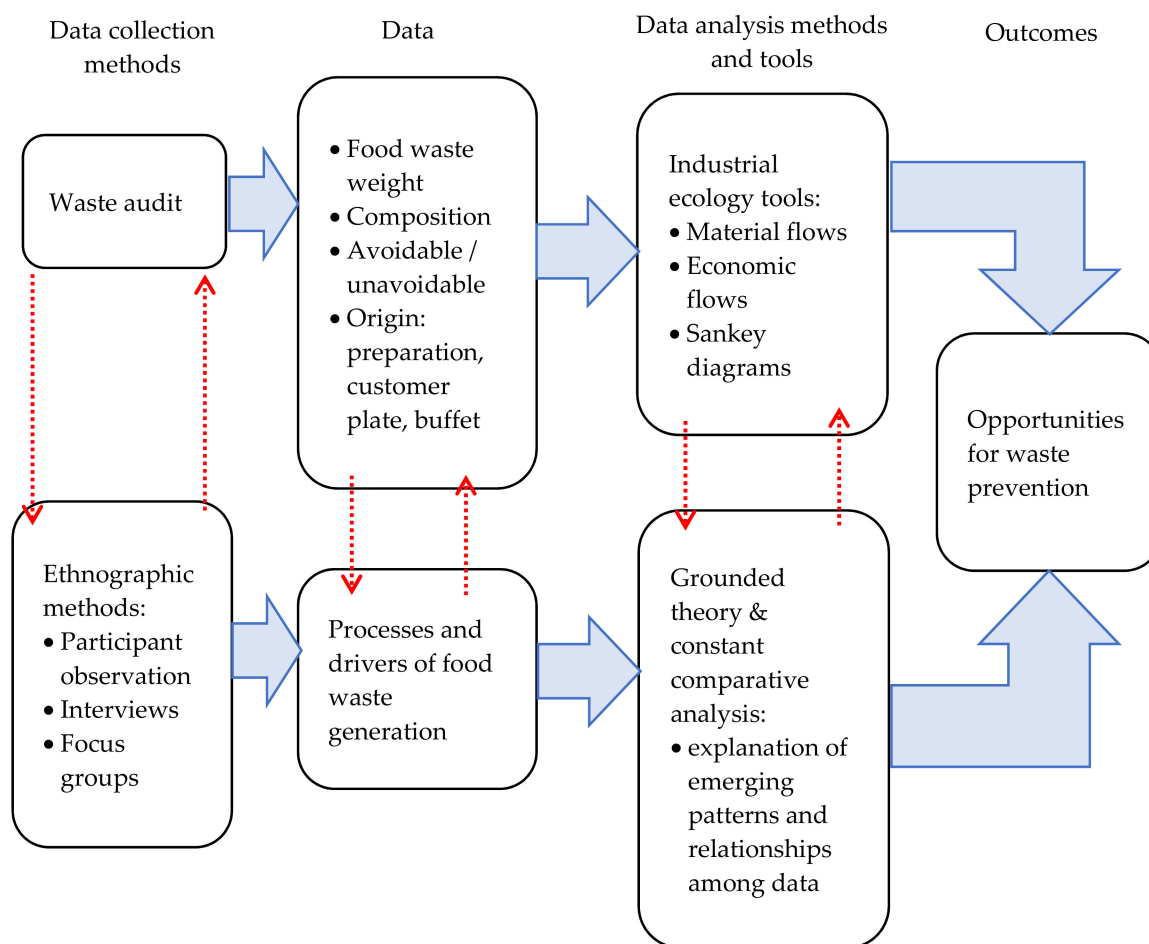

Figure 1. Conceptual framework for the study of food waste generation and prevention in the hospitality and food service sector (Adapted from [81]).

Table 2. Food commodity groups used in this study to categorise incoming food and waste.

Food Commodity Category	Type of Foods Included in the Category
Cereal and grains	Rice, pasta, noodles, bread, flour, pastries, other wheat, barley, maze, oats products
Dairy	Milk, cheese, yogurt, ice cream, and other dairy products
Eggs	Eggs
Fish and seafood	Fresh water fish, demersal fish, pelagic fish, other marine fish, crustaceans, other aquatic animals, and plants
Fruits	All fruits
Meat	Bovine meat, mutton/goat meat, pig meat, poultry meat, other meat, offal
Oils and fats	Olive, palm, vegetable oils, butter other animal and vegetable oils and fats
Sauces incl. liquid fraction of dishes	All premade and in-situ prepared sauces, including tin tomatoes, salad dressing, canned soup, and all other liquid fractions within dishes
Vegetables, roots, and pulses	All vegetables, potatoes, and pulses

The weight and composition of the food waste were combined with the food purchasing inventory to calculate the economic losses due to food waste. Sankey flow diagrams were used to visualise the magnitude of the material flows taking place within the HaFS operations. The thickness of each link represented the amount of flow from a source to a target node, on this occasion from food provisioning to food consumption. The flows are presented in % rather than kg/day to facilitate comparison amongst the case studies.

Qualitative data collection and analysis methods complemented the quantitative methods. Qualitative data were collected via interviews, participant observation, and focus groups. In-depth structured and informal non-structured interviews of the employees and customers from across the five restaurants and representatives of the National Solid Waste Management Department (NSWMD) were carried out (25 interviews with staff and 2 customers across all HaFS operations and 3 interviews with representatives of the NSWMD). Following the initial round of in-depth interviews, participant observation combined with informal non-structured interviews with the restaurant employees were conducted while collecting quantitative data. The observations were recorded through field notes in the form of a diary [85]. Three focus groups with employees from the participating HaFS operations were also undertaken following some preliminary data analysis. The participants of the focus groups comprised members of the management, procurement, sales, finance, food preparation, and operations teams (for stakeholder engagement methods see [86,87]). The first focus group included staff from 3 HaFS operations 1, 2, and 3. The second focus group included staff only from Operation 4, and the third included staff only from Operation 5. The focus groups allowed for verification of the data collected through the other data collection methods and offered an opportunity to seek clarification on behaviour recorded during the participant observation. It offered further insights as to where, how, why food waste was produced, and recommendations on how to prevent it.

Qualitative data were analysed with the use of the constant comparative method, an inductive and iterative data coding process used for categorising and comparing qualitative data for analysis purposes [88]. The constant comparative method is a key principle in Grounded Theory [89,90]. This coding process allowed for key themes to emerge from the qualitative data, and for relationships between these themes to become apparent. It allowed to again a better understanding of why and how food waste was produced in the participating HaFS operations, and what can be done to prevent it.

The quantitative methods identified the type and measured the amount of food waste generated, whereas the qualitative methods built a better understanding of the causes and patterns of food waste generation. Gaining an understanding of how much, what type, why and how food waste was generated, ultimately helped to identify the most promising measures for food waste prevention. The proposed waste prevention measures target the causes of food waste generation identified, and draw on insights from the interviews conducted in this study, as well as recommendations from the wider literature.

4. Results and Discussion

The characteristics of the five case studies presented in this paper are summarized in Table 1. Case Study 1 (HaFS Operation 1) was a high-end banquet facility, serving food for a number of events every day such as conferences, meetings, weddings, promotional events, workshops, and annual general meetings. It served on average 560 meals throughout the day, either buffet style or full table service to a variety of customers. Case Study 2 (HaFS Operation 2) was a mid to high-end standalone Chinese restaurant, serving *a la carte* lunch and dinner to approximately 210 customers a day. Case Study 3 (HaFS Operation 3) was a mid-range, buffet or *a la carte* style, Malay restaurant, serving approximately 160 meals a day. Case Study 4 (HaFS Operation 4) was a mid to high-end restaurant operating within a five-star hotel, and serving approximately 170 meals throughout the day, with buffet or *a la carte* service. Case Study 5 (HaFS Operation 5) was a university canteen comprising nine independently ran food outlets operating within the same 'food court' space. It serves more than 6000 affordable meals throughout the day to university students and staff.

4.1. Patterns and Causes of Food Waste Generation

Food waste generation varied substantially amongst the HaFS operations studied. Figure 2 compares the HaFS operations according to their average food waste generation per customer. On average 0.53kg of food waste was produced for every meal/ customer served, however the most wasteful restaurant (Operation 4) produced over eight times more waste per customer compared to the least wasteful restaurant (Operation 5). This result highlighted how case-specific conditions can have a very significant impact on food waste generation, as suggested by other studies [6,14,18,58,91]. The top three restaurants in Figure 2 offered buffets where the customer could enjoy unlimited food for a fixed price. In the least wasteful restaurants, the customers paid according to what they consumed. These results indicate that 'all you can eat' buffets are more wasteful compared to the *a la carte* food service. Several reasons were behind this result and are elaborated on below.
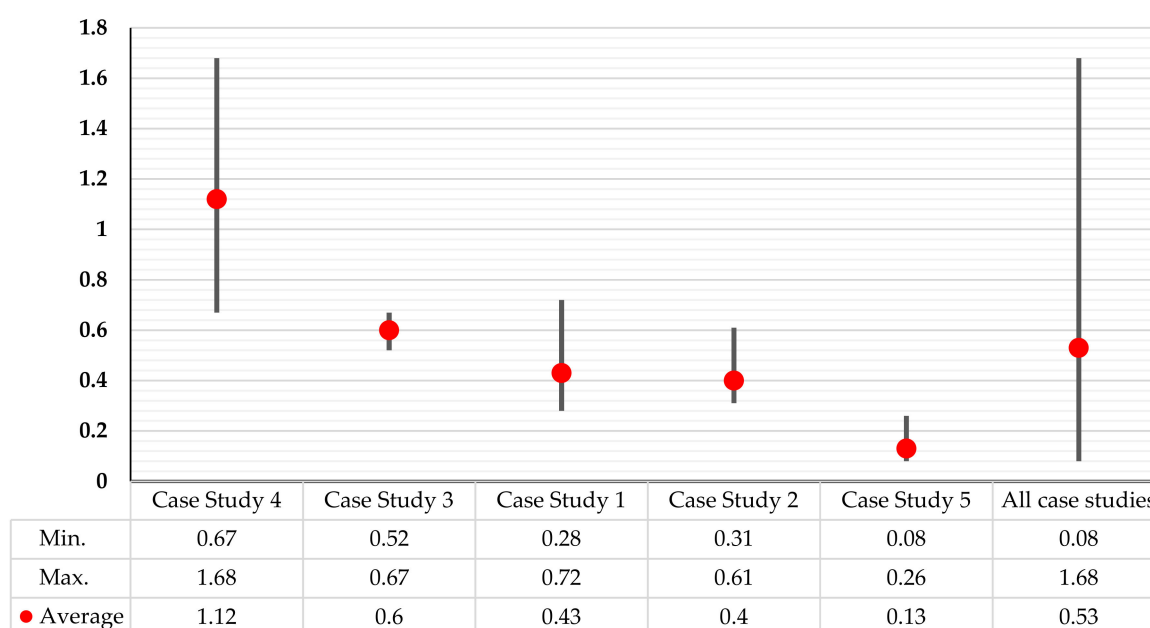

	Case Study 4	Case Study 3	Case Study 1	Case Study 2	Case Study 5	All case studies
Min.	0.67	0.52	0.28	0.31	0.08	0.08
Max.	1.68	0.67	0.72	0.61	0.26	1.68
● Average	1.12	0.6	0.43	0.4	0.13	0.53

Figure 2. Food waste per customer (kg/ customer).

Preparation waste was 15–55%, buffet leftover 22–50% and customer plate waste 23–35% of total food waste, showing significant variation across the HaFS operations studied (Figure 3). Operation 2 did not offer a buffet, therefore did not generate any buffet leftover waste. This led to the other two waste types, e.g., preparation and customer plate food waste to appear seemingly higher as percentages of the total food waste. Significant variation has been reported in other studies where preparation waste was 5-31%, buffet leftover 7-44%, customer plate waste 4–37% [68]. Customer plate was the smallest fraction of the food waste produced, contrary to the opinions of the restaurants' staff and management as revealed during the interviews and focus groups. As the porter in Operation 3 explains while he is washing the dishes:

> I see the plates when they come back here to be washed. The stuff that people waste is so much. And good food too. We need to educate them [customers] but it's hard because they don't see all the work that goes on back here, just the finished dish. I tell you, this is where the problem is.

The customer was often blamed for the high food waste generation rates (for blaming the consumer see [40,92,93]). The restaurant staff and management were surprised by the results of the study showing that a significant potential for food waste prevention was within the scope and power of the restaurant itself, e.g., reducing preparation and buffet leftover waste.
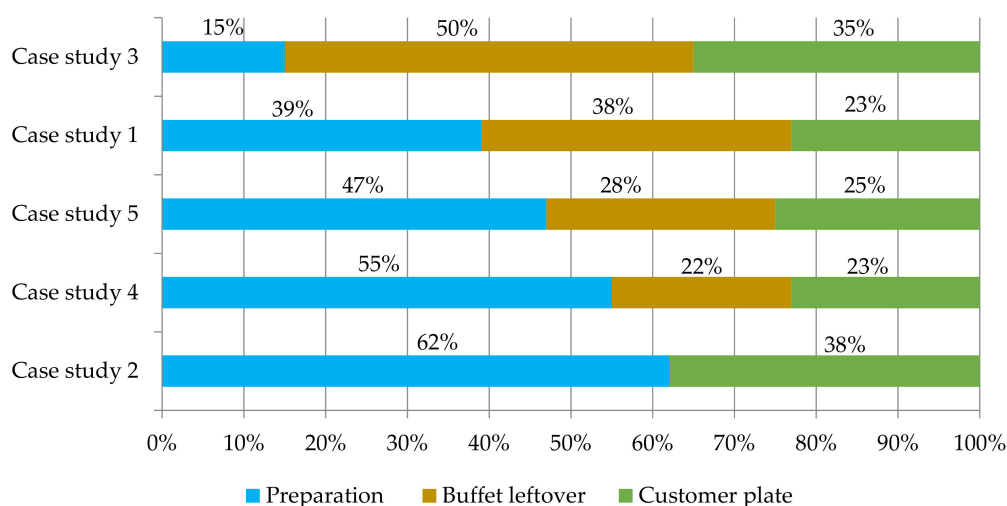
Figure 3. Percentages of preparation, customer plate, and buffet leftover waste fractions.

Customer plate waste showed the least variation across the HaFS operations, however, preparation and buffet leftovers were significantly different across the restaurants studied. The highest preparation waste percentage was observed in Operation 2, followed by Operation 4, Operation 5, Operation 1, and finally Operation 3. The order of the HaFS operations in terms of buffet leftover waste percentage from highest to lowest is the reverse i.e. Operation 3 has the highest percentage of buffet leftover, followed by Operation 1, Operation 5 and finally Operation 4 (Operation 2 did not offer a buffet, therefore is excluded from this analysis). These patterns are explained below: Operation 3 (Malay restaurant) is attached to Operation 1 (banquet hall) and operated by the same company. Buffet leftover from the banquet hall that had not been served was directed to the Malay restaurant and included in their buffet. This method reduced buffet leftover waste from the banquet hall and preparation waste from the Malay restaurant. It also made Operation 3 preparation waste percentage seemingly appear low and buffet leftover percentage to appear high.

Preparation waste percentage was the highest in Operation 2, Operation 4 and Operation 5. These were the restaurants where meals were prepared from scratch using fresh ingredients, leading to higher preparation waste rates. Observations and interviews identified poor cutting skills during food preparation as one of the contributing factors for high food wastage. For example, as the Head Chef in Operation 4 suggested:

> Some of the younger cooks don't know how to and they don't care. They have no training and they learn on the job, but they rush things to go faster and you see what they do [he points to a discarded watermelon skin with a lot of the ripe, red edible part of the fruit still on the skin]. That's why I only trust my experienced staff to cut the expensive stuff like meat and fish.

Avoidable food waste was 32–63% of total food waste across all HaFS operations, illustrating the substantial potential for waste prevention (Figure 4). The avoidable fraction measured in this study is comparable to that reported by Beretta et al [58] (p 771) at over two thirds of the total food waste. Preparation waste primarily consisted of unavoidable waste, such as inedible fruit and vegetable peelings, fruit stones, and bones. Customer plate waste had both inedible (unavoidable) and edible (avoidable) parts, whereas buffet leftover waste primarily consisted of edible (avoidable) parts.
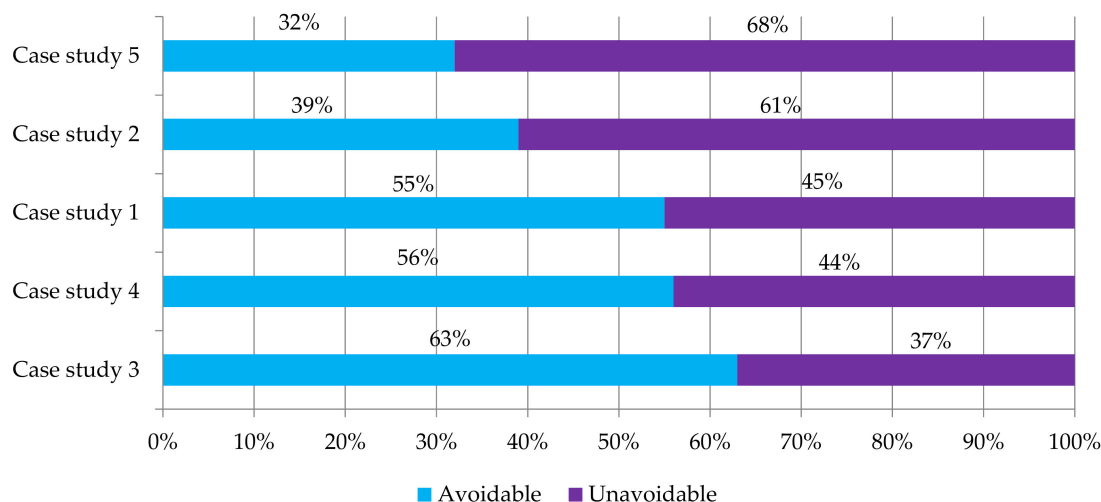
Figure 4. Avoidable and unavoidable food waste fractions.

Operation 3 (Malay restaurant) had the highest avoidable food waste fraction, due to the high buffet leftover rate. Operation 4 (hotel restaurant) had the second highest avoidable food waste fraction. Observations suggested that this was linked to the high preparation waste generated by the hotel restaurant due to high aesthetic standards (e.g. shaping a whole watermelon into a flower for buffet decoration) and cooking from scratch using fresh ingredients. Customer expectations for high aesthetic standards is potentially influenced by local culture. Although this study did not focus on this aspect, cultural factors can play a role in the way food is prepared, consumed and disposed of, as acknowledged in studies across different cultural contexts [15,16,19]. Operation 4 had in place a company-wide food safety policy stipulating that no food should remain on the buffet for a period longer than four hours. As a member of the kitchen staff in Operation 4 explained, this is a point of friction between the management team and the operations team:

> Look at this [pointing at food items on the buffet that have to be thrown away because they need to 'change over' the buffet]. This is bad, there's nothing wrong with this food, it could last for another 2 hours. We have to throw it away because they [pointing at the manager's office] are worried about HQ [headquarters].

As a direct result, every four hours staff would clear the buffet by throwing away all the food, and then replace it with a new batch of freshly prepared food. This practice generated quite substantial quantities of buffet leftover waste.

Although Operation 1 (banquet hall) diverted some of the buffet leftover waste (primarily avoidable waste) to Operation 3 and therefore practiced waste prevention, it still had the third highest avoidable fraction at 55%. Observations, discussions during the focus group, and the interviews revealed the following reasons behind food waste generation in Operation 1. As a banquet hall, Operation 1 catered for large functions such as weddings, conferences, workshops and marketing events. In many cases, the number of customers that turned up to these events was significantly lower than the number that the food was prepared for, for example as a waitress in Operation 1 explained:

> They [the customer] make a booking for 200 people and 100 turn up. They don't care, they have paid for 200 so we have prepared for 200. But it's such a waste, and we can't tell them off because you know, they are paying.

On other occasions, changes in the booking details, such as the menu and the number of participants, were made right up to the day of the event, as the Head Chef in Operation 1 stated:

> The booking department don't understand, they think we can change the menu and number [of meals prepared] last minute. I can't, I need at least a week, I need to put my order in purchasing [department] so I have the right ingredients and quantity.

In addition, the banquet hall had a policy of preparing 30% more food than what was required based on the reservations, in order to avoid running out. This practice led to a systematic production of food surplus that eventually caused food waste. Finally, there were instances where the menu that was selected was not appropriate to a specific event and layout, causing food waste. For example, a very 'heavy' and 'rich' menu comprising curries, stews, and rice, was selected for a marketing event where the layout of the dinner aimed to encourage networking amongst participants and as such did not have chairs. Participants could not easily eat the type of food offered without sitting down, which led to substantial buffet leftover waste. As a member of the staff from the Bookings department in Operation 1 describes, 'Finger' food would have been a more appropriate menu for this type of event [94]:

> I told them [the customer] this is not the best menu for the type of event he picked, but he didn't listen. He wanted 'proper' food you know, not 'finger' food. But the layout was set up for networking, no chairs, so people couldn't eat the curry standing up. And he had all these models and actresses coming, celebrities, you know they didn't eat anything!

Operation 2 (*a la carte* Chinese restaurant) had the second lowest avoidable food waste percentage, due to the fact that it only offered *a la carte* service. Operation 2 had no buffet leftover food waste and food was prepared for the correct number of customers, rather than the estimated number of customers such as in the case of the buffet restaurants. Observations revealed that the waiting staff of Operation 2 had the opportunity to consult customers on the right amount of food to be ordered and explain the items on the menu so that the customers could avoid ordering too much or food they did not like. A waiter in Operation 2 explained how he learned to do this during his training:

> At training they always tell us how to explain the menu to customers. They tell us to give advice if they start ordering too much. Tell them things like 'this dish is enough for 2 people', or 'this is a big portion'. Sometimes they [customers] listen. But sometimes they want to show off, you know, when business people take big clients out.

Operation 5 (university canteen) had the lowest avoidable waste percentage and the lowest food waste generation overall, making it overall the least wasteful HaFS operation. The meals at Operation 5 were very affordable compared to the other HaFS operations. The quality and variety of food reflected the low price in Operation 5, nonetheless, the profit margins were considerably lower compared to the other HaFS operations. Interviews with staff and management of the university canteen revealed that the low profit margins were the main driver for using food more efficiently and minimising food waste. For example, a food stall operator in Operation 5 described how and where she sourced, planned for and prepared the food she sold on her stall:

> Each food stall makes one dish so we know what we need. I buy everything I need from the Dato Karamat market [the nearest fresh produce market], in the morning then cook it here. I don't make much, so I don't have much 'balance' [leftover food] when I finish up. When it's gone, it's gone. The students know that, so they come early before I ran out. I know when the students go back home so I cook less then, enough only for staff.

The canteen prepared only enough food for the number of customers expected even if that meant that the last customers did not enjoy the same variety as the first (unlike Operation 1 and Operation 4 where 30% more food was prepared in order to ensure the buffet never ran out).

There was a correlation between the total amount of food wasted, and the proportion of avoidable food waste. For example, Operation 4 the most wasteful HaFS operation, and had one of the highest proportions of avoidable food waste, whereas Operation 5 was the least wasteful operation and had the lowest proportion of avoidable food waste. The order of the most wasteful operations was Operation 4, followed by Operation 3, Operation 1, Operation 2, and finally Operation 5, as expressed by the food waste per customer rate (Figure 2). The order of the highest avoidable food waste percentage was Operation 3, followed by Operation 4, Operation 1, Operation 2, and finally Operation 5, almost the same as the order for the food waste generation. The correlation between food waste generation and avoidable waste suggests that the restaurants that ensured avoidable food waste was reduced also practiced food waste prevention overall. The least wasteful (in terms of avoidable food waste and of overall food waste) operations Operation 5 and Operation 2 had one thing in common: the customer paid according to what they ordered and not a flat rate like in the other HaFS operations where 'all you can eat' type of buffet operated. They also avoided food surplus and thus prevented food waste (for the transition of food surplus into food waste see [95]). Operation 1 (banquet hall) practiced some food waste prevention by diverting buffet leftover to Operation 3 and to their staff's canteen.

The consumers' expectations of a continuously full buffet with an excessive number of different items on offer were given as the main reason behind the restaurants' practice of producing 30% more food than what was required. Observations of food consumption practices in buffets highlighted the link between food waste generation, in particular customer plate food waste, and the customers' perceptions of 'value for money'. Discussions with customers and staff revealed that the notion of 'value for money' closely related to quantity not necessarily quality of food. For example, when asked whether they were satisfied with the buffet in Operation 1, a customer referred to the variety and abundance of the buffet, not whether the food was tasty:

Researcher: Are you happy with the buffet?

Customer in Operation 1: Yes, the buffet is good value for money. It has so many items, a lot of choice, and it was full even towards the end. I tried them all.

Observations illustrating this point include customers taking too much food on their plate, consuming only a small fraction of it, leaving a considerable amount of uneaten food on their plate, before going back to the buffet to take another plate. This cycle was repeated numerous times. These examples demonstrate how food waste generation was affected by the type of service provided such as 'all you can eat' buffets, the customers' expectations such as the social norm of buffet abundance, and food consumption practices such as binge eating (for consumption practices see [12,96]).

The Mass Flow Analyses for Operation 1, Operation 2 and Operation 4 illustrate that food waste accounted for 16–28% of the total food (Figures 5–7). Operation 3 and Operation 5 did not provide sufficient data to carry out analysis of the material and economic flows. The average food waste rate was higher than the average 18% reported by Beretta et al [58] (p 771), 20% reported by WRAP [5] (p 4), and Engström et al [97] (p 206); however, lower than the maximum food waste Beretta et al encountered during their study, of 45% at a gourmet restaurant. Cereal was the most wasted food commodity across all HaFS operations, followed by fruits and vegetables for the operations that offered buffets. This result corresponds with WRAP's study that encountered 40% of all waste was carbohydrates such as pasta, rice and bread [5]. These patterns can be explained by the fact that the HaFS operations wasted a lot of rice as buffet leftovers due to overproduction. In addition, rice as a component of plate waste was often linked to customers perceiving rice as a 'cheap filler' rather than a main component of the meal. As the waiter in Operation 2 stated:
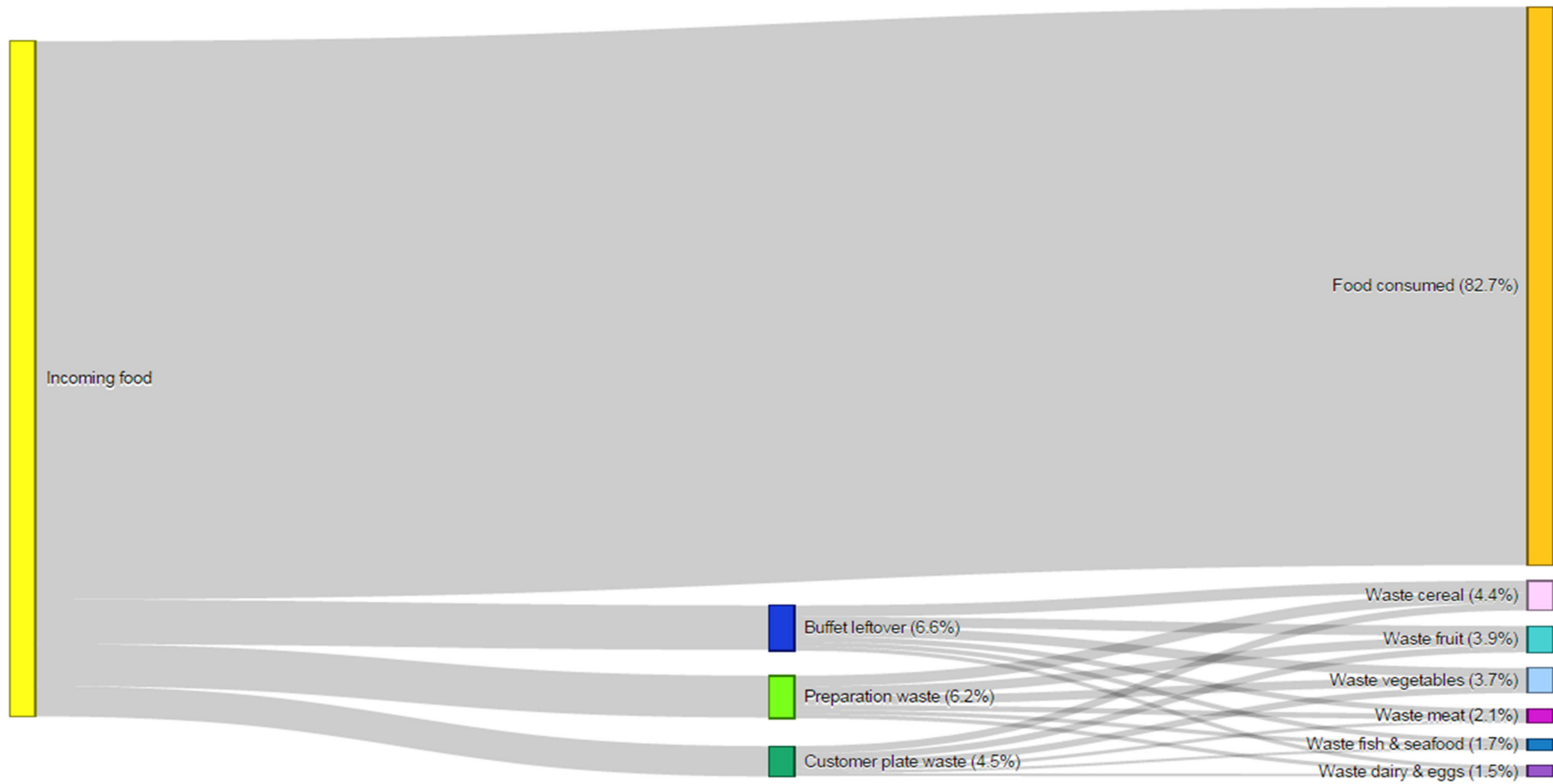
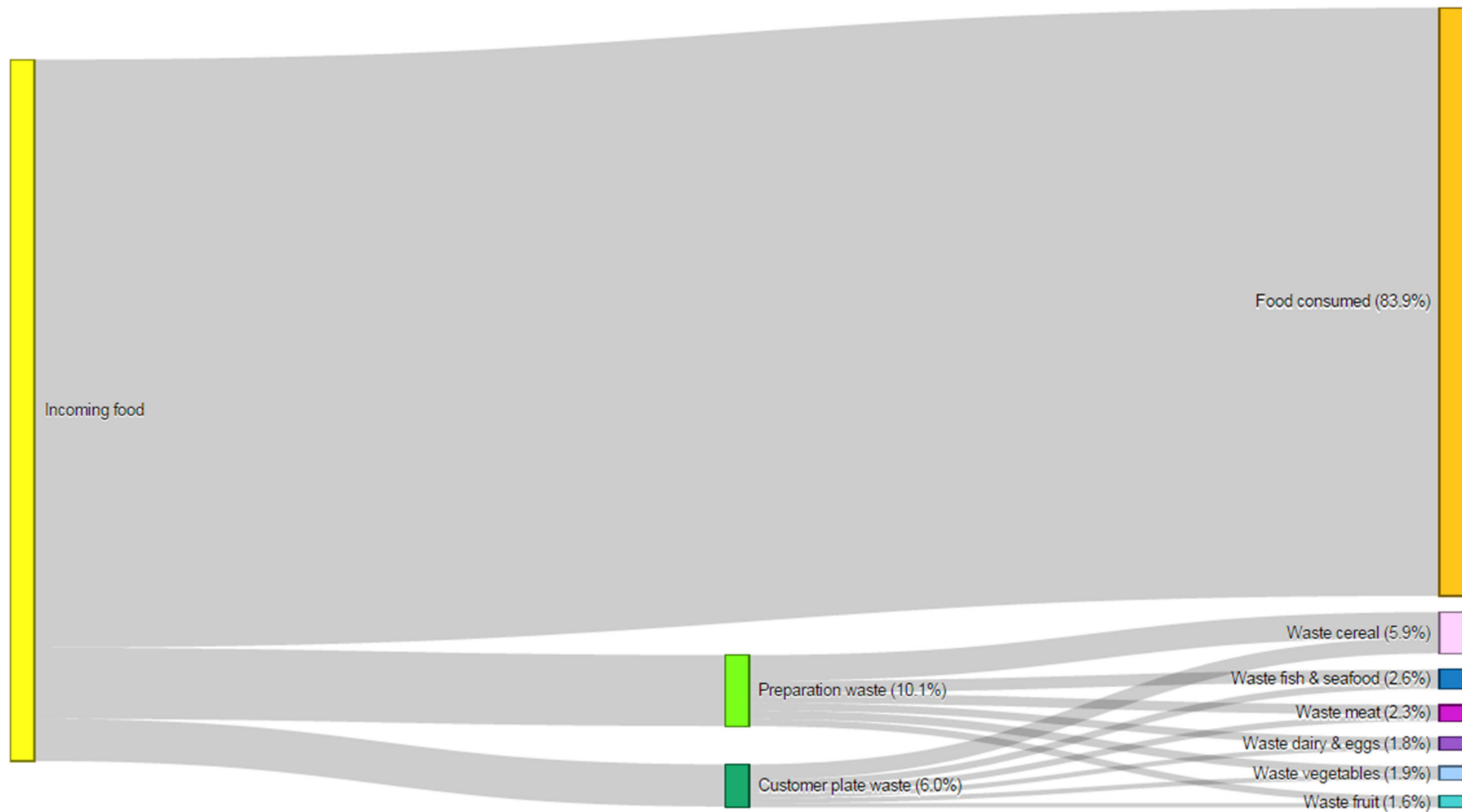**Figure 5.** Material Flow Analysis for Operation 1 (banquet facility).

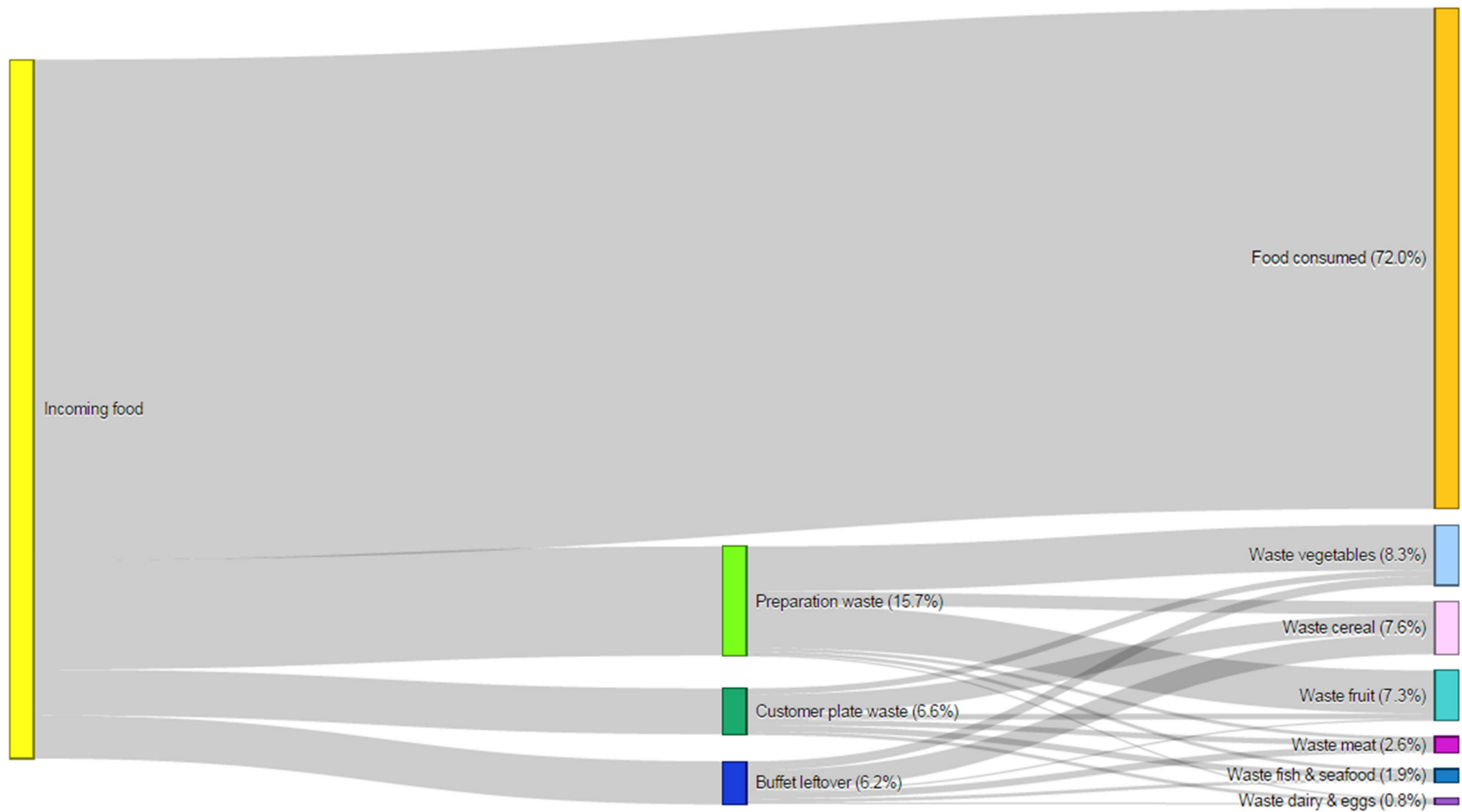**Figure 6.** Material Flow Analysis for Operation 2 (Chinese restaurant).

Figure 7. Material Flow Analysis for Operation 4 (Hotel restaurant) [81].

> The customers don't come here for the rice, they come because of our reputation for the meat and fish, and our speciality dishes on the menu. But the habit is always to order rice and most times they order more than they need. But it's cheap so they don't worry about it.

Fruits and vegetables were the main food commodities in the preparation waste of buffets, especially since they were quite heavy (for example watermelon skins) and were used in high quantities as they were cheaper than meat, fish, and seafood.

Food waste represented an economic loss of 16.4% of the value of the food purchased for Operation 1 (banquet facility), 16.8% for Operation 2 (Chinese restaurant) and 31.3% of Operation 4 (hotel restaurant). These results suggested that although Operation 1 was more wasteful in terms of mass, it performed better in economic terms than Operation 2. Operation 1 wasted more fruits and vegetables, that are cheaper compared to fish, seafood, and meat that were wasted in higher quantities in Operation 2. Operation 4 had significant losses both in mass and economic terms.

4.2. Food Waste Prevention Recommendations

The causes of food waste generation were grouped into two categories depending on whether they were related primarily to food production or consumption. In food production, food waste was generated in a systematic manner. The restaurants' operating systems and procedures (e.g. their food procurement, storage and preparation methods, and their reservation system) led to systematic food waste generation. During food consumption, the consumers' social practices were the main causes of food waste generation, however, the restaurants' operating procedures also led to systematic food waste generation. Recommendations for food waste prevention are presented in Tables 3 and 4 tailored specifically for preparation, buffet leftover and customer plate waste. These recommendations are designed to address the causes of food waste generation as observed in this study. They draw on recommendations that emerged in the interviews and from the wider literature.

Table 3. Recommendations for food waste prevention targeting systematic food waste generation.

Causes of Systematic Food Waste Generation	Food Waste Prevention Recommendations	Type of Food Waste Targeted by Recommendation
'All you can eat' buffets [15]	Opt for *a la carte* service	Preparation waste Buffet leftover Customer plate waste
	Opt for a 'pay what you eat' type of buffet	Customer plate waste
	Introduce a charge if food waste is left on customer's plate or offer a reward such as a discount, if no food waste is left on the plate [98]	Customer plate waste
Food surplus generation: policy of preparing 30% more food than what is needed	Prevent food surplus by preparing only what is necessary by improving the demand forecast [86]. This measure can be achieved by improving the reservation system in order to make accurate predictions of customer numbers (see recommendation below). Have staff on stand-by to prepare extra food if necessary. This measure requires the customers to accept that towards the end of the buffet all dishes might not be available. It also requires that the customer pays according to what they eat, or a type of compensation to the late customers that might not receive the full variety of the buffet, for example, a discount for customers arriving half an hour before the buffet closes.	Preparation waste Buffet leftover
Failure of booking system to accurately predict numbers [9]	Improve the booking system by confirming numbers the day before. Request a deposit when reservation is made to limit 'no shows'. Implement an 'only by reservation policy' where only customers that have made a reservation are accepted. A softer approach to this measure is to encourage customers to make a reservation by offering a discount. Customers that have no reservation can still dine, however they miss out on that discount.	Preparation waste Buffet leftover
Food safety policy stipulating that no food should be left on the buffet longer than 4 hours	Instead of having a 'blanket 'policy stipulating a specific number of maximum hours for food to be left on the buffet, develop a strategy that works in stages for assessing food safety. This strategy needs to be in line with the National Food Safety Regulations (Food Regulations 1985) and the Malaysian Food Act 1983. Chefs can assess on a case by case basis which dishes are more likely to become unsafe based on their ingredients, cooking and storage method. This way, dishes of higher risk can be removed from the buffet earlier than food items that can last longer (e.g. whole fruits such as apples, oranges, bananas, or pickled foods, or food items in protective packaging such as crackers). After the closure of the buffet, direct buffet leftover to staff canteen for immediate consumption. Ensure suitable food safety procedures are in place to avoid food poisoning and cross contamination in the staff canteen. Supervise this process closely to avoid staff eagerly removing buffet items earlier than they should in order to enjoy them in the staff canteen. Alternatively, redirect buffet leftover that is safe for human consumption to food charities and soup kitchens for immediate consumption [13]. This measure needs to be accompanied by strict food safety guidelines and a no liabilities agreement between the restaurant and the charity. The agreement needs to remove responsibility for food safety from the restaurant as soon as the food leaves its premises (see successful innovations in this field in [13]). Buffet leftover unfit for human consumption can be diverted to farms to be turned into animal feed. The animal feed needs to comply with food safety laws to prevent infecting animals with viruses such as Foot and Mouth. Diverting the remaining food waste to composting or energy from waste facilities is the next option for treating unavoidable food waste.	Buffet leftover
Lack of coordination between departments in restaurant	Improve communication between departments by regular meetings to resolve any conflicts and plan ahead for the daily schedule. In meetings the latest information should be shared amongst the departments, for example on the items and quantities of food supplies received, the cooking and food preparation schedule and menus, the reservations details including cancellations and last minute changes and feedback from customers and observations by the waiting staff for example which food items are always left on the plate, which buffet dishes need more or less frequent replenishment. Assign food waste prevention champions within each department. Align departmental performance criteria to resolve conflicts between the departments and have common targets [99]. Make food waste reduction one of these targets.	Preparation waste Buffet leftover
Inappropriate menu for eating occasion and sitting layout	In the cases of banquet facilities, train the reservations team to correctly advise the customer on the most appropriate menu for each sitting layout and type of function. Seek feedback from the waiting staff on the menus that work better with certain layouts and functions, based on their observations and customer feedback.	Preparation waste Buffet leftover Customer plate

Table 3. *Cont.*

Causes of Systematic Food Waste Generation	Food Waste Prevention Recommendations	Type of Food Waste Targeted by Recommendation
Aesthetic standards in the buffet and plate presentation	Avoid elaborate buffet and plate decoration designs where possible. Observe which items remain uneaten on the plates and eliminate them from the plate design. For example, garnishes that do not add flavour to the dishes could be eliminated without compromising the integrity of the dish. Reuse the decorative food items in other dishes. For instance, the watermelon cut into the shape of a flower to decorate the buffet, could be made into a smoothie or a juice to include as a special item for the next sitting.	Preparation waste Buffet leftover
Avoidable preparation food waste due to poor cutting skills	Train kitchen staff on cutting techniques. Observe and reward the best 'cutters' each month. Assign food waste prevention champions in the kitchen.	Preparation waste
The perceived value of food is linked to the price, for example, rice is cheap so it can be wasted (this is also relevant to food consumption practices - see Table 4)	Appoint food waste champions in the kitchen to highlight the importance of food waste prevention across all food groups, not only the expensive ones. Provide posters in the kitchen demonstrating good examples of food waste prevention and bad practices [100]. Provide training in cutting skills to reduce avoidable food waste especially of fruits and vegetables [101]. Update cooking equipment and improve cooking techniques to avoid instances whether rice is stuck at the bottom of the pan.	Preparation waste
	Avoid over production of rice, noodles and local fruits (all perceived less valuable due to their comparatively lower price) by reducing how much is prepared per customer in the buffet.	Buffet leftover

Table 4. Recommendations for food waste prevention targeting food consumption practices.

Causes of Food Waste Generation Related to Food Consumption Practices	Food Waste Prevention Recommendations	Type of Food Waste Targeted by Recommendation
Ordering too much food	Train waiting staff to correctly advice customers on the size and richness of the dishes. Offer smaller portions with the option to add more at no extra charge. Offer a range of dish sizes, such as small, regular, big and special sizes for children and side dishes [13,102]. Pack any leftovers and offer them as take away, as a standard practice unless customer instructs otherwise [11,103]. This measure should be accompanied by simple food safety instructions to the customer, such as 'consume within X hours and do not reheat', and a no liabilities clause for the restaurant for food that has left their premises.	Customer plate
Customer does not like a dish they ordered	Train waiting staff to explain the menu and ingredients to the customers, as well as give advice on which dishes complement each other.	Customer plate
Taking too much on plate in 'all you can eat' buffet	Reducing plate size has the potential to reduce food waste without compromising customer satisfaction [70]. Have restaurant staff stationed by the buffet to serve the food onto the customers' plates and explain the dishes and ingredients. Tray fewer systems have been proven to reduce plate waste especially in canteen settings [65].	Customer plate
Trying out all dishes in 'all you can eat' buffet	Offer the option for customers to taste the dishes as they go around the buffet before deciding whether they like it or not.	Customer plate
Customer's perceived value for money: quantity not quality	Altering the customer's perceptions of value is outside the control and remit of the restaurant. However, promoting the quality of the food rather than the quantity of the items on the buffet is one way of shifting the emphasis and attention of the customer. This can be done through the restaurant's marketing material for example by highlighting the culinary skills of the chefs, the uniqueness of the menu and the quality ingredients rather than just the number of the food items on the buffet. Use 'nudging' techniques to promote food waste reduction, such as displaying signs encouraging customers to come back to the buffet and help themselves more than one time, rather than take a lot of food on their plate all at once [70].	Preparation waste Buffet leftover Customer plate
The perceived value of food is linked to the price, for example, rice is cheap so it can be wasted (This is also relevant to the systematic food waste generation – see Table 3)	Display them in smaller serving dishes rather than in big containers. Reduce portion sizes for rice, noodles and local fruits in the *a la carte* service, but offer the option to add more at no extra charge. Place rice, noodles, and fruits at the end of the buffet line.	Buffet leftover Customer plate

5. Conclusions

This research's aim was to determine the patterns and causes of food waste generation in the hospitality and food service sector in Malaysia, in order to identify the most promising measures for food waste prevention. This aim was met by a) quantifying the biophysical and economic flows of food provisioning and waste generation, b) evaluating the social practices associated with food preparation and consumption, and c) linking the two (biophysical and economic flows, with social practices) in order to identify opportunities for food waste prevention.

A significant proportion of all food was wasted (16–28%) in the HaFS case studies presented in this paper, and almost half of it was avoidable (average avoidable food waste across all HaFS operations was 49% of total food waste). Food waste represented a substantial economic loss amounting to approximately 23% of the value of the food purchased. Preparation waste was the largest fraction, followed by buffet leftover and then customer plate waste, challenging the hypothesis that the consumer is to blame for the majority of the food waste. The restaurants' operating procedures and policies led to systematic food waste generation. Social practices related to food consumption were also identified as causes of food waste generation.

This paper provides new empirical evidence to highlight the significant opportunity and scope for food waste reduction in the HaFS sector. By identifying the causes of food waste, strategies for food waste prevention can be developed (for food waste prevention measures refer to Tables 3 and 4). Food waste prevention strategies should be twofold, tackling both the way the HaFS sector operates and organises itself and the customers' social practices related to food consumption. Food waste prevention measures targeting the systematic food waste production due to the restaurants' operations are within the restaurants' control, whereas changing social practices associated with food consumption is a more complex issue and requires a multifaceted approach. The main actor and implementer of these strategies should be the HaFS sector itself, as innovation and leadership in food waste prevention by the operators has the potential for significant cost savings. National policies and regulations can enable and reward food waste prevention. The HaFS associations can also provide support in the form of guidance, tools, and training.

Further research is required to expand on this study's findings in different contexts within the HaFS sector and to test the efficacy of the proposed food waste prevention measures. In this endeavour approaches, methods and tools from a variety of disciplines such as business, management, logistics, economics, environmental and waste management, sociology, phycology, behaviour studies, and sustainable consumption should be employed.

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