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WASTE STREAM ANALYSIS OF ALL-YOU-CAN-EAT BUFFET RESTAURANTS IN TOURIST HOTELS–THE STUDY OF THE INFLUENCE OF CURRENT RESTAURANT PRACTICES ON THEIR FOODSERVICE WASTE

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ABSTRACT: *This study is the first to study the waste stream of buffet restaurants in Taiwan. The daily food wastes generated, from three all-you–can-eat buffet restaurants, averaged from 304.43 to 565.09 kg with volumes ranging from 1.40 to 2.62 M^3. The guests were estimated to generate 449.71 to 928.84 g of waste per meal, which was much greater than the corresponding weight reported for other restaurant types. The theoretical food waste recovery rate of these restaurants was estimated to be higher than 70%. However, staff's failure in proper waste sorting and stacking observed during the study suggested a much lower waste recycling in actuality. It has demonstrated that the volume some foodservice waste could be reduced by 60 to 80% through stacking, while the weight of foodservice waste can be reduced by 50% when the waste is simply drained. In this study, interestingly found, the restaurant with open kitchen had the lowest buffet-counter food waste. Managerial implications to the restaurant operators are also suggested.*

KEYWORDS: All-You-Can-Eat Buffet Restaurants, Foodservice Waste, Turnover Rate, Open Kitchen, Theoretical Recovery Rate

INTRODUCTION

Due to rapid social and economic growth as well as family demographic changes and trends in increased female employment, household meal-preparation times have decreased, whereas the frequency of dining out has greatly increased (Klein et al., 2008; Li, 2005; National Restaurant Association, 2011; Directorate-General of Budget, Accounting and Statistics, 2011). Therefore, in the highly competitive foodservice business, the players in the industry must consider to ensure its sustainability to satisfy consumers by providing a wide variety of choices of food and service (Chiou, 2006).

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However, the growth of foodservice market and the diversified foodservice operations have also created problems related to food wastage. The waste generated from foodservice operations has increased over time and along with the food wastes from supermarkets and the kitchens of families, food waste has become an increasingly serious global problem (Food and Agriculture Organization of the United Nations, 2011; Pittman, 2010; Stuart, 2009). It is argued that, with the growth of foodservice industry, which contributed by the increasing domestic and international tourist activities around the world, would put the detriment to the already serious food wastes and related problems(Directorate-General of Budget, Accounting and Statistics, 2011; Klein et al., 2008; National Restaurant Association, 2011).

Among the numerous types of restaurants exist, all-you-can-eat buffets are favored by consumers because of its high-liberty of choice, multiple food selections, and unlimited supply of foods. However, the consumption with this approach also associated with increased food waste (Ai, 2001; Chiou, 2006; Just & Wansink, 2008; Lam, 2010). Researchers have observed that the buffet dining not only involves excessive food consumption and may therefore increase risks of excess weight gained and obesity (Chen, 2008a; Sarjahani, Serrano and Johnson, 2009). Even more, it also increases the possibility that food will go uneaten because restaurateurs must prepare a higher amount of food and because consumers might adopt the mentality of attempting to ‘‘feast’’ to recover their dining costs (Just & Wansink, 2008). This food leftovers and overeating associated with buffet produces food wastes that not only increase operating costs and waste fees but also negatively impact the environment (Chen, 2008b).

Recent studies of all-you-can-eat buffets have focused on eating behaviors and nutritional intake, whereas few investigations have explored the issue of foodservice waste. To address this issue, this study examined the operational effectiveness of the all-you-can-eat buffets at selected international tourist hotels and analyzed the foodservice wastes of these hotels to understand the current status of these establishments. In addition, this study explored how the ways in which restaurants provide meals and dispose of food waste affect foodservice-waste volumes. It is hoped that in addition to compensating for the current scarcity of academic research regarding this topic, the results of this study will not only provide recommendations regarding the services, waste disposal, and overall supply-chain management of foodservice enterprises but also prove useful as a reference for the development of relevant

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regulations by government and the exploration of foodservice waste-related issues. Therefore, the objectives of this study are as follows:

1. Understand the current foodservice-waste situations of all-you-can-eat buffets at international tourist hotels.
2. Explore the impact of the practices of all-you-can-eat buffet restaurants at international tourist hotels (methods of food provision and waste disposal) on foodservice-waste volumes.
3. Suggest plans and methods of reducing the foodservice waste and improving the recycling efficiency of all-you-can-eat buffets.

LITERATURE REVIEW

Foodservice waste

Studies have indicated that the final destination of various foods from supermarkets, hotels, small restaurants, and the kitchens of ordinary individuals is often the trash can rather than people's stomachs; in fact, food waste has become an increasingly serious global problem (Food and Agriculture Organization of the United Nations, 2011; Pittman, 2010; Stuart, 2009). It is observed that, in addition to excess household food purchases, ignorance of food shelf-life, poor storage facilities, the preparation of too much food, the overproducing, poor inventory management and fluctuation in sales all contribute to commercial food loss. Consumers also play a role in retail operation's waste (Kallbekken & Sælen, 2013; WRAP, 2007).

Besides, foodservice waste is also caused by an increase in the proportion of meals that are obtained through eating out. The United Nations Environment Program (2009) reported that more than half of the food at restaurants was wasted or discarded. In addition to the expense caused by discarded food, restaurateurs and governments must spend a great deal of money to dispose of this foodservice waste. In Europe, for example, more than 60,000 meals are discarded every year, resulting in a loss of 125 million euro. In Britain, restaurateurs and governments spend £722 million each year to dispose of 40,000 to 60,000 tons of restaurant-created food waste (Unilever Food Solutions, 2011). In the United States, consumers are accustomed to large meal portions marketed by the restaurants while they may not be able to consume these large portions, causing a great deal of food waste. It is estimated that 48 million tons of food are wasted every year in the United States (Green Business Bureau, 2011).

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In Taiwan, up to 30% of meals are eaten outside of home, and the problem of food waste at restaurants is very serious. Chen (2008b) found that on average, each restaurant spends approximately $51,000 each year purchasing food ingredients, and food waste accounts for 6.8% of this total purchase amount in Taiwan. It is argued that, with the growth of foodservice industry, which contributed by the increasing domestic and international tourist activities around the world (Directorate-General of Budget, Accounting and Statistics, 2011; Klein et al., 2008; National Restaurant Association, 2011), would put the detriment to the already serious food wastes and related problems.

All-you-can-eat buffet restaurant

Among various dining-out choices, all-you-can-eat buffet has being the popular approach for restaurateurs and patrons (Gao, 1995; Ma et al., 2005; National Restaurant Association, 2011). An all-you-can-eat buffet is a type of meal service in which the available dishes are placed on display in public areas accessible to consumers and directly obtained by the customers themselves. The customers are permitted to eat in accordance with their choices and satisfaction (Gao, 1995). Buffets have a rather long history in the United States as well as other countries, which features an enormous market for foodservice business. In 2007, the total turnover of all the types of buffet restaurants in the United States reached $550 million (National Restaurant Association, 2011). In Taiwan, the development of buffets can be traced back to the adoption of "all-you-can-eat" buffets by a number of international tourist hotels in the 1980s, which had a great impact on Taiwanese foodservice operations. Nowadays, virtually all hotels provide buffets as a strategy to gain market shares. Because of the customer-self-serve practice, all-you-can-eat buffet has become a popular foodservice approach nowadays whereas the labor cost is high. It allows a large number of customers to be served with minimal labor power (Ma et al., 2005).

Due to the nature and serving practices of all-you-can-eat buffet, it is under the impression that all-you-can-eat buffets has being associated with issues related to over-consumption, unbalanced diet and food waste. Researchers revealed that buffet at many school dining establishments have significant problems with food wasting (Kallbekken & Sælen, 2013; Lam, 2010; Sarjahani et al., 2009). They found that students left more food on their plates at buffets than other foodservice establishments. In addition, Just and Wansink (2008) indicated that higher buffet prices were correlated with more serious over-consumption and waste problems. They indicated that when compared

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with consumers who paid half of the regular price for buffet, consumers who paid the regular price consumed nearly 30% more food.

However, most studies regarding buffets still focused on the eating behaviors of buffet consumers (Lam, 2010; Sarjahani et al., 2009; Chiou, 2006; Just & Wansink, 2008; Ai, 2001; Su, 2000) and the explorations of consumers' food consumption volume and nutritional needs (Giannopoulos, 2007; Garrido et al., 2007; Lassen et al., 2006; Wadden et al., 2002). Few investigations have examined foodservice wastes in buffet restaurants.

Food waste generation and prevention in the foodservice industry

Given the current wave of carbon footprint-reduction initiatives, green operations have become an objective that foodservice firms are actively working to achieve. Public and private sectors have being studying and promoting the treatment options and standards for foodservice waste. Government agencies have largely focused on reducing the waste output of the foodservice industry and emphasized the concepts of recycling and reuse in various aspects of restaurants (California Integrated Waste Management Board, 1992; Chou et al., 2011; Environmental Protection Administration, 2008; King County Solid Waste Division, 1996). It is found that reducing food waste also represents a financial saving to the hotels, estimated at around USD 9/kg by one of the hotel. It indicates that 1 kg of food waste is responsible for lifecycle emissions of around 1.9 kg of CO_2e (ETAP, 2007).

In academic research, studies have concentrated on the analyses of the environmental impacts of restaurant activities (Davies & Konisky, 2000), issues related to green restaurants (Hu et al., 2010), and assessments of innovative restaurant waste-disposal models (Burka, 2000; Canakci, 2007; Goldstein, 2007).Many studies have discussed the reduction and disposal of foodservice waste (Davies & Konisky, 2000; Burka, 2000; Engler & Harding, 1999; Shanklin & Ferris, 1995; Kim et al., 1997; Hackes et al., 1997; Dilly & Shanklin, 1999; Kim & Shanklin, 1999; Wie et al., 2003). Studies addressed the reduction of discarded food have been all-inclusive, providing various recommendations for stages ranging from food purchase to preparation and the processing of food waste (Hu et al., 2010). These recommendations include the establishment of a food inventory list when conducting food purchases, the introduction of the concept of a food bank, and the conversion of waste into animal feed (Stuart, 2009). In practice, restaurant-chain operators have reported that 7,500 gallons of

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cooking oil can be recycled each month as the raw materials of biodiesel (Goldstein, 2007). Canakci (2007) indicated that with the increase in the proportions of local fruits and vegetables that restaurants purchase and thorough classification of garbage, up to86% of restaurant waste can be recovered and transformed into compost.

In addition, foodservice firms have independently promoted waste reduction and recycling activities. For example, international restaurant brands, such as Starbucks and McDonald's, have promoted plans to reduce waste and have developed waste-treatment plans involving the reduction, recycling, reuse, and composting of food wastes (Starbucks, 2016; McDonald's, 2016). Hu et al. (2010) suggested that restaurant that initiate sustainable practices, such as energy and water conservation, recycling, and environmentally friendly waste-management, would distinguish themselves from other restaurants and attract customers who patronize a green restaurant (Hu et al., 2010; Yesawich, 2009).

The impact of types of foodservice and meal-providing approaches on foodservice waste

Recent studies have explored how foodservice-waste contents and quantities are affected by various operational variables of foodservice firms, which the variables include business models (Ai, 2001; Su, 2000), types of meal-providing (Dilly & Shanklin, 1999; Giannopoulos, 2007; Hackes et al., 1997; Kim & Shanklin, 1999; Kim et al., 1997; Sarjahani et al., 2009; Shanklin & Ferris, 1995), the types of foodservice and prices of meals that are provided (Chiou, 2006; Just & Wansink, 2008; Lam, 2010; Lin et al., 2013).

Researchers at Kansas State University have investigated the waste produced by different types of foodservice establishments (ex. school cafeterias, commercial restaurants, hospital canteens, central kitchens, and nursing-home cafeterias). They provided the model of descriptive analyses for foodservice waste and established appropriate measurement (Dilly & Shanklin, 1999; Hackes et al., 1997; Kim et al., 1997; Shanklin & Ferris, 1995). Hackes et al. (1997) found that in nursing homes, the use of a tray service for meals generated greater waste than the use of table service or buffet approaches. Researchers also suggested that the reduction of food portions and sizes can reduce the foodservice waste generated in nursing homes. Thiagarajah and Getty (2013) observed a significant decrease in solid waste per person (0.81 oz) in switching from the tray (4.39) to the trayless system (3.58 oz).

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Dilly and Shanklin (1999) analyzed waste in U.S. military-hospital canteens and found that factors such as food procurement, food quality, type of food packaging, and the provision of disposable packaging material could affect the volume of waste produced in this context. Kallbekken and Sælen (2013) on the other hand demonstrated that by reducing plate size and communicating to the consumers the social cues using printed messages, the restaurants can reduce the amount of food waste to hotel restaurants by around 20%. Whitehair, Shanklin, and Brannon (2013) observed a 15% decrease in food waste after posting the prompt-type message in the university canteen. It indicates that exposure to the simple message of reminding food waste triggered an increased awareness of food waste that influenced the students' food waste behavior.

In addition, Lin et al. (2013) analyzed the waste from three different restaurant chains in Taiwan and found that beef-noodle restaurants produced the highest weight and total volume of waste per meal, while coffee stores produced the largest un-stacked volume of foodservice waste. Lin et al.(2013) observed that none of the examined restaurants properly sorted and stacked their foodservice waste, resulting in an increase in the volume of foodservice waste and unnecessary resource expenditures.
Researchers have also calculated the theoretical recovery rates for the foodservice wastes of different foodservice businesses (Aarnio & Hamalainen, 2008; Lin et al., 2013). These data can served as a reference for governments and foodservice administrators in the implementation and supervision of foodservice waste-disposal procedures. Aarnio and Hamalainen (2008) observed that, for the waste generated from fast food restaurants in Europe, the theoretical recovery rate of the wastes was 93%. However, only 29% of the waste was actually recovered, with the remaining 64% of recoverable waste buried in landfills. Lin et al. (2013) studied the foodservice waste of coffee store, western fast food and Chinese beef noodle restaurant chains in Taiwan and obtained the waste recovery rate of 97.49%, 93.9%, and 83.39%, respectively.

Currently, it is becoming popular to adopt an open kitchen design for preparing meals in restaurants. Alonso and O'Nell (2010) indicated the restaurant considers the open kitchen as a unique selling proposition. They suggested that the open-kitchen concept provides not only entertainment in the form of the display of cooks at work but also a way for consumers to see firsthand how the food is handed. Researchers also found that restaurant operators view the open-kitchen concept as overall conductive to better hygiene and to positive behavior among kitchen employees, who might feel observed

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by consumers (Chow et al., 2010). However, no research has examined the impact of an open kitchen layout on chef's performance as well as consumer dining behavior.

METHODS

Research subjects and timeline

In this study, all-you-can-eat buffets restaurant at tourist hotels were examined to investigate the foodservice waste generated at the restaurants and the factors that influence the amount of the waste generated. Three examined buffet restaurants were located in Taipei and Taoyuan City in Taiwan. Two of these restaurants are at five-star international tourist hotels, and the third one was operated by a local brand tourist hotel. The pricing, number of seats, and type of kitchen for these buffet restaurants are described in Table 1. Hotel B restaurant has higher prices and considered expensive as compared to the other two. The data were collected from April 2012 to June 2012; in total, 14 days of foodservice waste data were collected and analyzed for each restaurant.

Table 1- Information of the all-you-can-eat buffet in three research target hotels.

Hotel	A	B	C
Grade	Five-star International Tourist Hotel	Five-star International Tourist Hotel	Tourist Hotel
Location	Taoyuan City	Taipei City	Taipei City
Price (USD/person)	Breakfast Weekday 18.33 Weekend 18.33 Lunch Weekday 18.33 Weekend 18.33 Dinner Weekday 25 Weekend 25	Breakfast Weekday 26 Weekend 26 Lunch Weekday 46.33 Weekend 46.33 Afternoon tea Weekday 26.33 Weekend 26.33 Dinner Weekday 46.33 Weekend 46.33	Breakfast Weekday 16.67 Weekend 16.67 Lunch Weekday 23.30 Weekend 30.00 Afternoon tea Weekday16 Weekend 19.33 Dinner Weekday 23.3 Weekend30
Seating	212 seats	230 seats	120 seats
Kitchen style	Closed	Open	Closed

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Research tools

This study collected foodservice-waste data for the examined restaurants at different operation periods (including weekdays and weekends , day-parts: breakfast, lunch, afternoon tea, and dinner) and different locations (the food-preparation areas and the dining area, with waste including the food left on service counter which were not taken by customers; and the leftovers, dirty napkins, and other garbage from dining table). Researchers collected foodservice waste at the aforementioned times and locations for each observation day, classified the waste and measured the weight and volume of this waste, and recorded the number of consumers present at each examined daypart for each observation day. The weights and volumes of different types of foodservice waste at the restaurants (including stacked and un-stacked volumes) were measured using the approaches adopted by Kim et al. (1997) and Chan & Lam (2001). The collected foodservice wastes were categorized based on the waste-classification standards specified by the Environmental Protection Administration (2009), which the examined wastes into the six categories of paper, plastic, metal, food, glass, and general waste.

In this study, the comparisons and discussions among the foodservice waste generated at different restaurants were based on "waste per meal" (calculated by dividing the measured weight or volume of waste on a day by the number of customer on that day) to exclude the effects of non-operating factors. The "theoretical recovery rate" of foodservice waste at three buffet restaurants was also determined. Among the sorted foodservice wastes, only general waste needed to be incinerated or buried, whereas foodservice waste from the remaining five categories could be recycled. Therefore, the theoretical recovery rate can be obtained as the ratio of the weight of waste from these five categories of recyclable waste to the total weight of waste (Aarnio & Hamalainen, 2008).

Data analysis

The collected data were analyzed with the SPSS 18.0 for Windows software package, using the following statistical methods. Frequency distributions and percentages of test samples were used to depict the relationships between operating variables of the different restaurants (such as the business day, day parts, and dining area) and aspects of the food waste of these restaurants (such as the daily weight of waste, waste per meal, counter food waste, and guest waste at dining tables). The analysis of variance (ANOVA) approach was employed to explore the differences in waste per meal related to different operating variables, using Scheffe's test to verify the obtained results. In

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addition, regression analysis and Pearson correlation analysis were conducted to examine the relationships among the total weight of foodservice waste per day, the weight of foodservice waste per meal, and the two operating indicators of the number of customers and table turnover of the three hotel buffets.

RESULTS AND DISCUSSION

Descriptions of the foodservice wastes of all-you-can-eat buffet restaurants

This study collected foodservice waste from different areas of the restaurants for analysis, and the results revealed that the wastes from the three examined restaurants were similar in content (Table 2). The kitchen of the restaurant included the areas for the raw material-preparation and cooking; and waste generated in this area included all types of packaging materials, containers of raw materials, and cleaning supplies as well as the raw and cooked food waste generated from the preparation of raw materials. The dining areas of the examined buffets were the areas where customers obtained and consumed food; the waste in this area included beverage and condiment packaging, the gas and alcohol containers used to warm food, and unconsumed food, dirty napkins, and food on the buffet counter that was not taken by customers.

Table 2、The wastes description of all-you-can-eat buffet restaurants.

Type of waste	Location	
	Kitchen	Dining area
Papers	Cardboards(ex. wine, beer, alcohol, shrimps, fruits), containers(ex. milk, tea, oat meal, butter, seasonings)	coaster for dish and cup, sugar packets
Plastics	Containers(ex. soybean milk, juices, soy sauces, salad oil, seasonings, ready-to-eat desserts), and cleaners bottles.	Fork, portion butter container, PET bottle for drinks
Metal	Containers for raw materials (ex. tomato paste, olive, corn kernel, etc)	Containers for gas, and drinks
Food waste	Fruit and vegetable peels, left-over from meat preparation, materials for preparing stock	Unfinished food or residues on plates, unattended foods from display counter
Glass	Containers(ex. sauce, jam, cured vegetables)	Water, beer and wine bottles
General	Tainted packaging materials, film and	Tainted tissues

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waste	Styrofoam container	

The results revealed that the all-you-can-eat buffet restaurant of hotel A produced an average of 304.43 kg of foodservice waste each day, which occupied an unstacked volume of 1.41 m^3. The one of hotel B produced an average 565.09 kg of foodservice waste each day, the greatest average daily weight of waste among the examined restaurants; this waste occupied an unstacked volume of 2.26 m^3. The restaurant of hotel C produced an average of 482.07 kg of foodservice waste each day, which occupied an unstacked volume of 2.62 m^3. An examination of the waste weight generated in the dining and kitchen areas revealed that, for the hotel C buffet, the waste from the dining areas accounted for 64% of the total weight of food service waste; this number was higher than the corresponding percentage for the other two examined restaurants (51% and 53%). However, the unstacked volume and stacked volume of the waste generated in the kitchen area were larger than the ones generated in the dining area for all three restaurants (Table 3). The foodservice wastes produced in the kitchen areas were mainly composed of waste packaging material and vegetable-peel and residues generated during the preparation of meals from raw materials, whereas the foodservice wastes from the dining areas were mainly composed of tainted tissues and leftover food, which were smaller in volume as compared to the wastes from the kitchen areas. However, the wastes from dining area had higher average weight than those from kitchen area, mainly because of the high water content in consumer's leftovers.

Table 3 - The weight and volume analysis of the waste in three all-you-can-eat buffet restaurants.

Hotel	A		B		C	
Location	Kitchen	Dining Area	Kitchen	Dining Area	Kitchen	Dining Area
Weight per day(kg)	148.1(49%)	156.3(51%)	265.8(47%)	299.3(53%)	175.3(36%)	306.8(64%)
	304.43		565.08		482.07	
Unstacked volume (M^3/ day)	1.1(73%)	0.38(27%)	1.56(69%)	0.7(31%)	1.59(61%)	1.03(39%)
	1.41		2.26		2.62	
Stacked volume (M^3/ day)	0.97(72%)	0.38(28%)	1.14(66%)	0.6(34%)	1.03 (50%)	1.02(50%)
	1.35		1.74		2.05	

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Customer count/day	677	812	519
Weight per meal (g)	449.71	696.41	928.84
Volume (cm^3/meal)			
Unfolded	2075.64	2793.74	4202.86
Folded	1982.78	2271.00	3110.20

The analysis of waste per meal indicated that at each meal, the restaurant of hotel A served an average of 677 consumers per day and produced 449.71 g of waste per meal, which occupied 2,075.64 cm^3 and 1,982.78 cm^3 of unstacked and stacked volume, respectively. The restaurant of hotel B served an average of 812 consumers per day and produced 696.41 g of waste per meal, which occupied 2,793.74 cm^3 and 2,271.00 cm^3 of unstacked and stacked volume, respectively. For hotel C, the restaurant served the lowest average number of consumers among three examined buffets (519/day) and produced 928.84 g of waste per meal, which occupied 4,202.86 cm^3 and 3,110.20 cm^3 of unstacked and stacked volume, respectively; these numbers were the highest among three restaurants (Table 3).

Scholars studied foodservice waste from different channels and found that university restaurants produced average of 232 g waste per meal, which occupied an unstacked volume of 2,500 cm^3; restaurant at senior care centers produced 450 g of waste per meal, which occupied an unstacked volume of 4,310 cm^3; and military hospital canteens produced 560 g of waste per meal, which occupied an unstacked volume of 5800 cm^3 (Dilly & Shanklin, 1999; Hackes et al., 1997; Shanklin & Ferris, 1995). In this study, the examined restaurants of hotels A and B produced similar weights but significantly lower volumes of waste per meal relative to these care centers and military hospitals. In contrast, the one at hotel C produced far greater weight of waste per meal than the aforementioned foodservice providers in the States.

In addition, the waste per meal produced by the examined restaurants was much greater than those from the chain coffee store, fast-food restaurants, and beef-noodle restaurants in Taiwan (Lin et al., 2013). Researchers observed that the quantities of leftovers on plates and the food waste are higher at buffet restaurants than at a la carte

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restaurants (Ai, 2001; Chiou, 2006; Just & Wansink, 2008; Lam, 2010; Sarjahani, 2009; Su, 2000).

Analysis of the types of foodservice wastes at the restaurants

In this study, the foodservice wastes from all-you-can-eat buffet restaurants were categorized into six different types, and significant differences in the volumes and weights were found among these different types of wastes (Table 4). Among these wastes, food wastes produced the greatest weight of wastes, accounting for 60-80% of the total waste weight, followed by general waste (16%-29%). With respect to waste volume, general waste accounted for the greatest volume of waste for all three restaurants (36-53%). It was followed by food waste for hotel A and B. For hotel C, paper wastes accounted for the second-largest quantities of waste (24.12%).

Among the six categories of waste, paper, plastic, metal, glass, and food waste could be recycled. Therefore, the calculated theoretical recovery rates for foodservice waste from the restaurants of hotels A, B, and C were 83.37%, 71.51%, and 71.15%, respectively. It indicated that 70-80% of the wastes from these buffets could be recycled and/or reused, whereas only 20-30% of the waste (the general waste) required burial or incineration. The difference in the theoretical recovery rate among three restaurants can be explained mainly by the different types and quantity of packages for food materials and different approaches of waste treatment by the staffs from the restaurants. It was observed during the study that, in the restaurant of hotel A, the food waste contained more water and fewer quantity of Styrofoam box were discarded, and consequently, the restaurant of hotel A had the highest theoretical recovery rate of the examined buffets.

Table 4– The weight and volume analysis of different types of foodservice waste in the restaurants.

Hotel		A		B		C	
Weight (kg)	Paper	3.39	1.16%	15.51	2.73%	17.15	4.63%
	Plastics	3.77	1.29%	4.77	0.84%	2.59	0.70%
	Metal	2.80	0.96%	5.51	0.97%	4.22	1.14%
	Food waste	232.18	79.48%	349.81	61.59%	237.63	64.15%
	Glass	1.37	0.47%	1.82	0.32%	1.85	0.50%
	General	48.58	16.63%	161.81	28.49%	106.87	28.85%
	Sum	292.13	100%	567.96	100%	370.43	100%
Unstacked Volume	Paper	0.09	6.60%	0.51	22.36%	0.63	24.14%
	Plastics	0.07	4.65%	0.14	6.14%	0.04	1.57%

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(m^3)	Metal	0.02	1.52%	0.07	3.12%	0.06	2.29%
	Food waste	0.48	33.91%	0.71	31.36%	0.57	21.86%
	Glass	0.00	0.25%	0.01	0.27%	0.00	0.14%
	General	0.75	53.07%	0.83	36.75%	1.31	50.00%
	Sum	1.41	100%	2.26	100%	2.62	100%
Stacked Volume (m^3)	Paper	0.04	2.86%	0.13	7.20%	0.10	4.92%
	Plastics	0.04	3.33%	0.12	6.82%	0.04	2.08%
	Metal	0.02	1.58%	0.04	2.44%	0.06	3.03%
	Food waste	0.48	35.85%	0.67	38.31%	0.59	28.79%
	Glass	0.00	0.26%	0.01	0.33%	0.00	0.19%
	General	0.76	56.12%	0.78	44.89%	1.25	60.98%
	Sum	1.35	100%	1.74	100%	2.05	100%
Theoretical recovery rate		83.37%		71.51%		71.15%	

The theoretical recovery rates for foodservice waste from all-you-can-eat buffet restaurants were lower than the corresponding rates for other types of foodservice operations (Aarnio & Hamalainen, 2008; Lin et al., 2013). In this study, on-site observations revealed that the chefs and service personnel in kitchen and dining areas of the restaurants did not thoroughly sort foodservice waste, resulting in mixtures of resource-specific waste and general waste. Other studies have reported similar observations, and researchers have noted that most customers and restaurant staffs do not sort or stack waste properly, and therefore fail to reduce the quantity and volume of the waste (Aarnio & Hamalainen, 2008; Lin et al., 2013).

An analysis of stacking benefits for the foodservice waste and restaurants

Among the various types of foodservice waste generated at the three examined restaurants, paper, plastic, and metal waste could be pressed and stacked. The paper waste was mainly composed of raw-material wrapping paper and containers. The plastic waste was mainly composed of plastic containers for raw materials and cleaning supplies, the plastic forks, wrappers of cream packets, and beverage bottles used in the dining areas of the buffets. The metal waste was mainly composed of the containers for raw materials and the beverage. Table 5 indicates the changes in the volumes of paper, plastic, and metal waste before and after stacking at the three examined restaurants, indicating that the volume of paper waste could be reduced by 59-85% through stacking. If all waste was stacked appropriately, the cumulative daily waste volume could be reduced by 0.5 m^3, a considerable contribution in post waste treatment.

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Table 5 – The effect of folding on the volume of the waste in three all-you-can-eat buffet restaurants.

Hotel	Type of waste	Unfolded volume (m^3)	Folded volume (m^3)	Volume reduced (m^3)	Volume reduced (%)
A	Papers	0.093	0.039	0.054	58.51
	Plastics	0.066	0.045	0.021	31.43
	Metal	0.021	0.021	0.000	0.48
B	Papers	0.505	0.125	0.380	75.21
	Plastics	0.139	0.119	0.020	14.48
	Metal	0.071	0.042	0.028	39.79
C	Papers	0.632	0.101	0.532	84.05
	Plastics	0.041	0.040	0.001	2.76
	Metal	0.061	0.060	0.001	0.83

The volume-reduced waste also resulted in decreasing the use of trash bags and reducing the subsequent energy consumption incurred during waste storage and transportation. Other researchers also indicated the same findings and provided similar recommendations (Aarnio & Hamalainen, 2008; Chang, 2009; Dilly & Shanklin, 1999; Hu., et al., 2010; Kim et al., 1997; Whitehair et al., 2013). However, as researcher observed on-site, the staffs at the examined restaurants did not appropriately stack their wastes and therefore failed to effectively reduce waste volume.

Analysis of the weight of food waste from dining areas, before and after water draining

The water content of the food waste from dining area was found relatively high during data collection. These food wastes were mainly leftover dishes, and beverages from customers and the remaining food at the buffet counter that was not obtained by customers. These leftovers were dumped directly into trash cans. In this study, it was found that the weight of the food waste from the dining areas could be reduced by 50% after it was drained (Table 6). This simple draining can reduce daily waste by approximately 32-80 kg for each of the three examined restaurants, which would not only improve the operational efficiency but also reduce resource expenditures during subsequent waste disposal (ex. containers, freezer space, and transportation costs).

Table 6 - The analysis of the full weight, drained weight of the food waste collected

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from dining area in three all-you-can-eat buffet restaurants.

Hotel	Day part	Full weight (kg)	Drained Weight (kg)	Water removal rate (%)
A	Breakfast	27.27	10.76	61%
	Lunch	13.82	6.75	51%
	Dinner	16.96	7.81	54%
	Average	58.05	25.32	56%
B	Breakfast	18.57	9.25	50%
	Lunch	63.25	30.39	52%
	Afternoon Tea	23.43	11.72	50%
	Dinner	48.95	25.28	48%
	Average	154.21	76.94	50%
C	Breakfast	65.93	31.65	52%
	Lunch	20.83	10.83	48%
	Afternoon Tea	31.13	18.06	42%
	Dinner	44.02	21.13	52%
	Average	161.91	81.66	50%

Analysis of the weight of the food waste from guest leftovers and buffet-counter leftovers

This study also examined customers' uneaten beverage and food residues on plates (referred to as guest leftovers) and food left on the buffet counter that had to be discarded (referred to as buffet-counter leftovers) to understand the relationships among restaurant operations, sources of food waste, and overall foodservice waste. Table 7 is the results for the weight of guest leftovers and buffet-counter leftovers collected at each meal period for these restaurants. The weight of guest leftovers was higher than that of buffet-counter leftovers for all three of the restaurants ($p<0.001$), which was related to the fact that guest leftovers contained higher water content than buffet-counter leftovers. The weight of both guest leftovers (307.37g/meal) and buffet-counter leftovers (140.40g/meal) at the hotel C restaurant were significantly higher than the corresponding quantities for the hotel A (132.88g/meal and 92.66g/meal, respectively) and the hotel B (183.64g/meal and 72.51g/meal, respectively) ($p<0.001$). Among the weight of buffet-counter leftovers, hotel B buffet was found the lowest among three restaurants.

Table 7 - The analysis of food waste collected from counter and guest at different dayparts in the restaurants.

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Hotel	Daypart	TC/TOR*	Food waste/meal(g)		C/D**	C/T**
			Counter	Guest		
A	BK	401[b]/1.89	51.15	84.62	36.41%	23.51%
	LUN	146[a]/0.69	103.73	121.84	31.73%	15.39%
	DIN	130[a]/0.61	123.02	192.19	30.34%	14.65%
	Average	677[b]	**92.66[1a]*** **	**132.88[2a]**	**31.84%**	16.06%
B	BK	175[a]/0.76	108.05	111.11	30.51%	15.95%
	LUN	224[b]/0.97	30.81	282.16	6.96%	4.15%
	AT	184[a]/0.80	62.21	129.30	23.71%	9.71%
	DIN	230[c]/1.00	88.99	211.99	21.28%	11.68%
	Average	812[c]	**72.51[1a]**	**183.64[2a]**	**19.63%**	10.28%
C	BK	299[c]/2.49	78.06	222.97	20.35%	13.95%
	LUN	53[a]/0.44	373.89	378.20	33.06%	16.91%
	AT	107[b]/0.89	163.56	363.41	31.74%	19.40%
	DIN	61[a]/0.51	376.14	890.98	23.38%	16.04%
	Average	519[a]	**140.40[1b]**	**307.37[2b]**	**24.78%**	15.62%

*TC: Ticket count/customer count; TOR: Turnover rate.

**C/D and C/T: the ratio of the weight of buffet counter leftover to the weight of foodservice waste.

***The values in the line with the same number have no significant difference, and the values in the columns with the same letter have no significant difference.

Foodservice waste collected at different meal periods revealed that for the hotel B restaurant, breakfast (108.05g) resulted in higher buffet counter leftover than the other three day parts, quite contrary to the other two restaurants. However, B had significant lower weight of buffet-counter leftovers from lunch, afternoon tea, and dinner than those weights of the corresponding times at the other two restaurants. It is suggested that the weight of buffet-counter leftovers was related to the number of consumers (TC)/turnover rate (TOR) of the restaurant at different dayparts.

Further comparisons revealed that for the hotel B restaurant, the weight of buffet-counter leftovers was 19.63% of the waste weight of the dining areas (C/D) and 10.28% of the total foodservice waste weight (C/T), which were significantly lower than the corresponding percentages for the restaurants at hotel A (31.84% and 16.06%, respectively) and hotel C (24.78% and15.62%, respectively) (Table 8). Less amount of waste from buffet-counter indicated that less uneaten food from the buffet counter was

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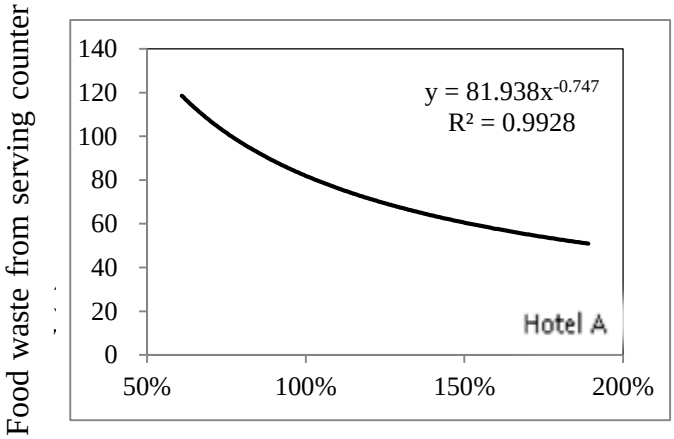
discarded. The restaurant at hotel B was the only restaurant with open style kitchen among the examined hotels, therefore, it's speculated that the open kitchen operation might provide easy-to-estimate dishes preparation for the chefs and help reducing the amount of the left-oven on the counter.

In this study, the perspective was brought to discussion that in addition to guest leftovers on plates, the food which was discarded because of not being obtained by customers from the buffet counter (buffet-counter leftovers) can be an important indicator of the efficiency of the operation of the restaurants. Therefore, to understand the influence of the kitchen practices and turnover rate of buffet restaurant on foodservice waste, a regression analysis was conducted on the weight of buffet-counter leftovers and the turnover rates of the three restaurants (Figure 1). It's found that a strong relationship (r^2>0.97) existed between the weight of buffet-counter leftovers and the turnover rate at the hotel A and C restaurants; the weight of buffet-counter leftovers decreased as the turnover rate increased, gradually reaching a stable level.

For the hotel B restaurant, which was different from other two, a quadratic relationship (r^2=0.91) was found between the weight of buffet-counter leftovers and turnover rate. The weight of buffet-counter leftovers was predicted to hit the lowest point at a turnover rate of approximately 90%. We speculated that the relatively consistent and stable turnover rate along the dayparts of restaurant B (75-100%), as compared to restaurant A (60-190%) and C (50-250%), and the open-style kitchen at restaurant B could help minimizing the buffet-counter leftovers.



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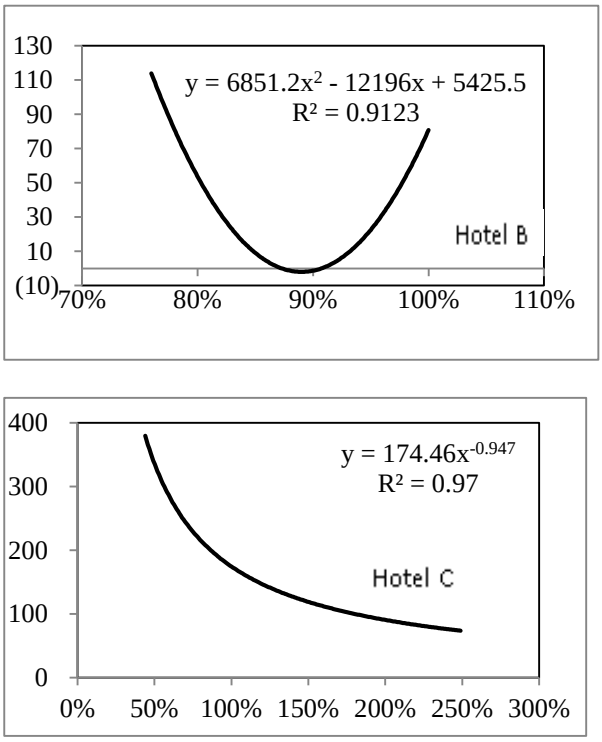

Figure 1- The relationship between food waste collected from buffet counter and customer turnover rate.

In addition, results from the correlations analysis between the total daily foodservice-waste weight and the per-meal foodservice-waste weight with the number of customers/turnover rate of the three restaurants indicated that, for hotel A and C, the waste weight per meal was significantly negatively correlated with the number of customers and turnover rate ($r<-0.69$; $p<0.001$). This finding suggested that higher numbers of customers (i.e., higher turnover rates) were associated with lower weights of foodservice waste per meal. However, this correlation was not significant for the hotel B buffet (Table 8).

Table 8 – The relationship among waste per day, customer count, waste per meal, and turnover rate in three restaurants.

Hotel	Variable	Waste per day	Customer count	Waste per meal	Turn over Rate
A n=30	Waste per day	1			
	Customer count	0.014	1		

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	Waste per meal	0.500***	-0.777***	1	
	Turnover rate	0.015	1	-0.776***	1
B n=56	Waste per day	1			
	Customer count	0.542***	1		
	Waste per meal	0.816***	-0.020	1	
	Turnover rate	0.541***	1	-0.021	1
C n=56	Waste per day	1			
	Customer count	0.675**	1		
	Waste per meal	-0.218	-0.697***	1	
	Turnover rate	0.675**	1	-0.697**	1

Note: two-tailed test; * $p<0.05$；** $p<0.01$；*** $p<0.001$

From the study, it revealed that a consistent turnover rate along dayparts of the restaurant could help optimizing estimates of the quantities of raw materials to prepare in the kitchen. It is also speculated that the open style kitchen adopted by hotel B buffet, a practice that was not approached in hotel A and C restaurants, allowing the chefs to directly observe customers' food consumption on site and then determine how much quantity of food for further preparation, thereby minimizing buffet-counter leftovers. In hotel A and C restaurants, the weight of buffet-counter leftovers decreased as the turnover rate increased, suggesting that the chefs of these restaurants had less control of the amount of food-preparation as compared to the chefs at restaurant B; thus, passively depended on the increase in the number of customers to decrease foodservice waste.

Researchers suggested that customers who ate at high-priced buffets would tend to over-consume food due to the tendency to compensate the money they spent on the meal (Just & Wansink, 2008). Among the three examined buffets, hotel B buffet has the highest prices ($26 for breakfast and $50 for lunch and dinner, approximately 1.5 to 1.9 times the price of hotel buffets A and C). However, the weight of guest leftovers per meal of restaurant at hotel A (132.88g) and B (183.64g) was significantly lower than that of hotel C (307.37g). Researchers indicated that food quality and customer consumption habits could affect the food wasted during dining (Chen, 2008a; Lam,

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2010).This study did observe the presence of relatively high quantities of guest leftovers at the restaurant at hotel C but did not further examine the causes of this phenomenon.

CONCLUSION AND SUGGESTIONS

This study revealed that the foodservice waste generated from the buffet restaurants of three tourist hotels ranged from 304.43kg to 565.09kg per day, with unstacked volumes of 1.41 m^3 to 2.62 m^3. The number can be demonstrated in per customer basis, which each customer produced average 449.71g/meal to 928.84g/meal foodservice waste while they were dining at the buffet restaurants. The foodservice waste per meal generated from the buffet restaurants were much greater than the corresponding weights reported for other restaurant types. With respect to the categories of foodservice waste, by weight, food waste accounted for the highest percentage (60-80%) of waste for all three examined restaurants, followed by general waste. By volume, general waste accounted for the highest percentage (36-53%) of waste for all three of the restaurants. This study also estimated theoretical recovery rates of 70-80% for the foodservice wastes of three restaurants. It is evident that, with proper sorting, restaurant could improve recovery rates and reduce the environmental impact of waste disposal.

The results of this study indicated that the foodservice waste produced at the buffets restaurants was subject to the number of customers/turnover rate and restaurant practices. With respect to waste disposal, this study demonstrated that the volume of paper, plastic, and metal foodservice waste could be reduced by 60 to 80% through stacking, reducing the daily waste volume by 0.5 m^3.This reduction would significantly decrease not only trash-bag use but also the energy required during waste storage and transportation. In addition, it has demonstrated that a simple draining practice of the leftovers from dining areas could reduce the weight of these leftovers by 50%, which could improve the staff's operational efficiency and reduce resource expenditures during subsequent waste-disposal processes.

In this study, the weights of guest leftovers and buffet-counter leftovers of three restaurants were analyzed to explore the potential impact of the restaurants' kitchen style on the waste volume. It was speculated that the relatively high and consistent turnover rate at the hotel B restaurant allowed chefs for better estimation of food-preparation quantities in advance and, in addition, the open kitchen operation would allow chefs to directly monitor the food consumed and therefore, effectively control the

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quantity of food to prepare. As a result, it could help minimizing the buffet-counter leftovers.

MANAGERIAL IMPLICATIONS

Enforce education to implement sustainable practices and the theoretical recovery rate as the indicator in foodservice waste treatment

This study found that both the staffs in kitchen and dining area dumped various types of waste into trash cans out of convenience without appropriate sorting, resulting in reduced waste recovery. Therefore, to effectively implement waste sorting and recovery, restaurateurs could educate and communicate with their employees, on a regular basis, the idea and advantages of implementing waste sorting. In addition, the theoretical recovery rates of foodservice waste can serve as an indicator of self-management by restaurant operators, to understand how well the waste treatment practices were implemented in their restaurants and also the effectiveness of these practices. Government can encourage and collaborate with restaurateurs to establish tools and methods for waste disposal by benchmarking the waste-recovery for restaurants, and thereby effectively promoting waste recovery.

Implement the draining of leftovers

The food waste in dining area contained high amount of water, primarily because out of convenience that staffs in this area often dumped leftover beverages and soup from customers directly into trash cans along with solid leftover, and unnecessarily increasing the weight and volume of waste. Therefore, it is recommended that restaurant can install a screen on trash cans or a simple draining unit next to the disposal areas to effectively drain the water from wastes.

Compact waste

It was observed that staffs in both kitchen and dining areas were often very rush, they just directly discarded the empty, used bottles and cans, too busy to compress the packing materials. Therefore, this study recommends the installation of compacting equipment to facilitate the waste compressing process.

Understand and improve turnover rate

The turnover rate of the all-you-can-eat buffets restaurants of the studied hotels was negatively correlated with the weight of waste per meal; thus, improving the turnover

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rate can effectively reduce quantities of foodservice waste. We suggest that foodservice operators should monitor and understand the relationship between the turnover rate and waste volume in their restaurants. Not only to increase their numbers of customers but, more important, to maintain a steady turnover rate along the dayparts through proper marketing strategy and campaign. It could help restaurants to improve sales performance and effectively reduce restaurant waste volumes.

RESEARCH LIMITATIONS

The all-you-can-eat buffet restaurants at three tourist hotels were selected as the objects of this study, which the operations may not be the same as the buffet restaurants associated with other types of foodservices. Therefore, the study results cannot fully represent all-you-can-eat buffet restaurants as a whole and may not be applied to other restaurants.

SUGGESTION FOR FUTURE RESEARCH

Researchers have indicated that restaurants consider the open kitchen design as a unique selling proposition. Through this study, it was speculated that the adoption of an open kitchen at all-you-can-eat buffet restaurants had better control of food preparation and reduced foodservice-waste volumes as compared to other kitchen practices. However, this observation was not further verified. It is recommended that future research could conduct in-depth explorations of the impact of kitchen practices (fully open, semi-open, and closed styles) on foodservice waste, in combination with the administration of questionnaires addressing consumers' perception and behavior, to understand the impact of kitchen design on the food waste and food consumption at all-you-can-eat buffet restaurants.

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