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The weight of unfinished plate: A survey based characterization of restaurant food waste in Chinese cities

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ABSTRACT

Consumer food waste has attracted increasing public, academic, and political attention in recent years, due to its adverse resource, environmental, and socioeconomic impacts. The scales and patterns of consumer food waste, especially in developing countries, however, remain poorly understood, which may hinder the global effort of reducing food waste. In this study, based on a direct weighing method and a survey of 3557 tables in 195 restaurants in four case cities, we investigated the amount and patterns of restaurant food waste in China in 2015. Food waste per capita per meal in the four cities was 93 g, consisting mainly of vegetables (29%), rice (14%), aquatic products (11%), wheat (10%), and pork (8%). This equals to approximately 11 kg/cap/year and is not far from that of western countries, although per capita GDP of China is still much lower. We found also that food waste per capita per meal varies considerably by cities (Chengdu and Lhasa higher than Shanghai and Beijing), consumer groups (tourists higher than local residents), restaurant categories (more waste in larger restaurants), and purposes of meals (friends gathering and business banquet higher than working meal and private dining). Our pilot study provides a first, to our best knowledge, empirically determined scales and patterns of restaurant food waste in Chinese cities, and could help set targeted interventions and benchmark national food waste reduction targets.

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1. Introduction

Food waste has gained increasing public, academic, and political attention in recent years (Godfray et al., 2010; Gustavsson et al., 2011; Charlebois et al., 2015; Gruber et al., 2015; Aschemann-Witzel et al., 2015). For example, the United Nations' recently released Sustainable Development Goals has set a specific target (SDG 12.3) for halving per capita global food waste by 2050. It has been estimated that one third of global food production is lost or wasted during the various phases of the food supply chain from farm to table (Steinfeld et al., 2006; Kummu et al., 2012). Consumer food waste at the consumption stage is usually high in developed countries (Gustavsson et al., 2011; Kummu et al., 2012). In Europe,

for example, as much as 42% of all food produced is wasted during the final consumption stage (Monier et al., 2011). The U.S. wastes 31–40% of its post-harvest food supply, with a substantial portion occurring at the consumer level (Neff et al., 2015). Such a high scale of food waste implies that significant resource, energy, environmental, and socioeconomic costs embodied in agrifood products during production, transportation, processing, and retailing are in vain (Koivupuro et al., 2010; Gustavsson et al., 2011; Lo and Jacobson, 2011; FAO, 2012; Eshel et al., 2014).

Addressing these consumer food waste issues requires an understanding of their quantity and patterns in different consumer segments, both in household and out of home. Examination of the existing literature indicates that mass feeding away from home often results in greater food waste than food preparation and consumption within home (Youngs et al., 1983). However, most of previous studies on food waste quantification focus more on households than the hospitality sector. In addition, the investigations that have been carried out to examine the extent of food

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waste at out-of-home eating locations in the past decades (Grey and Dubois, 1947; Banks and Collison, 1981; Youngs et al., 1982; Buchner et al., 2012; Silvennoinen et al., 2012; Parry et al., 2015) covered largely only the western countries such as UK and US, and this information remains poor for developing countries such as China.

It is usually believed that in developing countries food loss occurs mainly during the earlier stages of the food supply chain, i.e., production and postharvest handling, due to lack of financial, technical, and managerial resources, while food waste at the consumer stage is assumed to be low, especially when compared to that of developed countries (Parfitt et al., 2010; Dorward, 2012; Kummu et al., 2012). However, this pattern may change as the developing countries continue to urbanize, develop their economy, and change their dietary structure (Parfitt, 2013; Thi et al., 2015). For example, a study based on the scaling-up of household waste streams in South Africa generated significantly higher amount of household food waste than those widely cited but usually outdated literature data (Nahman et al., 2012). More updated and direct measurement based analysis of food waste in emerging and developing countries are badly needed.

In particular, the rising consumer food waste in China, the world's most populous and largest developing economy, deserves a closer look due to its significant impact on the global food market, resources use, and GHG emissions. China's out-of-home food consumption shows a dramatic growth in the past decade (State Administration for Industry & Commerce of the People's Republic of China, 2009; Bai et al., 2010), as a result of its unique food culture and increasing household income. Consequently, consumer food waste increases rapidly and repeatedly pops up in public debates on food security, human health, and waste management in China. For example, the illegal use of gutter oil from restaurant food waste has long been headlines of many news stories; the public's concern on the enormous amount of food waste found in government paid banquets has led to a national wide campaign against food waste that was initiated by the top leadership (Liu, 2014). Despite such growing public attention and media coverage, there is still little information on the scales and patterns of restaurant food waste in China (Liu, 2014; Liu et al., 2013). Two rough numbers were often blindly cited: on average about 10% of food ordered ended up as waste in Chinese restaurants and restaurant food waste in China per year would feed 200 million people (Zheng, 2011). But a closer check shows that these data are purely based on expert estimation with no empirical evidence.

We aim to address this data gap by making a first approximation of the current scales and patterns of restaurant food waste in Chinese cities, based on field survey and direct weighing of food waste from 3557 tables in 195 restaurants in four case cities in China. Such an empirically determined and quantitative understanding will help inform the public, restaurant managers, and policy makers about the escalating scale of food waste and consequently help explore strategies for food waste reduction. The main objectives of this article are two folds: (i) to characterize the total and per capita food waste generated in Chinese resultants and their composition based on field survey and direct weighing in the four case cities; and (ii) to explore the patterns of and reasons behind restaurant food waste generation in China and their implications on food waste reduction strategies.

2. Materials and methods

2.1. System definition and sample selection

Consumer food waste can be found in different segments of the consumer stage from restaurants to canteens to all other types of

hospitality sectors. We focus only on the restaurant in this analysis, due to the growing public attention it received and its rising contribution to the generation of food waste in China (Liu, 2014). Food waste is defined as the edible part that is left in the plate after the meal, and the non-edible part such as food additives, flavorings, cooking oil, and bones is not counted in our measurement.

Considering the varying cuisines and people's consumer habits in different parts of China, we selected four typical cities (Beijing, Shanghai, Chengdu, and Lhasa) for case studies. Beijing is the capital of China and the largest city in northern China. Shanghai is the economic center of China and one of the largest in the east. Chengdu locates in western China and is the capital of Sichuan province, hometown of one of the most popular Chinese cuisines. Lhasa, the capital city of Tibet Autonomous Region of China, has a unique food and culture tradition with an average altitude of 3650 m. More information and characteristics of the four case cities were summarized in Table 1.

A stratified sampling method was used for the sample selection of restaurants. We first analyzed data from the municipal Food and Drug Administration, the main bureau of restaurant management in China, about the number of all restaurants and the proportion of different categories in different districts of each city. On the basis of the data, we determined the sample districts in each city and the number of restaurants of each category in the survey.

- In China, restaurants are classified as different categories based on their floor areas of business, i.e., large-size (more than 500m²), medium-size (between 150 and 500 m²), and small-size (less than 150m²) restaurants. In addition, snack bars which mainly provide refreshments, snacks, and fast food were also selected in our survey. The number of surveyed restaurants of each type (including snack bars) in different cities was summarized in Fig. 1.
- Three administrative districts within Beijing (Chaoyang District, Haidian District, and Changping District), Shanghai (Changning District, Minhang District, and Fengxian District), and Chengdu (Wuhou District, Chengdu Hi-Tech Industrial Development Zone, and Shuangliu County), were chosen based on a downtown-to-suburban transect theory for sampling. Lhasa is relatively small and thus we considered only the municipal administrative district (Chengguan District) in the sampling. Fig. 2 shows an example of Beijing for the total number of restaurants by category and by district, which confirms the representativeness of our sampled districts (e.g., Chaoyang, Haidian, and Changping are the top three districts in terms of the number of restaurants) and the share of different categories of surveyed restaurants (when compared with Fig. 1).

In total, we have selected 195 restaurants in the four cities, including 63 in Beijing, 51 in Shanghai, 54 in Chengdu, and 27 in Lhasa. Most of Chinese people share all the food ordered on a table when eating out, therefore we take each dining table as the basic unit of our survey. For each restaurant, 20 tables of consumers were randomly selected to conduct our survey. This all together adds up to 3557 tables that were investigated in detail (Fig. 1). In China, apart from tourism hotels which provide accommodation together with a simple buffet breakfast, few restaurants provide breakfast. Therefore, only lunch and dinner were included in our survey.

2.2. Questionnaire design

For each table, two questionnaires were used to investigate the amount and composition of food waste and consumer food waste behaviors.

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