



Full length article

Horeca food waste and its ecological footprint in Lhasa, Tibet, China

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ARTICLE INFO

Keywords:

Consumer food waste
Ecological footprint
Horeca sector
Lhasa

ABSTRACT

Consumer food waste in developing countries becomes increasingly important as they continue to urbanize and raise the income of their inhabitants. However, there are few empirical studies on the scales, patterns, and impacts of consumer food waste in emerging economies (compared to industrialized countries). Here we report an exploratory study on the amount of Horeca (hotels, restaurants, and cafés) food waste and its ecological footprint in Lhasa, Tibet, in western China, based on a direct-weighing bottom-up approach of 35 representative restaurants in 2011 and 2015. We found that, on a per capita level, Horeca food waste in Lhasa has already reached a high-level (128 ± 3 g/cap/meal in 2011 and 98 ± 2 g/cap/meal in 2015) close to that of western countries despite a lower level of income. The decline of per-capita Horeca food waste generation from 2011 to 2015 most likely reflects the reduction among local residents as a result of recently issued strict regulations (especially those targeting official extravagance and governmental reception meals at public expenses), as similarly observed in Japan and Germany. On the contrary, as a main tourism destination, tourists showed an increasing trend of food waste on a per capita level and contributed over half to the total Horeca food waste in both 2011 and 2015. This also leads to, together with other factors such as growing dining-out frequency of local residents, a sharp increase (39.7%) of total Horeca food waste in Lhasa from 2011 (15 ± 1 kt) to 2015 (21 ± 2 kt). The total ecological footprint of wasted food in the Horeca sector of Lhasa in 2015 is equivalent to $71,516 \pm 7,705$ ha, almost two times the arable land area of Lhasa.

1. Introduction

Food losses and food waste, together referred as food wastage, has been widely recognized as a key barrier to achieving global sustainability. Food wastage occurs throughout the agri-food supply chain, from agricultural production, postharvest handling and processing, distribution, to final consumption (Parfitt et al., 2010). According to the Food and Agriculture Organization (FAO) of United Nations, food losses refer to the decrease the quantity and quality of food occurring at production, postharvest and processing stages in the food supply chain, while food waste is connected to human behavior taking place in the end of the food supply chain (Gustavsson et al., 2011). FAO has also estimated that about one third of the annual global food production, or about 1.3 billion tons, will never enter the final consumption stage and is instead lost or wasted (Gustavsson et al., 2011). This significant amount of food losses and food waste simply diminish our arduous efforts to increase food production and ensure food security.

There are growing concerns worldwide on the negative social, economic, and environmental impacts of food losses and food waste.

For example, the FAO calculates the full cost of the annual global food wastage as a direct economic cost of 1 trillion US dollars, a social cost of around 900 billion US dollars, and an environmental cost of about 700 billion US dollars (FAO, 2014). Food losses and food waste inevitably means massive amounts of the resources used (e.g., land, water, fertilizer) and greenhouse gas (GHG) emissions emitted in production in vain (FAO, 2013; Grizzetti et al., 2013; Kummu et al., 2012; Liu et al., 2013b; Scholz et al., 2015), as well as additional energy use and GHG emissions in waste management (Bernstad Saraiva Schott and Cánovas, 2015; Dorward, 2012; Eriksson et al., 2015; Zhao and Deng, 2014).

The scales and patterns of food wastage vary in different countries (Xue et al., 2017). In industrialized countries, food is to a large extent wasted at the consumption stage due to, for instance, abundance and consumer attitudes (e.g., poor purchase planning) and high-quality standards (e.g., misinterpreted “best-before-dates”). For example, US Department of Agriculture estimated 31% of food produced in the US was wasted at the retail and consumer stages in 2010 (Buzby et al., 2014). The EU27 has an annual food waste generation of approximately 89 million tons (Mt), or 179 kg per capita (Monier et al., 2010). In the

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UK, households alone wasted about 7.2 Mt of food in 2012, over 60% of which was identified as “avoidable” (i.e., the waste that is edible or potentially edible) (WRAP, 2014). In low-income countries, on the contrary, food is mostly lost during the production-to-processing stages due to, for example, insufficient technologies and infrastructure.

While growing attention has been paid to the evaluation and mitigation of postharvest food losses in developing and emerging countries (Affognon et al., 2015; African Postharvest Losses Information System, 2011), data on consumer food waste generation in these countries are largely missing (Parfitt, 2013; Parfitt et al., 2010). For example, a recent review on the global food wastage data reveals high uncertainties in the consumer food waste data, especially for those countries and regions that have undergone the most-rapid shifts away from starchy staples toward more varied and fresh diets (e.g., China and India) (Xue et al., 2017). What's more, as these countries continue to urbanize and raise the income of their inhabitants, their consumer food waste is also becoming increasingly important (Wang et al., 2017a; Xue et al., 2017) and has been considered as a serious obstacle to sustainable development. Therefore, more research and first-hand data on consumer food waste in emerging countries are badly needed (Liu et al., 2013a), particularly for big developing economies like China (Wang et al., 2017a). We have reported some earlier studies for food waste in school lunch programs (Liu et al., 2016) and restaurants (Wang et al., 2017a) in Chinese cities based on field survey, but these studies didn't include any temporal changes of food waste nor their environmental impacts.

In this paper, we aim to address such a data gap by an explorative case study of the Horeca sector (i.e., hotels, restaurants, and cafés) of Lhasa, which is the capital city of Tibet in western China. Such a case city was chosen because: First, Lhasa is an important tourism city that attracts huge number of tourists each year due to the unique natural and cultural attractions of the Qinghai-Tibet plateau, with about 11.8 million tourist arrivals in 2015 (while the population of Lhasa is only about 0.53 million in 2015). As a result of urbanization and tourism development, the Horeca sector of Lhasa has grown rapidly and the revenues have almost tripled in the past decade (Lhasa Statistical Bureau, 2015). Second, as a plateau city, Lhasa relies heavily on external supply of food and hence the economic and environmental cost of food consumed and wasted would be high. Third, known as “the third pole” of the earth, the Qinghai-Tibetan Plateau has an average elevation of 4000 m, and its ecology and environment security is important not only to East Asia but also to the rest of the world (Wang et al., 2017b).

Differing from previous studies which evaluate mainly the GHG emissions (Eriksson et al., 2015; FAO, 2013; Scholz et al., 2015) and water use (FAO, 2013; Liu et al., 2013b; Song et al., 2015) impacts of food waste, we used ecological footprint as an indicator in this case study. The ecological footprint method refers to the biologically productive land area required to maintain the consumption of resources and waste absorbing in the given population and economic conditions (Gössling et al., 2002; Wackernagel and Rees, 1996). By taking advantage of area unit to measure the ecological space (including farmland, grassland, waters, forest land, and other agricultural land resources) that food waste required to occupy, the generated footprint results are more intuitive to raise awareness on food waste and help identify priorities of mitigation strategies.

2. Materials and methods

2.1. Scope of the study

Consumer food waste can be found both at home (household) and in different segments of the out-of-home food service sector (also called hospitality sector), for example, catering, canteens (education, enterprise, hospital, etc.), hotels, and restaurants. These segments can be divided into commercial and non-commercial sectors (Betz et al., 2015). The non-commercial sector comprises the non-profit food

services within the public sector and the self-operated canteens within the private sector. The commercial sector consists of two main types (Marthinsen et al., 2012): (i) hotels, restaurants and cafés (together called Horeca in this paper); and (ii) canteens and catering. This study examines only a part of the consumer stage, which is the Horeca sector of Lhasa.

Food waste can also be categorized as avoidable waste (the waste that is edible or potentially edible) and unavoidable waste (the waste that is not or has not been edible under normal circumstances) (WRAP, 2009). The scope of these two categories may vary depending on a cultural context (Liu, 2014). In this study, we have counted food additives, flavorings, cooking oil, and bones as unavoidable waste and thus have excluded them in our measurement.

2.2. Field study, questionnaire design, and data measurement

We have conducted our field survey twice in Lhasa, once in 2011 (July and August) with 8 selected restaurants and once in 2015 (August) with 27 selected restaurants, both in high tourism season. The selection of restaurants was based on our pre-survey and communication with local authorities and data from the Lhasa Food and Drug Administration (which is in charge of restaurant management in Lhasa) on the overall number and proportion of different classes of restaurants (large-sized with business area of more than 500 m², medium-sized with business area between 150–500 m², and small-sized with business area of less than 150 m²). These samples cover a wide range of restaurant types (e.g., from Tibetan food to western dishes) and classes (e.g., from café style to five-star hotel restaurant) and locate evenly across Lhasa. See locations, types and names of the thirty-five restaurants in Fig. 1.

Due to pragmatic challenges such as economic and labor cost and the change of restaurant managers/operators, the selected restaurants in our surveys in 2011 and 2015 are not the same (Table 1). In 2015, the 27 investigated restaurants included 5 large, 9 medium, and 13 small restaurants and involved 1162 consumers (232 tourists and 930 local residents) of 460 tables. In 2011, the 8 investigated restaurants included 2 large, 4 medium, and 2 small restaurants and involved 2947 consumers (1189 tourists and 1758 local residents) of 318 tables. No tables with mixed tourists and local residents were found in the sample. Because we included large numbers of buffet in our investigation in 2011, the number of consumers per table in 2011 (with 9 people per table) was much higher than that in 2015 (with 2.5 people per table).

The detailed categories of food considered in the 2011 and 2015 surveys are also different. In 2011, we divided all food into 10 categories, i.e., pork, beef, lamb, poultry, aquatic products, eggs, vegetables, fruits, rice, and pasta (including noodles and other grain). In 2015, we used a more detailed classification system of 16 categories, i.e., pork, beef, lamb, poultry, aquatic products, other meats, eggs, vegetables, beans, mushrooms and fungi, potatoes and tubers, fruits, rice, pasta, maize, and other grains. For the convenience of comparison, the 2015 classification of food was converted to the 2011 list based on the criteria as follows: (1) Maize, wheat, other grains, and potatoes and tubers have been aggregated into pasta; (2) Beans and mushrooms and fungi were classified as vegetables; and (3) Other meats, such as rabbit meat and goose meat, were accounted in poultry.

For both 2011 and 2015, we used the same questionnaire that includes questions on (i) the surveyed restaurants (e.g., name, class, and capacity) and surveyed tables (e.g., dining time and number of consumers); and (ii) the measurement of food consumption and food waste. We included only lunch and dinner in both surveys, because very few restaurants in Lhasa provide light buffet breakfast, and our pre-survey shows that the amount of breakfast food waste is much less than that during lunch and dinner in the Horeca sector of Lhasa. We got the request ethical clearance prior to conducting the survey.

Electronic loading balances with a scale of 2 g to 5 kg were used for the physical weighing on spot. To reduce potential random errors, we

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