

## Article

# Plate Waste in School Lunch Programs in Beijing, China

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**Abstract:** School plate waste is of particular concern worldwide due to its adverse impacts not only on resource use and the environment, but also on students' health, physical maturation, and academic achievement in the long term. Previous studies on school plate waste have all been conducted in industrialized countries, and more studies are badly needed in developing countries. In this paper, we report a pilot study on the patterns and causes of plate waste in school lunch programs in Beijing, China, by a combination of physical weighing, questionnaire survey, and semi-structured interview approaches. Our results show that the average amount of food waste generated by school students in Beijing in 2014 was 130 g/cap/meal, accounting for 21% of total food served. Staple food (43%) and vegetables (42%) were the dominant proportions. Buffet meals resulted in less plate waste than packed meals and set meals. Food supply patterns, the quality of canteen service, and the dietary habit and students' knowledge of food production were the main influencing factors behind plate waste. To our best knowledge, our pilot study provides a first understanding of the overlooked plate waste in school lunch programs in China, and a good basis for further analysis in this field, and will be helpful in informing policy-making in relevant nutrition and education programs in schools in China.

**Keywords:** food waste; plate waste; school nutritional lunch program; dietary habit; sustainable consumption; China

## 1. Introduction

Food loss and food waste has become a worldwide concern in recent years due to its negative impacts on resource use, the environment, and social development [1–4]. Although food loss and food waste occurs throughout the whole food supply chain, from farm to table, food waste at the consumer stage attracts particular attention because the relatively large amount of consumer food waste means that all resources input at production, processing, storage, and distribution stages was used in vain, and a significant amount of greenhouse gas (GHG) emissions occurring at these stages and at waste management is added [5]. Besides, considering the rapid growth of the global population and the declining of the per capita availability of resources and energy for food production, food waste also intensifies the global food shortage and malnourishment [6]. Previous studies on consumer food waste mostly take consumption as an aggregated sector [1–3] and do not have a focus on different segments within consumption. In recent years in China, there has been increasing public awareness of food

waste and campaigns against food waste (e.g., the “clean your plate” initiative); consequently, a few researchers have also made some rough estimation of the scale of food waste in China [7–9]. However, none of them have reported results for schools.

The school canteen is one important segment of food consumption outside the home. School-aged children are experiencing rapid body growth and maturation, therefore a nutritious and balanced diet benefits their health, well-being, and academic achievement in the long term [10–12]. In recent years, a few studies have focused on school food waste using case studies in different countries. For example, according to an assessment of the American National School Lunch Program (NSLP) during 1991–1992, approximately 12% of calories from food served to students were lost as plate waste, causing a cost of over 600 million US dollars [10]. For early elementary students in the U.S., nearly 45.3% of foods and beverages were wasted in a full school week [13]. In the U.K., food waste was the dominant composition of school waste, accounting for one-third to a half by different grades of students [14]. A study by Falasconi et al. [15] found that more than 15% of school food in Italy was lost. Silvennoinen et al. [16] quantified food waste in different food service sectors in Finland, and found that the ratio of total school food waste (including kitchen waste) accounted for nearly 17%. Ishdorj et al. [17] found that vegetable plate waste in elementary schools increased from 52% to 58% after the implementation of a new school meal standard in the USA. Ferreira et al. [18] analyzed food waste in a Portuguese university setting, and proposed the reduction of food waste as a significant solution to improve food service sustainability. Liz Martins et al. [19] validated the visual estimation method for plate waste of main dishes at primary school canteens by comparing it with direct weighing. However, almost all existing studies on school food waste to date were carried out in industrialized countries. More case studies on the school plate waste phenomenon in developing countries—especially large emerging countries (e.g., China, as the world most populous country)—are therefore very important and badly needed.

The food waste generated in schools is influenced by multiple factors, such as the quality and efficiency of catering service, the dietary habits of students, and the national diet culture. Wansink et al. [20] stated that children eating with larger bowls wasted significantly more than those with smaller ones. Getlinger et al. [21] proposed that scheduling recess before eating lunch would help to significantly reduce food waste. The research of Casimir [22] suggested that the large amount of food waste generated in Sweden was strongly related to children’s ignorance of the impact of food waste on the environment and ethical issues associated with it. The study of Marlette et al. [23] indicated that changing preparation methods and limiting the availability of competitive food items would help to reduce plate waste in school lunch programs. Falasconi et al. [15] argued that lack of attention to dietary habits was the most important factor behind school food waste. Abe and Akamatsu [24] concluded that low self-efficacy for completely finishing meals was the main reason for Japanese students’ food waste behavior. Other factors, such as food logistics, food menu, food pairing, and distance to dining hall were also analyzed in other studies [25–29]. In short, there are some common factors behind school food waste, but they may also differ in different case studies. A better understanding of these driving factors in a local context would help to explore specific solutions to address school plate waste issues.

In 1993, China launched the National School Lunch Program, aiming to strengthen the health and physique of Chinese adolescents. In Beijing, nearly one third of primary and middle schools joined this program [30,31]. However, after over twenty years’ practice, it was gradually realized that solely implementing these nutrition lunch programs without taking food waste into consideration seemed to be inefficient and costly, and food waste issues among school-aged children started to cause wide attention from the public. First, according to the National Health and Nutrition Examination Survey by the Chinese government, the health condition of Chinese children has continued to decline in the past two decades, with the ratio of over-weight and obesity in children up to 5.05% and 9.41%, respectively. Some chronic diseases, like diabetes mellitus, dyslipidemia, and metabolic syndrome have also been found among school-aged children. Zhai et al. [30] and Duan et al. [32] made an

assessment of school children's diet quality in Beijing, and found nearly 29%–30% of food provided was not eaten by students, which significantly lowered the efficiency of the National School Lunch Program. Second, such school plate waste led to a great concern on the loss of the Chinese traditional value of “saving food” among school-aged children. Among other side-effects, this emerged as an important challenge faced by Chinese schools and educators with the improvement of the living standard and the implementation of the One Child policy.

Although plate waste is considered to be serious in Chinese schools, how much food is actually wasted and the main causes remain unclear. In this paper, we report a pilot study on the patterns and causes of plate waste in school lunch programs in Beijing, China. To our best knowledge, this is the first study of its kind in China, and provides a first sign of the normally-ignored amount of plate waste in China's lunch program. We believe that the results of this study provide a good basis for further analysis in this field, and can help to inform policy-making in relevant nutrition and education programs in schools in China (supported by the fact that a report of our preliminary survey results was actually read and commented by China's top leadership, which led to a city-wide crackdown on plate waste in all schools in Beijing).

## 2. Materials and Methods

### 2.1. Sample Selection

Our pilot study was carried out in late September 2014. We chose six schools and all the associated stakeholders along their lunch supply chain in Beijing. The selection of the surveyed schools was based on a discussion with the local authority and our feasibility study beforehand. These six schools are located across Beijing from downtown to suburban areas to ensure a diversity of students' family backgrounds (Figure 1).

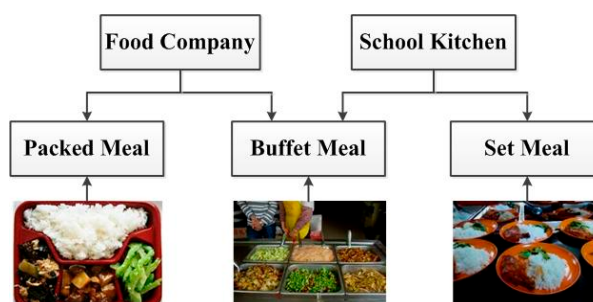


Figure 1. Location of the six surveyed schools in Beijing.

Both public and private schools were included in this study, and different food supply patterns were taken into consideration (Table 1). There are three types of supply patterns in school lunch programs in Beijing: packed meal, buffet meal, and set meal (Figure 2). Packed meal is delivered from food supply companies with pre-ordered variety and weight. Buffet meal is provided both by school canteens and external companies, and is thus more flexible in food variety and weight. Set meal generally comprises half grains and half vegetables and meat (usually two types).

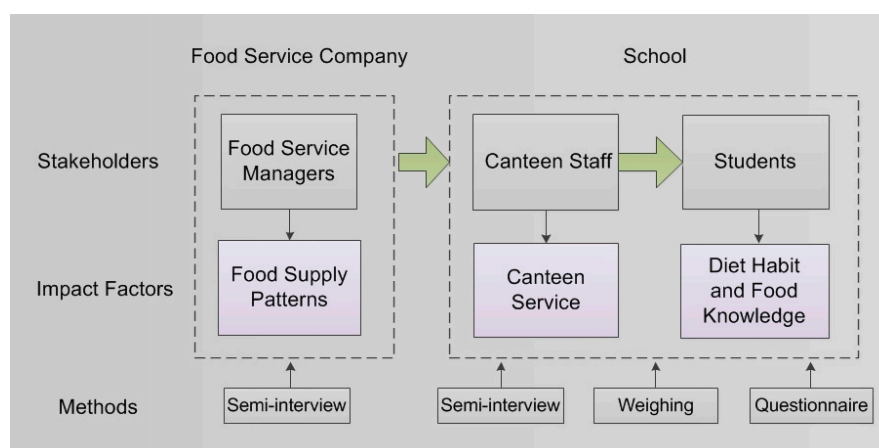
**Table 1.** Basic information on the six sample schools in Beijing.

Name	Category	Number of Students/Samples	Number of Boys/Girls	Age Ranges			Food Supply Pattern
				10–12	13–15	16–18	
School 1	Private	1200/134	60/74	0	134	0	Buffet meal
School 2	Public	1600/232	126/106	215	17	0	Packed meal
School 3	Public	2500/180	82/98	4	96	80	Set meal
School 4	Public	2800/145	51/94	0	34	111	Set meal
School 5	Public	1000/110	55/55	9	40	61	Packed meal
School 6	Public	4000/197	97/100	22	174	1	Buffet meal

**Figure 2.** Different food supply patterns of school lunches in Beijing.

## 2.2. Data Collection

We combined several methods in this study to collect data, including a physical weighing of the amount of food served and wasted in school lunches, a questionnaire survey for the impact factors behind food waste, and a semi-structured interview with all stakeholders along the supply chain (Figure 3).

**Figure 3.** Overall framework of our data collection.

### 2.2.1. Food Waste Measurement

In this paper, food waste is defined as food that is ordered but left uneaten after lunch. The food items considered include staple food (including rice, steam buns, and noodles), vegetables (both fresh and cooked), meats (including chicken, pork, beef, and lamb), and others (including soup, oil, and ingredients). A food waste ratio was calculated as the percentage of the amount of food waste relative to the weight of food served or ordered.

The weight and proportions of packed meals served were measured before lunch. For buffet and set meals, as it is very difficult to measure the original amount of food picked by individual

students without disturbing them in the rush lunch time, we estimated them by a combination of sample weighing and visual observation (which was applied in previous studies on school plate waste and proved as a useful way [19,33]) with the assistance of experienced kitchen staff. We found that although the ordering amount and proportions of buffet and set meals were different individually (for example, boys generally eat more and prefer meat more than girls), the average amount for each person did not strongly differ from that of the packed meal. Therefore, we assumed that the average amount of ordered food in buffet and set meals was the same as that in packed meals in this analysis.

Different weighing methods were used to measure the amount of food waste (all of these measurements were conducted secretly to prevent impacts on students' normal consumption and waste behavior):

- For packed meals: we randomly selected 100 boxes of packed meals after lunch and measured each edible food item left in the box by physical weighing.
- For buffet and set meals: all of the waste after lunch was mixed together and discarded into large bins. Therefore, we used a proxy by dividing the total weight of the bin by the number of students (counted by trained observer) who had discarded their food in it. Then, we stirred the bin of food waste evenly and poured them into small basins, where we classified the composition of food waste with the assistance of experienced kitchen staff.

#### 2.2.2. Questionnaire Survey

The aim of the questionnaire survey was to find out the reasons for school plate waste and to explore feasible countermeasures. In total, 998 questionnaires were conducted among school students through a face-to-face interview, in which 923 were effective (92%). The respondents consisted of 443 boys and 480 girls. The questionnaire included the following student information:

- Demographic background: age, gender, height, and weight;
- Dietary habit: taste preference, snack food preference, picky dietary habit, frequency of dining outside during school time, favorite dining places outside, and habit of taking doggie bags;
- Attitude and knowledge: general awareness of food waste, view on school canteen service, view on the risk of food shortage in China, knowledge of food production, knowledge of water, mineral, and energy scarcity, attitude on environmental protection, attitude on frugality tradition, and nutrition consideration in food choice.

Data were recorded using Microsoft Excel (version 14.0, Microsoft Corporation, Redmond, WA, USA, 2010). Dietary behaviors and preference were reported as frequency (%), and significances of differences were analyzed using  $\chi^2$  test at  $p < 0.05$  using the Statistics Package for Social Sciences software (Base 10.0, 1995, SPSS Inc., Chicago, IL, USA).

#### 2.2.3. Semi-Structured Interview

The semi-structured interview was carried out on a range of stakeholders, including the managers of food supply companies and canteen staff in the schools. All the interviewees had at least 5–10 years working experience for school food supply and service, and had a good understanding of the plate waste issue. The content of the interview was focused on their opinions on the school food waste issue, the advantages and disadvantages of different food supply patterns, and suggestions on canteen service improvement and food waste reduction.

### 3. Results

#### 3.1. Food Waste Disparity under Different Food Supply Patterns

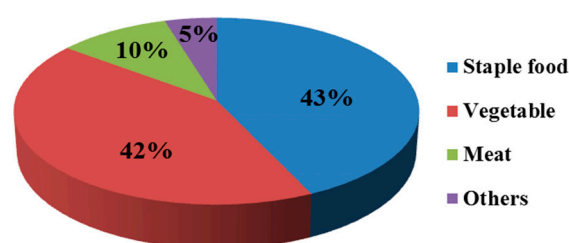
Food waste in schools varies significantly by food supply patterns, among which packed meals are the most wasteful, with an average of 216 g/cap/meal, accounting for nearly 1/3 of the food

served. Set meal waste (on average 109 g/cap/meal) was half of that of the packed meal. Buffet meals had the least amount of plate waste, with an average of 63 g/cap/meal (Table 2).

**Table 2.** Food waste disparity under different food supply patterns in Beijing.

Supply Pattern	Food Waste (g/Cap/Meal)	Share of Food Served (%)	Food Waste Composition (g/Cap/Meal)			
			Staple Food	Vegetables	Meats	Others
Packed Meal	216	35	84	105	24	3
Buffet Meal	63	10	45	12	3	3
Set Meal	109	18	39	49	10	11
Average	130	21	56	55	12	6

The average amount of school plate waste was 130 g/cap/meal in Beijing, which accounted for approximately 21% of total food served. Staple food and vegetables were the main proportions of food waste, accounting for 43% and 42%, respectively. Meats followed as the third, with a share of approximately 10%. The other leftovers, with food oil, soup, and ingredients made up 5% (Figure 4).

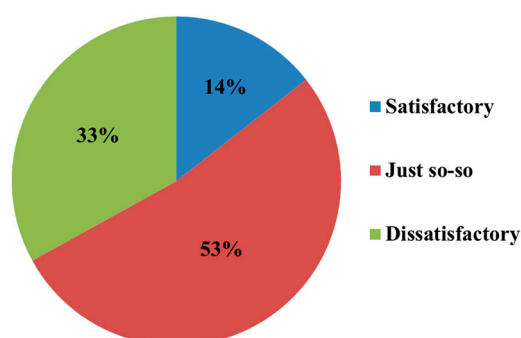


**Figure 4.** Composition of school food waste in Beijing (% weight).

In addition to the plate waste mentioned above, it is important to point out that there was an approximately 5% extra food waste for buffet meals due to food over-preparation. This is mainly caused by the food demand fluctuation as a result of students' taste change and unforeseen reasons like out-school activities or half-day classes.

### 3.2. Deficiency of Canteen Service

The school canteen is the main place where most students have lunch; therefore, the quality of canteen service is a key factor influencing students' food consumption and waste. Our survey showed that only 14% of the respondents were satisfied with canteen service, 33% dissatisfied, and 53% thought it as just so-so (Figure 5).

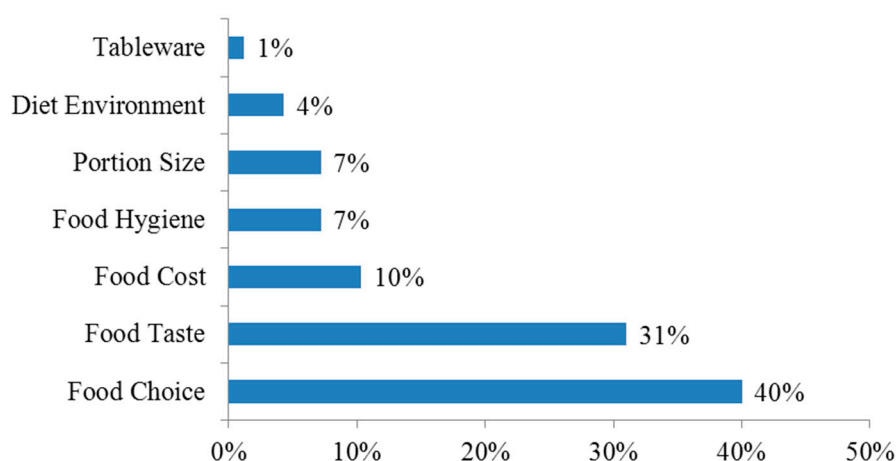


**Figure 5.** Canteen service satisfaction of respondents in our survey.

The problems of school canteen service are categorized as food choice, food taste, food cost, food hygiene, portion size, diet environment, and tableware in Figure 6. The lack of food choice and



unsatisfactory food taste were the two main drawbacks, which made up 40% and 31% of the total respondents, respectively. Ten percent of students thought the food was too expensive. Seven percent of students worried about the hygiene of canteen food. Besides, 7% of students complained that they could not order food as they wanted with the fixed portion size containers (more students given set meal and packed meal lunches complained about this—as high as 12%). In addition, 4% of students were disturbed by the crowded and noisy diet environment. One percent suggested the tableware should be upgraded.



**Figure 6.** Main problems in school canteen service in Beijing.

### 3.3. Dietary Habit and Knowledge of Food Production

As shown in Table 3, 44% of students had a picky dietary habit. Girls (48%) were significantly more serious than boys (39%) ( $\chi^2 = 8.4$ ,  $p < 0.05$ ). Twenty-seven percent of students did not take nutrition into consideration when ordering food. Seventy-seven percent of students prefer snack food in their spare time, with 78% for boys and 73% for girls.

**Table 3.** Students' picky dietary habit and snack food preference.

Gender	Picky Dietary Habit				Snack Food Preference			
	Yes		No		Yes		No	
	Person	Percentage	Person	Percentage	Person	Percentage	Person	Percentage
Male	174	39%	269	61%	320	73%	119	27%
Female	231	48%	249	52%	372	78%	102	22%

Compared with dining at school, 52% of students preferred having lunch outside if possible, and the frequency of dinning outside during school days was 1.2 meal/cap/week. These outside-school lunch choices are diversified, including Chinese restaurants (48%), Western fast food restaurants (37%), Chinese fast food restaurants (21%), kiosks (13%), and street food (9%). Such a high share of fast food consumption leads to severe food waste, food safety risk, and nutrition balance problems. Additionally, when eating outside, over half of the students reported that they never or seldom take doggie bags (packing and taking) if there are left-overs.

Regarding knowledge of food production, only 28% of students understood how food is produced and distributed from land to table, 57% knew little, and 16% did not know at all. Fourteen percent of students thought food supply is not at all a problem anymore in China, and 18% of them did not take plate waste as a problem at all. Regarding the awareness of food waste, about 80% of students realized that food waste is an important issue, while the remaining 20% did not think so or did not care about it at all.

## 4. Discussion and Conclusions

### 4.1. Uncertainties and Implications of Our Results

Our pilot survey covered only six schools, and only one day for each school in Beijing, due to pragmatic constraints such as time, budget, and cooperation of schools; therefore, the results could not reflect potential seasonal variations and disparities (e.g., gender, age, and family socioeconomic background) of different student groups, which would be important directions for any follow-up research. Without panel data on individual students, statistical analysis on the relationship between food waste amount and impact factors could not be performed either. Food pairing in meals is also an important parameter behind plate waste, but was not included in this analysis (because food pairing changed every day but our survey was for one day only and it is difficult to measure food pairing in buffet meals).

The lunch time of school students is relatively shorter than that of other food service sectors, so it is more difficult to weigh and measure the food waste plate by plate and student by student, especially for buffet meals and set meals. We thus used a combination of physical weighing (usually more accurate and reliable, but more time, labor, and cost intensive [33]) and visual estimation (more efficient and less costly) for food waste measurement to balance feasibility and data reliability in this analysis. Our assumption that the ordered amounts of food in buffet meals and set meals are the same as that in packed meals may lead to uncertainties in the calculated food wastage ratio (Table 2), though this is based on our observation and discussion with experienced kitchen staff. All these uncertainties (e.g., geographical and temporal variations) and gaps (e.g., cause and effect analysis of influencing factors) mentioned above should be addressed in future study.

Nevertheless, our pilot study provides (to our best knowledge) a first understanding of the food waste patterns in schools in China, and unveils the overlooked facts on plate waste in school lunch programs. Our initial case results indicate that food waste in these lunch programs can be substantial (21% of total food served) in Chinese megacities like Beijing. Further and more in-depth studies in different regions and cities could provide a better overview of plate waste in Chinese schools.

The quantification of food waste provides a physical basis for further analysis on its economic, social, and environmental impacts. At present, there are 1.11 million primary and middle school students in Beijing, and approximately 0.71 million of them have lunch in schools. If our results were extrapolated to all schools in Beijing, we calculated that the total amount of lunch plate waste in Beijing would be as much as 15,560 tons per year. If we simply multiply this by the average price of a packed lunch (12.5 Yuan), this total waste would cost 0.31 billion Chinese Yuan (simply calculated as  $0.71 \text{ million/day} \times 12.5 \text{ Yuan} \times 21\% \times 168 \text{ school days}$ ). This also means 554 km<sup>2</sup> of land (approximately 4% of total land area of Beijing) and 23.12 million m<sup>3</sup> of water (approximately 1.2% of all water resources in Beijing) were lost idly to produce this amount food (calculated by food waste amount multiplied the conversion ratio of ecological footprint for food consumption in Beijing [34]).

### 4.2. Comparison with Other Studies

In this study, plate waste in school lunch program in Beijing was determined to be as high as 130 g/cap/meal, accounting for 21% of the total food served. This share appears even higher than typical average wastage in industrialized countries; for example, 5.7% in Finland [16], 12% in the U.S. [10], and 15% in Italy [15]. Although these differences may reflect temporal and regional variations, characteristics of different age groups, food supply patterns, and food waste quantification methodologies, such an alarming number calls for immediate action and more in-depth research on this issue, especially considering the rapid urbanization and household income increase in China.

Food supply patterns, the quality of canteen service, and the dietary habit and students' knowledge of food production are the main influencing factors discussed in this study. First, as found in earlier studies [10,20,24,35], food waste generation correlates significantly with unfit portion size, and buffet meals were found to be a more efficient food supply pattern in the surveyed schools in



Beijing, because they offer flexibility to students in food variety, taste, and weight (while the choices are forced on the students through set and packed meals), and 80% of the surveyed students realize the food waste issue is serious and would tend to waste less if possible. Second, our results also proved that improving canteen service is an efficient way for plate waste reduction [12,24]. In particular, more delicious food would lead to more food intake and less plate waste. Third, school students' unhealthy dietary habits and ignorance of food production aggravate the plate waste problem, which is consistent with findings in Sweden [22] and Japan [24]. This is caused by several reasons: many students never experienced farm work as China continues to urbanize and increase its household income; many of them are also spoiled by parents as a side effect of the One-Child policy in the past three decades; and the food waste and dietary behavior issues get less attention in schools under a grade-oriented education system in China.

#### 4.3. Policy Recommendations

Reducing food waste in schools is important and necessary and has further implications on children's physical and psychological growth. Based on our investigation and stakeholder interview in this case study, we highlight the following policy recommendations to address this issue in China.

- (i) To increase food supply efficiency and promote buffet meals in schools. The long distance and consequent transportation time (on average 2 to 3 h in Beijing) to deliver food from supply companies to students result in a degradation of the freshness, color attractiveness, and taste of off-site school lunches. Such declining of lunch quality leads further to the increase of plate waste and the frequency of outside-school food consumption. Food supplied from school kitchen or pre-processed food cooked on-site should be encouraged to reduce food waste (as a result of more efficient food supply and more accurate and timely demand estimation [36]). Buffet meals—which cause less plate waste than packed meals and set meals—should be promoted for school lunches.
- (ii) To improve the quality of school canteen service. The school canteen is the main food service institution in schools, and plays a significant role in plate waste reduction. More regular communication among food suppliers, canteen staff, school teachers, and students (e.g., in the form of a “school lunch committee”) may help react immediately to feedback from students on canteen service and food taste, and thus improve the canteen service and reduce plate waste. For large-scale school canteens, introducing market competition in food supply may push forward the reform of canteen management and improve the quality of service. Additional assistance, including financial support and guidance from schools and the government are also necessary to implement good practices such as nutrition labels and food saving and waste reduction tips; e.g., table cards with a note “take small portions and many times” in canteens [37,38].
- (iii) To join efforts of schools and families to ensure a better knowledge of food production and a healthier dietary habit of students. Adolescence is a critical stage in one's lifetime in the cultivation of a healthy dietary habit. Dietary education on food supply, food culture, and nutrition balance should be introduced as part of schools' standard curriculum [39,40]. This may also include various agricultural practices, such as visiting farmland and participating in farming and planting in their spare time. At home, involving children in cooking is a good way to familiarize them with food nutrition and the value of food. Supervision and correction of children's bad dietary habit and education on Chinese tradition of “saving food” both at schools and at home are also necessary [41,42].

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**Author Contributions:** Shengkui Cheng and Yao Liu conceived the idea. Xiaojie Liu and Gang Liu contributed to the research design, field survey, and literature review. Yao Liu collected the data, with assistance from Xiaochang Cao and Xue Li. Gang Liu and Yao Liu analyzed the data and drafted the paper. All authors proofread and approved the final manuscript.

**Conflicts of Interest:** The authors declare no conflict of interest.

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