

Based on the carbon footprint, how much waste does takeout produce compared with the traditional way

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Abstract. With the development of the Internet and the expansion of online to offline delivery services, takeaway food becomes a part of food consumption. This paper examined the difference between the dine-in and take-out food with a carbon footprint of food waste among 346 people in Jiangsu Province, China, by using the online questionnaire to figure out how much food they may waste in daily meals. Three aspects were researched in the questionnaire: food classification, the quantity of waste food, the waste of takeaway food packaging. The result showed that the waste caused by takeaway is one-third more than the waste caused by dine-in. People might waste more due to the sale promotion strategy of merchants and the discounts they offered. The result also showed that the diversity of food was relative to the waste of rice. The higher the variety was, the more rice people might waste. The environment is damaged by sophisticated packaging due to its difficulty to degrade.

1 Introduction

Now the world is in the fourth industrial revolution stage, many new businesses emerged, like online takeaway food. Waste and polluted gas were created or produced by the new company. In the producing step, some waste gas and carbon dioxide were emitted during that stage, and the environment was damaged in many aspects like the global temperature and pollution. People all over the world worked and endeavored to reduce the emit of greenhouse gas. According to researches, carbon dioxide, which took 78.7 percent of artificial greenhouse gas, is the main component of greenhouse gas, and it is crucial to control the emitting of carbon dioxide [1]. Significant changes in temperature and environmental variations were caused by the emit of greenhouse gas [2]. People worked hard to study climate change and tried to clarify the impact of human activities on nature and the relationship between greenhouse gas and the environment. The development of new industries must balance the environment and climate to live peacefully with heart [2]. Calculating the carbon footprint in the take-out food can help to figure the carbon consume and environmental impact of take-out food consumption.

In China, there are mainly two ways to consume food in universities. One is dine-in and the other is take-out [3]. According to the Research, online takeaway food delivery had taken up 5.3% of the whole catering market in China with total revenue of 205.3 billion RMB [4]. The development of the Internet stimulated the take-out service. They offered customers coupons to get cheaper

food to eat online and then people are attracted by the discount [5]. When they were used to order meals online or on some mobile applications, the convenience of online food ordering has turned them lazy. They did not need to deal with the waste after having meals, and send-to-home service reduces their time to prepare.

A lot of university students ordered a lot of take-outs in their dormitory. The waste would not be dealt with by students themselves due to their laziness and unawareness. A lot of polluted waste was thrown into the garbage bin together without classification and simple treatment. The process accelerated the production of waste and greenhouse gas. Contaminated waste would be burnt and produce more toxic gas, which harmed the environment. It creates a heavier impact on the environment [6]. Meanwhile, the improvement of people's life quality and tricks which the developer of ordering applications used always led people to order more to get the so-called discount. That increased the food waste in another way even that some people did not detect it. The data from the Meituan app showed that since August 2020, the revenue from dishes increased about 30 percent more than July 2020 [7]. Sometimes online ordering would mislead customers with pictures because they could not estimate the ratio of the food they ordered. The discount might intrigue customers to order more than they cannot eat up [8]. But takeaway food in China is still not straightforward so that this study will determine the actual food waste in takeaway food.

According to research, more than 54 percent of food waste happened in harvesting, transportation and storage, and 46 percent rest was at the end of the supply chain [9].

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A lot of research had calculated the waste in harvesting, transportation and storage, and based on simple formulas. When food was harvested, it has bulged with hundreds of different items and all of them would go bad despite the temperature control, moisture control and wax coating [10]. From the data from FAO (Food and Agriculture Organization), it was said that 14% of food is lost after harvesting in the whole world [11]. The industry of dealing with waste garbage, especially plastic, was stressed because more plastic was produced due to takeaway food packaging. It was calculated that over two hundred and forty tons of plastic were utilized every year [12]. Also, the plastic contained a component called a plasticizer which is harmful to human beings. According to research, this compound is toxic to the liver and kidney and leads to cancer [13]. Over 100 compounds in plastic and about 27 kinds of compounds would transfer to toxic to humans with the Tenax migration test [14]. There was little research about calculating the difference between dine-in and take-out based on the carbon footprint of food waste in the final part of the supply chain by collecting data from university students. In the research, we would calculate the weight, the energy and the carbon emit of food waste to figure out how much food was wasted due to takeaway. This research was based on the analyze of carbon footprint in take-out food and traditional dine-in food. The data were compared by switching the food waste into carbon emit to compare.

2 Methodology

2.1 Content and object of the questionnaire

The primary method was to ask students, especially in high school or college to finish a questionnaire. The purpose of filling out the questionnaire was to collect waste in ordering takeaway food delivery service compared with dine-in. It was known that in most cases, people wasted less in the dining room than takeaway food because they had to see the food was thrown into a swill bucket. The questionnaire was to get the specific data of waste by asking people in school directly to make the comparison clear.

In the questionnaire, there were mainly three-part. The first one was about takeaway food. First, the frequency of ordering takeaway food could help us know the condition of takeaway food ordering among students. It was easier to calculate their cost in ordering takeaway food. Besides, ordering takeaway food could offer information about why students order takeaway food and how they benefit their lives. In some cases, it states the necessity of takeaway food. In addition, asking about the classification

of takeaway food would help identify which kind of food was chosen as takeaway food often. And we asked about the impact of discounts on customers. This could figure out how did some merchants attract customers to consume in their online food applications. Then there were a few questions about the waste rate of each kind of food like hamburgers, chips and snakes, and beverages. The second part was about dine-in. There were also some questions about the waste rate of each kind of food like staple food, vegetable and soup. These questions were used to compare with the takeaway. The third part was about the package of takeaway food. This could help figure out customers' opinions towards the package and improve the package of takeaway food.

2.2 Analyze about the life cycle of take-out food and traditional food

2.2.1. Life cycle of traditional food and take-out food.

Life cycle assessment (LCA) is a popular method to analyze the impact of production systems on the environment. It can effectively and comprehensively analyze every link in the production process. So we list the whole life cycle of two systems firstly [15]. Then we identified the links to be compared and transferred the consumption into carbon footprint to evaluate their impact on the environment.

From planting to recycling, we divided the life cycle of traditional food into four parts(Fig 1):Row material producing, Packing and delivery, Consumption and Post-treatment [16].

(1) Row material producing: Before we think about cooking food, we need to grow all kinds of crops and spices, which are the raw materials for a meal. The production will cost water, diesel oil, chemical fertilizer and other energy and will cause pollution.

(2) Packing and delivery: After the crops are ripe, they will be harvest, processed, packaged and then will be transported to restaurants. This link mainly consumes electricity and diesel.

(3) Cooking: It includes storage, reprocessing and cooking, which will cost oil, gas and other energy.

(4) Post-treatment: Dispose of leftovers, kitchen waste and packing bags.

The life cycle of take-out food is similar to traditional food (Fig.1). But there is an additional link: packing and delivery after cooking.

Because of the separation between cookers and costumer, we can imagine it will consume lots of packing bags to repackaging food and cost lots of gasoline or electricity to deliver food.

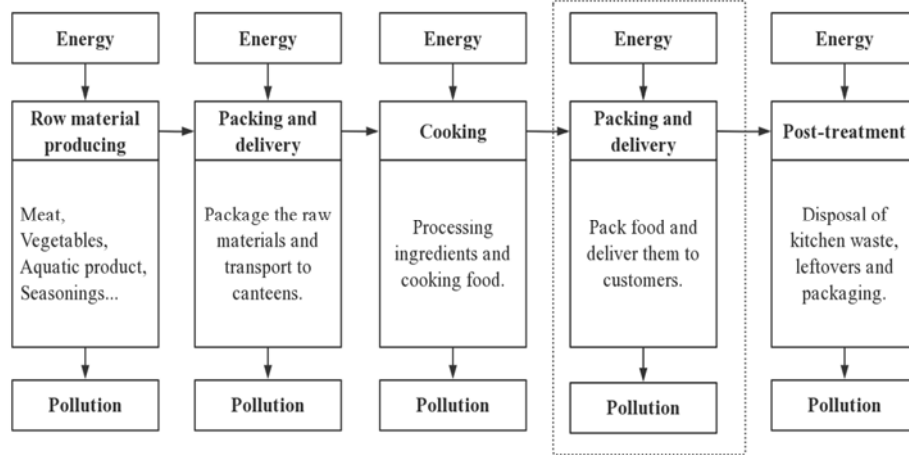


Fig.1 Life cycle of traditional food and takeout food

2.2.2 Compared links

Our research aimed to find out whether take-out food leads to higher carbon emissions. It's depended on whether take-out food causes more consumption and whether the emission will be higher for one meal. So, we mainly focused on the 'packing and delivery' and 'post-treatment' links.

Packing and delivery: The average consumption of each takeout is 3.27 disposable plastic lunch boxes/cups, 1 set of takeout tableware and 1 takeaway package [16]. Currently, most of the disposable plastic and takeout tableware is made of polypropylene [17]. Meanwhile, take away package is mainly made of polyethylene. Both main materials are non-degradable plastics, which will harm the environment greatly.

According to Research, the average distance of delivery is 6km for one meal[18]. A small mileage multiplied by a huge base will probably lead to a lot of

waste.

Post-treatment: Both traditional food and take-out food will cause waste. But different cooking methods and different amounts of wasted food can lead to extra waste.

2.3 Calculation methods of carbon footprint

Carbon footprint refers to the sum of carbon emissions generated in each activity link, usually expressed as carbon equivalent.

The calculation formula of carbon emission is as follows: [16]

$$CF = \sum_{i=1} Q_i \times EF_i \quad (1)$$

Where CF means Carbon footprint; Q_i means Quality and EF_i means Unit carbon emission factor

Through literature investigation and software query, we got the reference data of several links were as follows (Table.1-2):

Table 1 Carbon emission coefficients in Raw materials production stage

Raw materials	Emission factor	Unit	Data sources
Rice	2.7	kg CO ₂ eq/kg	Carbonstop
Beef	27	kgCO ₂ eq/kg	Carbonstop
Pork	12.1	kgCO ₂ eq/kg	Carbonstop
Fried chicken	1.8	kgCO ₂ eq/kg	Carbonstop
Egg	4.8	kgCO ₂ eq/kg	Carbonstop
Tomato	1.1	kgCO ₂ eq/kg	Carbonstop

Table 2 Carbon emission coefficients in Packing and delivery stage

Packing and delivery	Emission factor	Unit	Data sources
One-off chopsticks	1	kgCO ₂ eq/100pairs	Carbonstop
Lunch box	0.49	kgCO ₂ eq/kg	SimaPro
Electricity	1	kgCO ₂ eq/degree	Carbonstop

Through investigation and calculation, we got the parameters of each part (Table 3). EF was obtained from the weighted average of the typical foods we mentioned above. And the quantity of food will be a little bit difference between take-out food and traditional food like

meat and rice were more weight in take-out food. The packing and delivery refer to the process of food being delivered from the store to the customer, so we ignored the filling and delivery stage in the traditional way.

Table 3 Carbon footprint calculation parameters

		EF	Unit	Quantity(g)	
				Take-out	Traditional
Raw material production	Meat	12100	gCO ₂ eq/kg	150	100
	Vegetables	350	gCO ₂ eq/kg	150	150
	Rice	2700	gCO ₂ eq/kg	250	150
Packing and delivery	Disposable tableware	10	gCO ₂ EQ/pair	2	0
	Lunch box	490	gCO ₂ eq/kg	30	0
	Electricity	120	gCO ₂ /time	1	0

We chose scrambled eggs with tomatoes as vegetables to study. Each contains 50g eggs and 100g tomatoes. For meat, beef contains 50g and pork contains 100g. And for rice, you can get 150g rice for once in the canteen and 250g in take-out food. If you order a piece of fried chicken, you will get around 200g for once. Based on the data above, we could calculate the extra emission in take-out food compared to traditional food.

times in a week. And 71.21% people order takeout more than 3 times in a week. The main reasons for them to order takeout were time-arrangement and poor tasted canteen food, which more than 45% chose.

According to the results, we could see students like to order barbecue, fried rice and milk-tea best. And by comparing the data, we can conclude: Takeout wastes less meat than traditional food. Only 2.95% of people waste more than 50% meat if they order takeout, but there are 16.62% people in the other situation. They waste almost the same on vegetables. But takeout wastes much more rice than traditional food apparently (Fig.2). More than 60% of people will strain no less than 30% rice if they order takeout, but the number will be cut down to 37% if it comes to eat in the canteen.

3 Result

3.1 Survey results

We had 373 participants, 107 high school students, and 266 college students. 28.69% of people order takeout 0-2

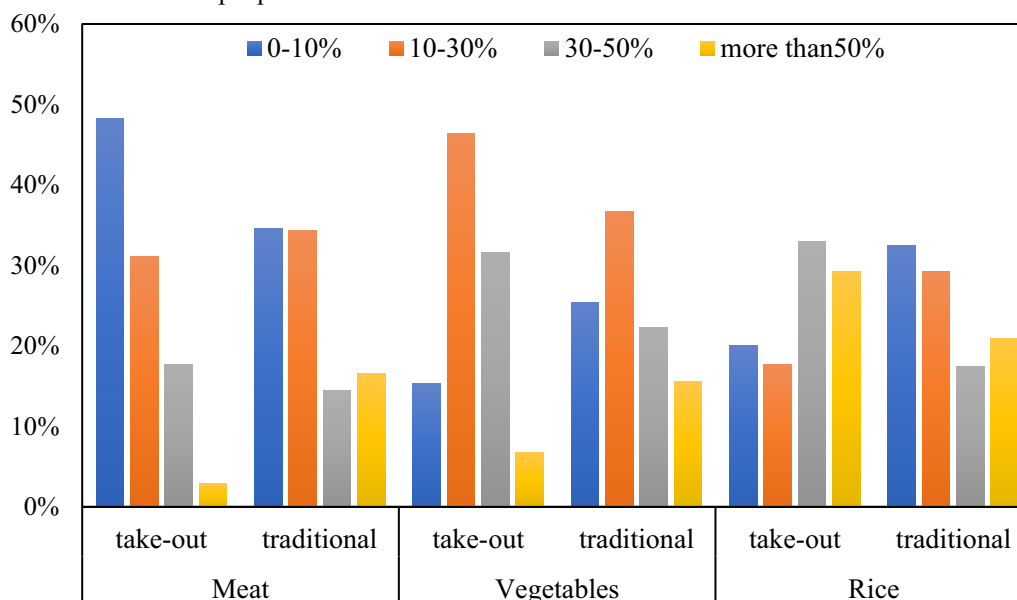


Fig.2 Waste of meat, vegetables, and rice in two situations

Furthermore, we studied how the promotion policy on takeaway software affects the customers. Because this was a multi-topic, there was no significant gap between the options. But we could still conclude that people will tend

to choose shops with total discount and order much more than they need, which means they will be affected by the promotion policy.

Table 4 People' attitudes towards promotion policy

Option	Proportion
Priority will be given to shops with the total discount	49.33%
Just order what you want	44.5%
Although you do not want drinks or dishes, you will choose a package	46.11%
To make up for the decrease, you will often order more	47.99%

Finally, we investigated the views of the people on the takeaway package (Table 5). This was also a multi-topic. We could see that 52% of people, who chose the second

and fourth choice, were environmentally conscious and willing to make concessions. But it was still too few for environmental protection.

Table 5 People' attitudes towards taking away package

Option	Proportion
The separate packaging of each part is reasonable	49.87%
It is not environmentally friendly to pack all the parts separately	52.01%
It is acceptable to add ingredients to food without disposable tableware	46.11%
In the future, we must reduce the consumption of packaging	52.55%

3.2 Carbon footprint calculation results

We got the total consumption of the two methods in the two links (Table 6). We could see the waste of take-out

food was much higher than traditional food. It caused 34.6% more consumption if we order take-out food. The waste of rice played a critical role in this result. Though the stage of packing and delivery only occupied 2.4% of the total consumption, it could be a large number with the amount increasing.

Table 6 Carbon footprint calculation results

		Sum(gCO ₂ eq)	
		Take-out	Traditional
Raw material production	Meat	325248	324885
	Vegetables	14553	15319.5
	Rice	267637.5	121986
Packing and delivery	Disposable tableware	20	0
	Lunch box	14700	0
	Electricity	120	0
Sum		622278.5	462190.5

4 Discussion

From the results, we can see that people will order takeout for various reasons. In a way, ordering takeout has become the spice of life. We can also see that taking out is a waste of extra resources compared with eating in the canteen. Taking 39 million college students in China as the base, and if each person orders 3.5 takeout times a week[16]. Then multiplying by our calculated waste rate, we can get the conclusion that we will produce an extra 1.2×10^{12} kg CO₂eq, which means we should plant 1.2×10^9 trees to offset emissions.

So why does takeout lead to more waste? We think there are several reasons: Rich promotion methods will lead to unnecessary waste [19]. People usually order an

extra chicken leg or a bottle of drink for the sake of complete weight loss. Too much weight leads to waste. We can see less meat left in takeout from the questionnaire, but the calculation is not like this. That's because takeout usually contains more amount in one piece of food. The variety of food leads to the waste of rice. Rice in takeout usually fills a whole lunch box, and a total amount of food will lead to people eating first and then having more rice left. So, the extra waste from rice accounts for most of it. Nondegradable and complex packaging. We can know that we still hope that the takeout can be packed separately through the questionnaire survey. This will result in an average of two plastic bags, three lunch boxes, and a set of cutleries for a takeout. Although the carbon emissions caused by takeaway account for only 2.4% of the total emissions, most of the packaging is difficult to handle, and the impact on the environment cannot be ignored.

To deal with the problem, we propose several suggestions: For the sellers: The seller can divide the food into different weights and write down the reference amount of other people to prevent unnecessary consumption. For government: The government needs to implement environmental protection materials for takeaway packaging materials and give appropriate subsidies. And for consumers: To try to point for their weight, not affected by promotional activities, you can accept takeout, not independent packaging.

5 Conclusion

The Research showed that people now had to live with the service of online to offline food delivery. Their lives could not live without it because most of them thought the dining hall tasted bad, and their time arrangement did not allow them to go dining hall. It seemed that people were unwilling to have meals with dine-in due to the fast life pace. Meanwhile, according to the questionnaire, it showed that over 70% of students had to order takeaway more than three times a week. The times they called takeaway proved the significance of takeaway food in catering. When the online to offline food delivery service began to grow, the comparative research and technology should change to match the development of takeaway food in waste dealing and packaging.

According to the Research in the classification of food ordering, it is found that students like barbecue, fried rice, and milk tea best. As a result, people wasted less meat on takeaway food rather than that in the canteen. They were prone to finish meat when ordering a takeaway. For vegetables, both takeaway food and dine-in is nearly 30%. However, takeaway wasted about 10% more rice than dine-in. The research figured out that people ordered diverse vegetables in takeaway food and were prone to finish vegetables first. The consequence was much more rice was left in take-out food.

At the same time, the promotion policy of application also aggravated the waste problem. The adverse effects would attract people to order more to get the discount. However, it exacerbated the waste condition. People tended to order more food that they were unable to eat up just for those discounts. This part of the food was wasted due to the abuse of promotion strategy and value of food delivery applications. It affected customers and led to a dire consequence of food waste.

In addition, people were working together to make takeaway food more environmentally friendly. Less than half of the questionnaire participants often choose for environment protection. The others would still prefer to make concessions for a lower price in takeaway food even though they did not need it. There was still much space to endeavor. The good news is that over half of people thought that packing food separately was bad for the environment and would reduce using packaging in the future.

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