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Chapter 30
A Sustainable Product-Service System (PSS) Design for Retail Food Loss and Waste: Research Through Design

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30.1 Introduction

30.1.1 Research Background

In the coming years, increasing population and rising incomes will lead to much more consumption of meat, dairy and biofuel around the world, which will place unprecedented demands on the world's agriculture and natural resources [1]. What's more, agriculture is one of the main causes that results in extreme climate change, biodiversity loss and degradation of land and freshwater [2–4]. A recent study conducted by Food and Agriculture Organization of United Nations suggested that about one-third of food is never consumed [5], others have suggested that nearly half of all food grown is lost [6] and some perishable commodities have post-harvest losses of up to 100% [7].

Food wastage results from a complex pattern of extremely diversified and interconnected causes. Developing countries lose more than 40% of food post-harvest or during processing due to insufficient infrastructure in harvest and a limitation of the storage and transport conditions. Industrialized countries have

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lower producer losses, but at the retail or consumer level more than 40% of food may be wasted [4].

The food waste phenomenon that majorly occurs in developed countries and it is more likely to occur in downstream of the food supply chain, for example, in the interaction between retail, food service and the consumers [7–9].

There are many causes of food waste explained by inherent characteristics of food products and the ways they are produced and consumed, individual behaviours and general expectations of consumers towards food non-readily changeable. Besides, consumers demand high quality of food. Normally, they are unwilling to buy food that looks odd. In addition, non-use or sub-optimal use of available technologies, organizational inefficiencies of supply chain operators legislation and bad behaviours of consumers depending on unawareness, scarce information and poor food skills will lead to food wastage [10].

30.1.2 Product-Service System and Sustainable

Product-service system (PSS) combines tangible products, intangible service and infrastructure elements to satisfy consumers' needs, reducing environmental impact and bringing more competitive advantages [11, 12]. In the past decades, product-service system (PSS) has received much societal attention as a business strategy for sustainable development [13]. Tukker [12] classified PSS into three types: product-oriented PSS, use-oriented PSS and result-oriented PSS. In product-oriented PSS, the provider sells a product to consumers with some extra services (e.g. advice and consultancy) to support the products to be sustainable in the use phase. This type of PSS focuses on providing added value to minimize costs for durable products in a long term [14]. In use-oriented PSS, the product stays in ownership with the provider. Consumers do not purchase products; instead, they pay for the use of the product or take advantage of the availability [15] (e.g. Product lease, Product renting/ sharing and Product pooling). Through this type of PSS, the products sometimes can be shared with a number of consumers to maximize and extend uses and lives, respectively [13, 16]. Result-oriented PSS offers a consumer a result or outcome rather than a product [16]. The customer pays only for the supplier providing the agreed-upon result (e.g. cleaning) [14].

Previous research pointed out that result-oriented PSS had the highest environmental sustainability and innovation level [11, 16]. Therefore, it was selected as our design direction.

Sustainable innovation is defined as 'the development of new products, processes, services and technologies that contribute to the development and well-being of human needs and institutions while respecting the worlds' natural resources and regenerative capacity [17]. It considers human health, equity and environmental and economic balance in the whole life cycle of the product or service or production-consumption systems [18, 19]. Furthermore, sustainable innovation is a key to

enable green and growth to go hand in hand, and design has gained the multidisciplinary expertise to drive it in the right way [20].

30.1.3 Research Aims and Questions

Reducing food waste can contribute to overcoming a set of sustainable problems. However, there is a poor understanding of causes and coping strategies for food waste throughout the supply chain in China [21]. Due to the growing affluence, continuing urbanisation, consumer food wastage in China is estimated to continue to increase in the future [21]. Therefore, this study aimed to observe the existing food waste phenomena and look for potential solutions to solve them from a sustainable product-service system design perspective. In this study, the authors answered the following questions:

1. What are the causes resulting in food waste in the process of marketing chains and distribution, and consumer purchases?
2. How to solve the food waste problems from a sustainable product-service system design perspective?

30.2 Methods

A Research-through-design (RtD) method was performed in this study. RtD is defined as knowledge generation through design actions as well as research structures from other disciplines (e.g. Psychology, engineering or anthropology) [22]. This method is regarded as conceptualizing research done utilizing the skilful practice of design activities revealing research insights [23]. With regard to the result-oriented PSS, designers need to carefully explore end users' (buyers and sellers) requirements for defining the appropriate service level in the design process [24]. Thus, it was important to know end users' opinions through interviews. By following the RtD methodology, a set of design methods were used in the design process.

Firstly, the authors used the ethnography-field research method in the supermarket and wet market in Wuxi China. The authors collected the evidence and causes of food waste through observations. In this stage, the authors mainly observed consumers' selection process of food products, then analysed what kind of product conditions were preferred by the consumers.

Secondly, to understand the impact of food waste on those people who work in the relevant fields, the authors conducted semi-structured street interviews in the wet market and the supermarket respectively. The participants (over 18 years old) were selected randomly, but with the main focus on local retailers, salesmen and pass-by

consumers in the above two places. The questions used in the interviews, including five aspects as the following to understand the current food waste situation:

1. The ways retailers, salesmen and/or consumers have used to deal with the decayed or surplus food;
2. The ways they have used to deal with inedible part of fruit and vegetables (e.g. peel and kernel of fruit);
3. The general interactions between retailers, salesmen with consumers;
4. The common consumers' behaviours in selecting process;
5. The incentives they have used to trigger consumers' purchase intentions.

After understanding the phenomena in the real world, the authors generated the main insights and brought them to the sensorial brainstorming session [25]. Designers were required to generate design ideas responding to the problems which were observed in the field research. The design process was useful to identify some elements that could be applied in the potential solutions.

This ideation phase resulted in several basic design directions. After evaluating the generated design ideas through several parameters, one solution was expected to be selected and further refined.

30.3 Results

30.3.1 Causes of Food Waste

To study and understand the current situation of food wastage in Chinese markets, an observational study was performed in a wet market and a supermarket in Wuxi. As Fig. 30.1 presents, the authors observed that food waste phenomena were remarkable and universal in the markets. Among the wasted food, the amount of fruit and vegetables which have a short shelf life occupied the largest proportion. Plenty of vegetables and fruit which had ugly shapes, or seemed like not fresh very well were treated as rubbish and threw into the garbage or on the street.

The authors observed that most consumers had negative consuming behaviours; they preferred to select apples, watermelons or potatoes by pinching, rolling and tapping them. These behaviours may cause scars on the surface of the food products, and lead to a negative effect on further sales. Besides, the authors noticed that the supply and demand were unbalanced, consumers, normally, had limited demands on the amount of food. Therefore, if the market managers reserve too many food products, such as cherries or blueberries, that have a short shelf life, it may lead to large overstocks.

To know how do sellers in supermarket and/or small retailers in markets deal with the overstocks, the authors conducted semi-structured street interviews. Sixteen persons were randomly invited to participate in the street interviews; they were retailers in the wet market, salesmen in the supermarket and nearby consumers. All of them said they had realized the significant food waste phenomena in markets.

Fig. 30.1 Food wastage observation

Most consumers said it was normal and necessary to select the fruit by looking at its appearance and feeling the tactile of goods. These behaviours can help them identify high-quality products. Some consumers expressed that they prefer to buy fresh vegetables, which have better looks and are of very high quality.

The salesmen and retailers said that it was a common phenomenon for them to throw the unmarketable food products into the garbage. They had to deal with the overstocks in a short time because of the limited storage places. Although they have

Fig. 30.2 Food wastage phenomena

tried to offer a discount on stale vegetables or fruit that can still be edible, there were still remaining a lot of surplus food. Even though they were willing to offer the food to the person who needs it, there were plenty of barriers that stop them to do like this. For the small retailers in the wet market, it was hard for them to find a person who wants to accept the surplus food. People in China currently have a better life quality; they pay more attention to their health in daily life. They believe that 'you are what you eat', and they worry about the freely surplus food offered by the retailers is bad for their body health. For the salesmen in the supermarket, they were not allowed to offer food to others for free because of the strict company regulations. Therefore, one of the most common ways for them to solve the surplus food was to throw it into the garbage. Even though they expressed that sometimes they also felt guilty and realized this was a waste of resources, and it was not a sustainable lifestyle. They can't find another suitable option to address the surplus food. As Fig. 30.2 presents, the authors picked up some wasted food, which was thrown by the retailers and salesmen, from the garbage. The wasted food either looked odd or not fresh at all.

The authors identified four causes that resulted in food waste and loss in the process of marketing chains and channels for distribution, and consumer purchasing from the observations and semi-structured interviews. The causes were divided into four aspects: (1) Consumers' consuming preference and behaviours; (2) A lack of channels to share surplus food; (3) A lack of effective utilization of the nearly expired food; (4) Unbalanced supply and demand between consumers and sellers.

30.3.2 Potential Design Solutions

The authors kept the observed problems in mind and attempted to find design solutions to address these problems through brainstorming. As Fig. 30.3 presents, during brainstorming sessions, four design directions included eight design ideas were proposed from two perspectives to address food waste generation and deal with

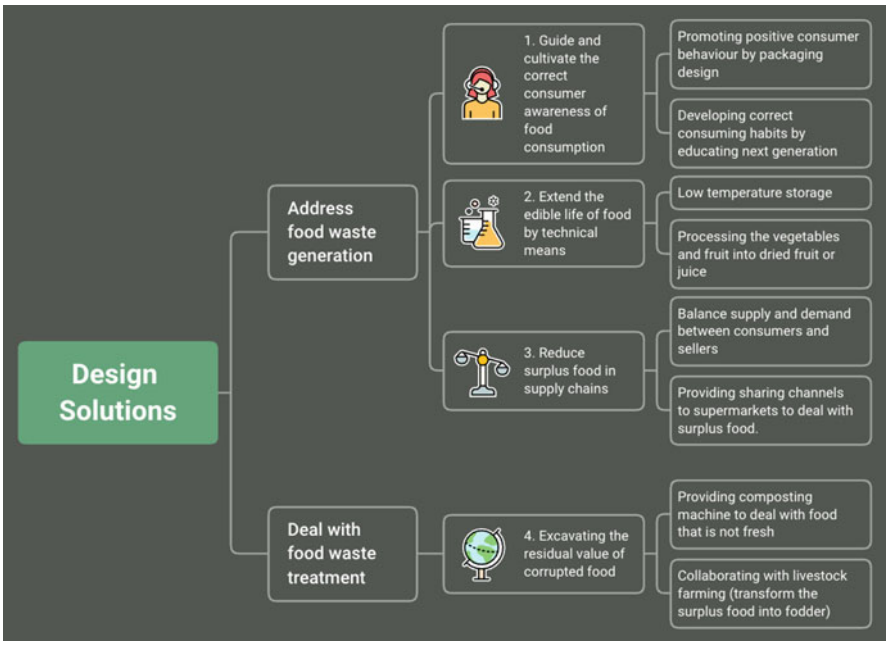

Fig. 30.3 Potential design solutions

the wasted food. (1) Increasing sustainable food consuming awareness and guiding positive behaviours; (2) Extending the edible life of food by using technical means; (3) Reducing surplus food in supply chains and establishing redundant food sharing mechanisms on the retail side; (4) Recycling and utilizing the decayed food.

In order to choose one of the most suitable directions and further develop it, we chose five scales which were excellent (4 points), good (3 points), fair (2 points), poor (1 points), very poor (0 points) to evaluate the generated design concepts' quality. The quality evaluation parameters were the potential level of feasibility, acceptability, completeness, flexibility, social efficacy and user empowerment of each design solution. Finally, the ideas of balancing supply and demand between consumers and sellers, and providing a composting machine to deal with the decayed food won the first place by obtaining 18 points. The design idea of developing sustainable consumption habits by educating the next generations won the second place by getting 17 points. Therefore, the authors decided to propose a sustainable result-oriented PSS by combining the top three design ideas.

30.3.3 A Case-Study

Considering food security-relevant issues, based on the results of observations, interviews, brainstorming and evaluations, a sustainable result-oriented PSS called

'Refresh' product-service system, which contains a mobile application and a composting machine, was proposed as the final design deliverable to solve the fruit and vegetable waste problem in the markets. The mobile application was designed to address food waste generation by balancing the supply and demand information from both supermarket and consumer sides, and providing educational information to trigger sustainable food consumption awareness for the public. The composting machine was designed to deal with the already wasted food by composting the decayed food.

The app and machine were the touchpoints of the 'Refresh' PSS which can help to save resources in supermarkets before and after generating the wasted food. 'Refresh' PSS provided a sustainable way to help users get much more fresh fruit and vegetables, and gave new value to the decayed fruit and vegetables.

As Fig. 30.4 presents, in this new PSS, relationship between six stakeholders, namely the third platform refresh, supermarkets, consumers, flower markets, primary schools and logistics companies, was considered. By adopting the sales model of online booking and offline purchasing to help solve the problems of retail food loss and waste before retailer purchasing.

In this product-service system, there were four flows, including capital flows, material flows, labour flows and information flows, in terms of two layers (i.e. the core layer and the second layer). The core layer represents the main flows between the multi-stakeholders in the product-service system, such as the capital flows between the third platform 'Refresh' and the rest stakeholders. 'Refresh' platform needs to place the composting machines in the supermarkets, which takes place in the markets' physical space. At the meanwhile, the markets need to sell and advertise their products on the 'Refresh' application, which utilizes the capital resources of 'Refresh'. Besides, consumers also contribute capital flows to both 'Refresh' and 'flower shop' by consuming products. The fertilizer produced by 'Refresh' would be delivered by the 'Logistics' company to the 'Flower shop' and sold here. Therefore, the 'Refresh' platform needs to pay for the delivery, and the 'Flower shop' needs to pay for the fertilizer, too. Compared to the core layer, the second layer presents the potential or minor flows between each stakeholder, and it refers to less contributions to the workflow in the product-service system. For example, the 'Refresh' platform may organize the food saving-relevant education and training activities at the 'Primary school'. However, these activities are not the main business of the 'Refresh' platform. Therefore, the labour flows from the 'Refresh' to the 'Primary school' is a second layer.

The product-service system provided two approaches for reducing food waste in supply chains and one way to deal with wasted food. Two approaches were (1) balancing the supply and demand: supermarkets can accurately estimate reasonable supply according to consumers' reservations, then reducing the food waste caused by potential overstocks; (2) linking consuming behaviours with the public welfare education: consumers can order fresh fruit and vegetables based on their demands at a reasonable price from nearby supermarkets by using the 'Refresh' app, they can follow the information about the production and delivery of their ordered food at any time. Then they are able to set a shopping filter based on their diet plan to

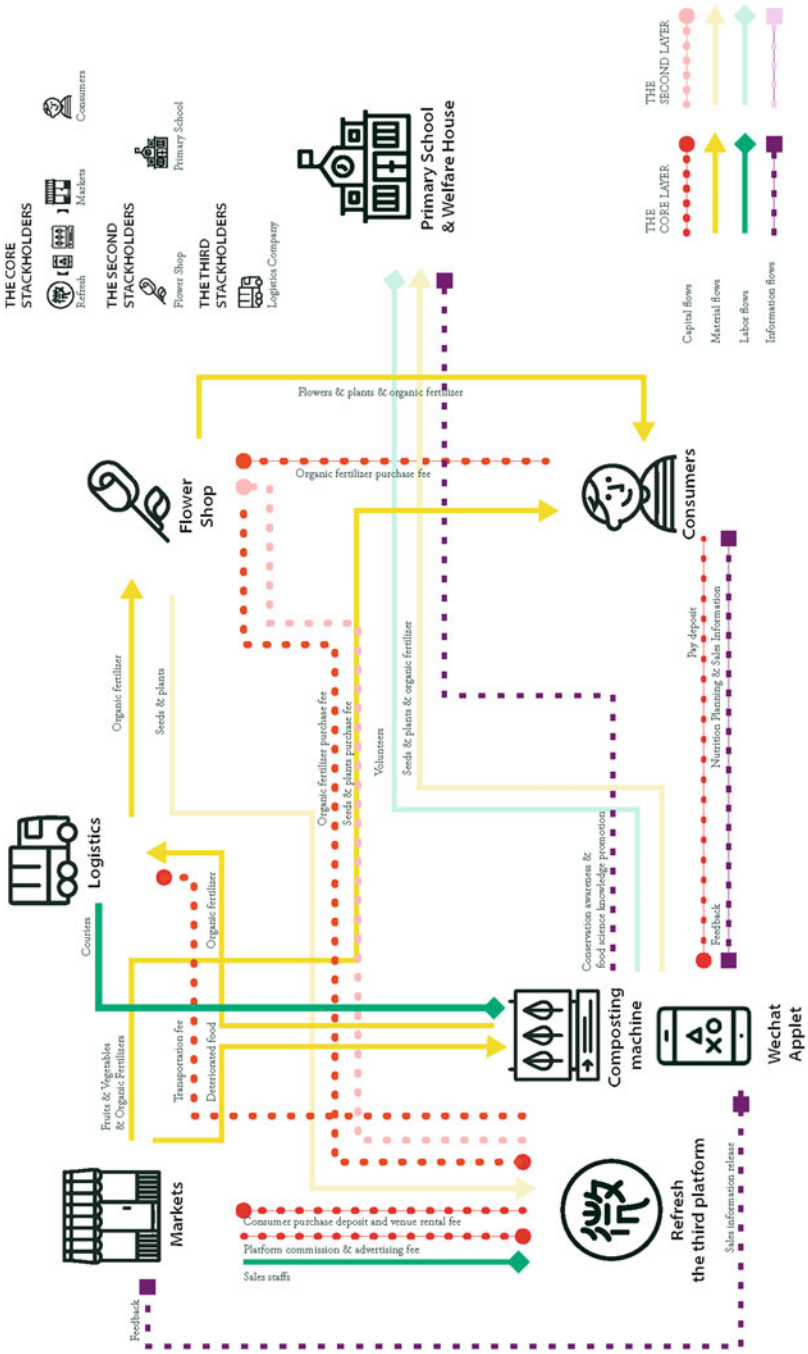

Fig. 30.4 'Refresh' sustainable service system map

Fig. 30.5 Mock-up interface design of 'Refresh' app

help them make shopping decisions. And the number of their consumption times can be exchanged for equivalent virtual public welfare education energy value to support sustainable food consumption education. One way was (3) providing composting machines: both sellers and buyers can use the composting machines to deal with their wasted food. By using the composting machines, the decayed fruit and vegetables are able to convert into organic fertilizer for selling; this provides an opportunity to save resources from the wasted food.

Figure 30.5 presents the mock-up interface design of the 'Refresh' application for the mobile version. It shows different user interfaces, including landing pages, home pages, event pages and setting pages. When the end-users first launch this mobile application, they can see a simple splash screen that presents the brand logo. And then they can choose to sign in or sign up for this application. After that, three

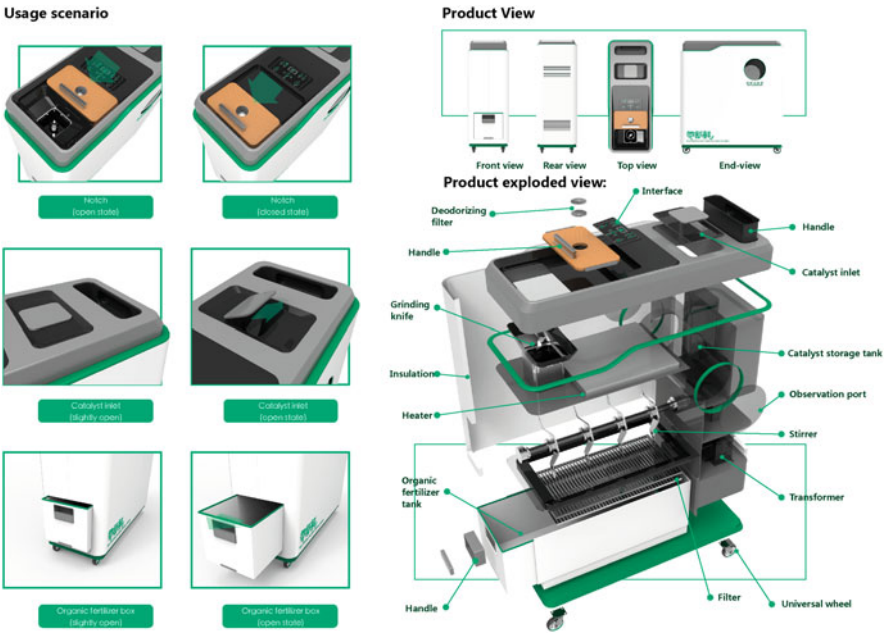

Fig. 30.6 3D modelling product design of 'Refresh' composting machine

onboarding screens will help users to be familiar with the three key functions of this application, including (1) Reservation function: users can order fresh vegetables and fruit from nearby supermarkets by browsing catalogue screens and product card screens, and they can obtain discount information in the nearby supermarkets, too; (2) Bonus activity: they can take part in specific activities (such as helping the nearby primary schools get free food saving education and training activities for experiencing planting) by accumulating and redeem their shopping points; (3) Personalised diet: users can list their nutrition needs based on their health conditions and allergies, then they can set up their shopping filters to choose the food products that they need and/or like, also skip the food products that they allergic to and/or dislike.

Figure 30.6 shows the 3D modelling product design of the 'Refresh' composting machine which can help sellers and buyers deal with the decayed food and transform it into fertilizer. Therefore, it will help to reduce the waste of resources, and the produced fertilizer can be sold at flower stores and supermarkets to obtain extra profits.

30.4 Discussion and Conclusion

30.4.1 Discussion

Food waste has always been a complex issue involving multi-stakeholders (from producers, processors, transporters to sellers and consumers) and multiple sectors (from the Ministry of Agriculture to market control to the government). The development of retail food sustainable service system is also affected by many factors, such as the characteristics of consumers, the market background of new retail and the cooperation of supermarkets. Therefore, one limitation of this study is that the collected data is limited in analysing the inter-relationship between each factor. Besides, how to implement this new sustainable PSS, and expand the influence and cultivate the user's usage habits need to be further investigated. Additionally, the proposed mobile app and composting machine are applicable primarily on the retail supermarket. Even though in the beginning, we focused on both supermarket and wet market; however, after finishing the observational studies, we found that the situation in wet market was far more complex than the context in supermarket. Therefore, the final results were focused on solving the food waste problems in the supermarket. We suggested that there were need more specific design solutions for solving the food waste problems in wet market. Also, we didn't produce the detailed recommendations for the education and training programs in our results. We think it would be helpful if there are more further studies focus on investigating what and how the education and training programs for consumers should be developed and implemented for improving their sustainable consuming awareness and positive consuming behaviours.

Another limitation of this study is that some design methods used in this study for generating design ideas, such as brainstorming, were hard to be scientifically repeated. Brainstorming basically depends on the involved designers' previously design experience and research knowledge, which normally impact the creativities and innovations. However, we think this is a common limitation in most design activities, and we believe that the design rationales and outputs of this study can be used as insights to inspire more design solutions for solving food waste problems.

Short distances and direct relationships between producers and consumers represent an emergent form of food governance. What's more, a large number of literary studies have found that the longer the food supply chain, the more likely it is to cause food waste [26]. Although we didn't shorten the supply chain, we proposed to establish a 'Refresh' platform to bridge the relationship gap between buyers, sellers and even farmers. The visible information about demand and supply relations and online pre-sales help buyers and sellers reflect upon their use of resources and make informed decisions, thus eliminate food waste caused by information asymmetry. To get bigger achievements, we need to test if this solution can help reduce food waste in practice and consider how to further shorten the distance between consumers and producers, and establish a direct relationship.

30.5 Conclusion

This chapter contributes by providing a promising solution to tackle the food waste. The observational results in this study presented that the vegetables and fruit waste phenomena were significant in supermarkets and wet markets in China. Four key causes that result in food waste were concluded: (1) Consumers' consuming preferences and behaviours; (2) A lack of ways to share the surplus food; (3) A lack of effective utilization of the nearly expired food; (4) Unbalanced supply and demand between consumers and sellers.

Four design opportunities were generated as the following: (1) Increasing sustainable food consuming awareness and encouraging positive consuming behaviours on the public; (2) Extending the edible life of food by using technical means; (3) Reducing the surplus food in supply chains and establishing redundant food sharing mechanisms on the retail side; (4) Recycling and utilizing the decayed food.

This study explored the potentials of sustainable PSS for retail food from a downstream perspective of the supply chain by considering ways to improve supply chain efficiency and reducing excess inventory in the retail system. In the end, a sustainable PSS was proposed by combing an application and a composting machine to balance the supply and demand relationship between buyers and sellers. It adopted the sales model of online booking and offline purchasing, which helps to solve the problems of retail food waste before retailer purchasing. And the composting machine could be used to recycle the expired food.

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