

# National review on food waste recycling into animal feeding in China



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## National context of Food waste

China is the country with the biggest population country in the world and the food waste has been a problem in the country. It is said that nearly two million tons of food wasted every year from the restaurants and canteens in over one hundred medium and large cities in China which has resulted in serious environment pollution and resource waste (Ding et al., 2011). According to the news, the total value of food wasted is around 200 billion RMB and the amount can afford 200 million people for one year<sup>1</sup>.

The amounts of food wasted are slightly different across cities. In Shanghai city with around 17.66 million population in 2003 which located in the eastern China and being the commercial center, it is estimated that around 1,100 tons food wasted daily, 56% of them are commercial food waste from the restaurants and canteens and over 30% from enterprises, institutes and schools (Xia and Zhou, 2003). Similarly, in Beijing, a city with 14.56 million population which located in the north part of China and being the capital city, there are around 1,200 tons food wasted every day and over 80% from the urban and centre districts while nearly 20% from peri-urban and rural areas (Xia and Zhou, 2003). On average, it is estimated that 0.1 kg food waste per person is being produced every day in the urban area in China which produced nearly 60 million tons of food waste every year.

The Golden Beetle is a company engaged in waste processing in Beijing. They have conducted an experiment in three compounds in the south part of Beijing in 2014 which covered 8,021 households. They sent the transportation and staff to collect the waste in the compounds and separated them in the sorting room for three months. It shows that on average 7,128 kg rubbish was collected every day, i.e. one household produced 0.89 kg garbage daily. Of them, 2,393 kg are food waste which not includes the water and oil which mixed by the dry-basis and wet-basis rubbish. That is, over one third of the rubbish in Beijing is from food waste (Figure 1). Usually there are around 3 - 4 persons in the compounds, which indicates that each person produce around 0.2 food waste every day. Since the compounds selected are all located in the center, the rate of food waste might be higher than the national average estimation, 0.1 kg per person.

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<sup>1</sup><http://news.sohu.com/20141021/n405328617.shtml>

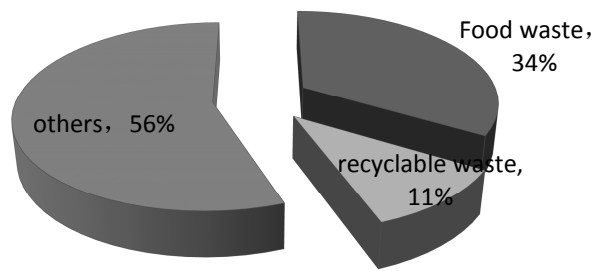


Figure 1. Component of the waste in the sample communities in Beijing

In China, food waste has been paid more and more attention recently. Particularly since June 2013, the county started “to clear your plate” campaign to encourage and appeal the public to reduce wasting food. According to the media<sup>2</sup>, the protein and fat wasted in the catering industry from 2007 – 2008 is eight million and 3 million tons, respectively, which could afford the demand of 260 million and 130 million people, respectively. The news of CCTV (China Central Television) on January 22<sup>3</sup>, 2013 reported that the value of the food wasted from the Chinese table is around 200 billion RMB which could afford over 200 million people for one year. With that, the restaurants started to provide the half order or small plate which may be helpful to reduce the amount of food waste. Due to the change of the traditional “dinner social activity”, it is expected that the amount of food waste would be reduced in the future.

To our knowledge, there is no study to project the amount of food waste in China. However, the amount of 0.1 kg food waste per day per person is reasonable. In the experiment by Golden Beetle company, each person produces 0.2 kg food waste every day in the urban compounds in Beijing. In the earlier literature, it is said that urban area accounts for over 80% of the food waste in Beijing. Taking the distribution of the population into consideration, it is reliable to take 0.1 kg per person per day as the basis to project the food waste in the future.

The general picture of the population would be helpful for the estimation. Although the size of the population in China has been increasing in the last decades, its regional structure has changed gradually. The number of people in the urban areas has been increased and was more than that in rural areas since 2011.

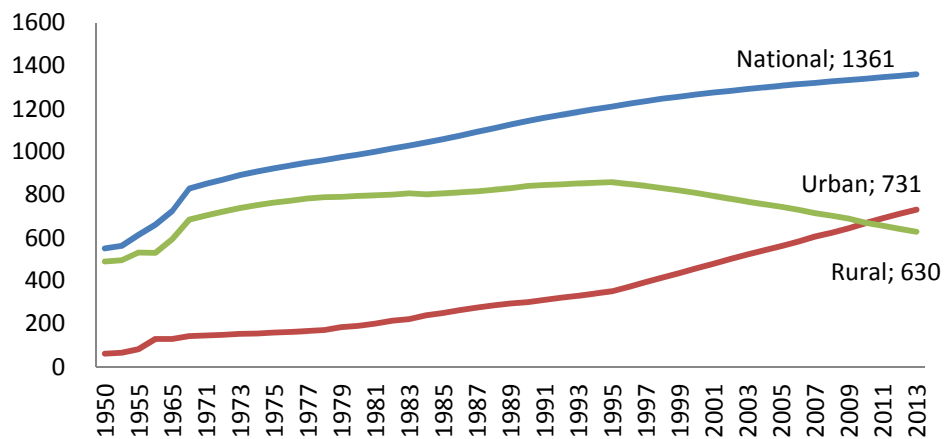
<sup>2</sup>

<http://baike.baidu.com/link?url=luKviCWCxQKdKk6flGVisCxcLhN2RPMU3yTC8jdXq17mVsIHYE52iH-1mvyuMoNmAPQYSqHpRiXDd0yHynA8MK> (Chinese)

<sup>3</sup> <http://finance.sina.com.cn/china/20130122/204914367214.shtml> (Chinese)

By the end of 2013, according to the national statistics, the share of the population in urban areas is over 50% and there have been 731 million people stay in the cities and counties (Figure 2). As China has been implemented urbanization continuously, it is projected that the urbanization rate in 2030 and 2050 would be 68% and 81%, respectively (Chen, 2006). As the population size is projected to be 14.4 billion and 13.8 billion in 2030 and 2050, it means there will be around 98 million and 112 million people in the urban areas in China in 2030 and 2050, respectively.

Figure 2. The population trend of China in 1950 - 2013  
(million persons)



It is expected that the rate of food waste would be reduced continuously in the future due to the change of the traditional habit, especially for the migration from rural areas to the cities. If we assume that each person would produce 0.1 kg and the 0.025 kg food waste daily in the urban and rural areas in 2030 which is quite similar to the rate at the moment. For one thing, the experiment by the company in Beijing still somehow indicates the rate of food waste is still quite high in the big cities, 0.2 kg per person per day comparing to the 0.1 kg in the earlier studies. For another, the food waste produced by the urban population is around three times than that in rural areas in the earlier studies. Considering the structure of the population and habit change, we think it is reasonable to keep the rate of food waste as 0.1 kg per person per day in the urban areas. However, in 2050, it is expected that the rate of food wasted per person per day should be much lower than that in 2030, if we assume that the rate in 2050 could be 50% lower than that of 2030. With that, the amount of food waste in 2030 and 2050 might be 109.56 thousand and nearly 60 thousand tons, respectively.

The calculation is as follows:

Amount of food waste in 2030 = urban population \* 0.1 + rural population \* 0.025;

Amount of food waste in 2050=(urban population\* 0.1+rural population \*0.025 )\*50%

Table 1. Projection of the food wasted in 2030 and 2050 in China

	National population	Urbanization rate (%)	Urban population	Rural population	Foodwaste (tons)
2030	144155	68%	98025.40	46129.60	109557.8
2050	138279	81%	112005.99	26273.01	59287.12

## Management of food waste

It has been a long way for China to continuously modify the regulations and laws on food safety. It could be divided into three periods as follows (Ni and Xu, 2012): (i) Budding stage of 1949 – 1963. At the moment, there is no formal and official law on food safety. Until 1953, the state started the food investigation and speculation. (ii) the Developing stage of 1964 – 1979. The food safety management was proceeding to the law-based control associated with comprehensive administration as well as multiple channels management. In 1964, the first regulation on food safety was released by the Ministry of Public Health and Ministry of Commerce which was officially released by the State Council of China. (iii) Stage of maturity of 1981 – 2009. The first Food Safety Law was officially released in 1995. By the end of 1998, there were 463 documents in total relevant to food safety including 236 regulations on the standards of food safety and 227 inspections. Although the Food Safety Law was modified in 2009, there is no specific authority or institute to implement and coordinate with different administrative departments. Thus, in February 2004, National Food Safety Commission (NFSC) under the State Council was established. Now the current government authorities involved in food safety supervision and management in China are shown in the following Figure 4.

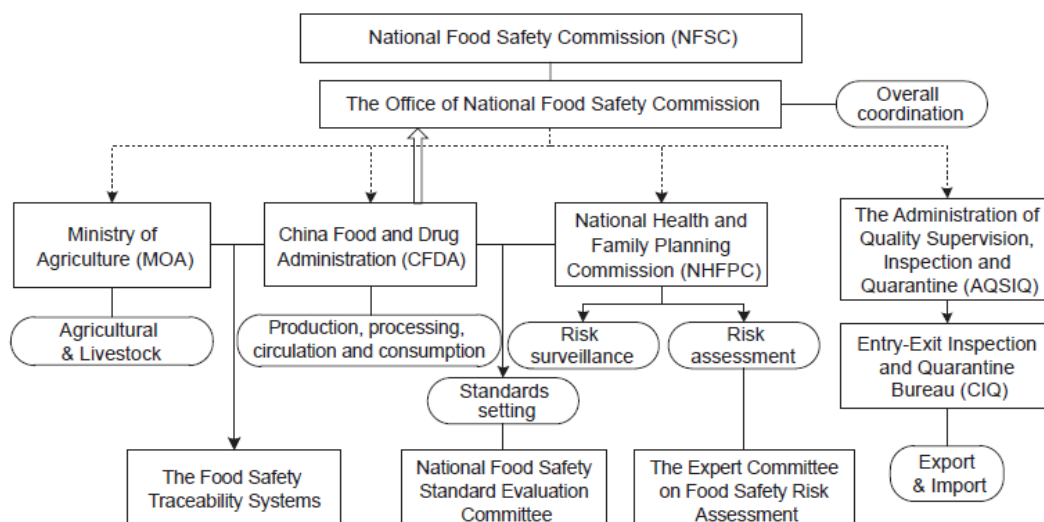


Figure 4 Current government authorities involved in food safety supervision and management in China

In the new 2015 edition's Food Safety Law (FSL) clearly claimed to "establishes the food safety traceability systems that cover the whole process" (Article 42, 2015 FSL). The food producers and traders are encouraged to "adopt information technology measures in collecting, retaining production and trading information and establishing the food safety". "The CFDA will work with MOA and relevant departments to establish the coordinated traceability system for food safety that covers the whole process" (Article 42, 2015 FSL).

The management of food waste is still as a new topic in China. Initially the relevant policies and documents were particularly for the domestic waste rather than food waste. Food waste was defined as one kind of domestic waste in the Law of the People's Republic of China on the Prevention and Control of Environmental Pollution Caused by Solid Waste in December 29, 2004. The particular regulations on the management of domestic waste were released by the Ministry of Housing and Urban-Rural Development of the People's Republic of China (MOHURD) on April 10, 2007. It is required that hotel, hostel, restaurant and canteens should collect and keep the food waste properly and then give the food waste to the authorized enterprises. It is regulated that the pollution discharger is the subject of responsibility.

People started to pay attention on the topic due to the increasing concerns on food safety issues, especially the spread of bovine spongiform encephalopathy (BSE) and mouth-and-feet disease in late 20<sup>th</sup> century. In 2009, the food safety concern was raised widely by the collection and transportation of food waste in China. With that, the particular regulations on the management of drainage oil and food waste were issued by the State Council in July 2010. On March 23, 2011, the government planned to implementing separate waste collection in 50% of living areas in urban China on the food waste collection and processing.

There are several departments involved in the food waste management. Basically Ministry of Housing and Urban-Rural Development of the People's Republic of China (MOHURD) is mainly in charge of food waste management. However, more departments need to be involved as the management is complex and comprehensive being associated with resource recycling, pollution control, investment and so on. There are 15 departments involved. At the moment, in terms of the specific functions, at national level, it is State Development and Reform Commission for the investment and budget, Ministry of Housing and Urban-Rural Development of the



People's Republic of China (MOHURD) in charge of project plan, design and construction, Ministry of Environmental Protection in charge of the environmental standards and pollution control, General Administration of Quality Supervision, Inspection and Quarantine of the People's Republic of China in charge of products and residues of food waste processing and management. In addition, the public health departments and market management departments are also involved. Thus, food waste management has been coordinated with multiple departments in China.

Except the national policy has been released and implemented on the management of food waste, there are more and more provincial and city level regulations issued. Table 2 indicates the regulations and policies related to the management of food waste. The national level is on the state policy, strategy planning, laws and the national standards as well as supervision on the provincial work. The responsibility of provincial departments is on the local policy and regulations making, planning and implementation. The responsibility of the cities is on the specific project and regular management work. Basically, the city is the key subject to manage the food waste. So far the implementation documents are only released in the large cities such as Beijing, Shanghai, Hangzhou, Suzhou and so on (Liu et al., 2014). In total, there are around 40 cities had the regulations and laws on the food waste management (Song et al., 2012). And it is started to release the regulations and documents on food waste in 2006 – 2012 for standardizing the procedures. However, the management in the rural areas is much weaker than that in urban areas according to our observations due to the weak monitor and inspections.

Table 2. Recent development in China's food safety regulations

Law and Regulation	Issuer	Effective
Food Safety Law Amendment	Standing Committee of China's National People's Congress (2015)	April 24, 2015
Proposal for General Food and Drug Administration	State Council of China	March 22, 2013
Draft Regulation on Risk Assessments	Ministry of Health of China	Draft, June 8, 2009
Food Safety Law of China	The National People's Congress (NPC)	June 1, 2009
Provisional Administrative Regulations on the Administrative Licensing of the Importation of Food without National Food Safety Standard	Ministry of Health of China	Draft, May 6, 2009
Provisional Administrative Measures of Administrative Licensing of New Food Related Product Varieties	Ministry of Health of China	Draft, May 6, 2009
Food Recall Regulation	General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ)	August 27, 2008
Food Labeling Regulation	Ministry of Health of China	January 2008
Regulations on Pig Slaughtering Management (Revised)	The State Council of China	December 2007
Regulation on the Supervision and Administration of Sanitation of Exported Fruits	AQSIQ	December 25, 2006
Regulation on the Management of Food Safety in Distribution	Ministry of Commerce of China	December 20, 2006
Regulation on Food Hygiene License	Ministry of Health of China	June 1, 2006
Regulation on the Supervision and Administration of Sanitation for Imported and Exported Food	AQSIQ	March 1, 2006
Regulation on Managing Hygiene in Food Additives	Ministry of Health of China	July 1, 2002
Regulation on Managing Hygiene in Genetically Modified Food	Ministry of Health of China	July 1, 2002
the Product Quality Law	NPC	September 1, 2000

Local government food safety regulatory responsibilities are set out in Article 5 of the 2009 FSL and in Article 6 of the 2015 FSL, which allocates responsibilities related to food safety supervision and administration at the county level or above. Local government regulations, which are enacted by the governments of the various provinces and which come into effect when they are recorded by the Standing Committee of the National People's Congress, are more suitable for local context. For example, based on local situations, Shanghai has formulated all kinds of criteria for food production, distribution and consumption, that improved the local food safety standards and developed some administrative measures such as Shanghai's Management Measures of Restaurant Kitchen's Waste Oil Processing, and Administrative measures of local food safety standards of Shanghai.

## **Industrial development of collecting and processing food waste**

We have collected over 620 papers related to the status, management and industry development of food waste in China. Of them, there are 102 papers relevant to the industrial development of collecting and processing food waste.

The technology to collect and process the food waste can be summarized as the composting aerobic, anaerobic fermentation processing, renewable sources of solid feed, vacuum frying techniques. Food waste was treated by biological and chemical-processing, and waste oil processing technology. And the outputs include biogas system, fertilizer which usually being taken as organic, feed, biomass fuel and hydrogen. The traditional way to process the food waste is to put the bacterial for the fermentation to reduce the amount of the waste. And the residues would be compressed and sent to the refuse landfill. Since the amount of garbage is increasing in the last decades, it is encouraged to reuse the garbage. But the methods being promoted in the rural and urban areas are different.

In the rural areas, the purpose of food waste processing not only to reuse the food waste but also to create a clean environment. Biogas system is one of the popular methods being promoted in the rural areas. Initially, the biogas technology was supported by the government to reduce the schistosome disease. The details of the biogas system will be presented in the next section. However, because food waste anaerobic digests alone easily results in acidification problem, there are increasing studies on biogas production from anaerobic co-digestion of food waste and animal manure (Zhu et al., 2015).

Since the urban population is producing a large number of food waste every day, the government also encourage the development of the transportation, collection and processing of food waste by the private sectors. Initially all the activities are responsible by the government department. For instance, in Beijing, the environmental protection department used to be in charge of collecting, transporting and processing all the domestic waste including food waste. The methods are mainly landfill and incineration Gradually, the private sectors are encouraged to be involved in the activities, particularly the food waste processing in the living areas. It is somehow like a contract service. The government called the project and provided the budget for the selected company. With the project funding, the company participate in the processing industry. Taking Golden Beetles as an example, the company was selected because of the good service, effective work and reasonable price. The company sold the machines to treat the food waste to the government. But because it is still not popular to separate the domestic waste in China, the company send the workers to separate and pick-up domestic waste. After selection, the food waste is sent to the machine for the fermentation. The recycled waste is sold to the collectors. The waste cannot be recycled being sent to the landfill or factories for burning. The pictures show the process of the activities. However, we did not get the detail information in terms of the industrial development. Besides, there are also companies in Suzhou, for instance, to use the residues for fuel production.

### Taking Golden Beetles



## Food waste for livestock

Historical perspectives in the use of food waste for livestock

Estimation of total hogs and livestock impacted by food waste

Current Practices on food waste to animal feed

Hogs industry is very important in China due to the increasing demand of meat consumption. In the study of Tian et al. (2015), it is mentioned that meat consumption, particularly pork consumption, has been growing substantially along with the rapid economic development. As part of nutrition transition, traditional Chinese diet which is high in vegetable and staple food is switching to a western diet characterized by intensive meat and dairy products (cited by Tian et al., 2015). Even though subject to substantial measurement errors (Yu and Abler 2014), the share of specialized households and commercial enterprises rose from less than 9% in 1980 to 61.33% in 2009 (Chen and Rozelle 2003; Somwaruet al. 2003; Rae et al. 2006; Qiao et al. 2011; Xiao et al. 2012). However, hog farm size in China is still generally small and a large number of hog farms still follow the traditional way of feeding with intensive labor input and using agricultural and household waste such as crop straw and table left-over (Hu 2004; Xiao et al. 2012). Most farmers in hogs industry are with small scale. Nearly 95% of the feeding scale is less than 50 hogs (Figure 5). The feeding scale in Beijing is somehow different from national level. More than half feeding scale is less than 50 hogs and nearly one quarter is between 50 and 100 hogs. And 14% of feeding scale is between 100 and 499 hogs. There are more medium and large scale in Beijing comparing to the national level (Figure 6).

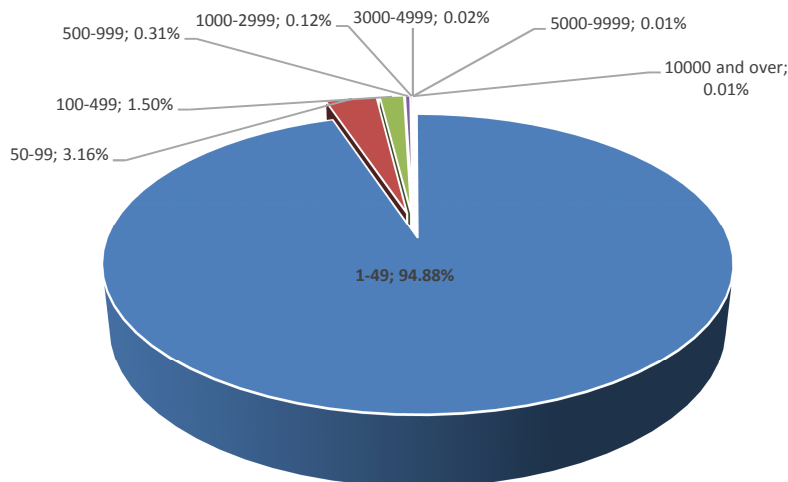


Figure 5. The distribution of hogs industry in China in 2012

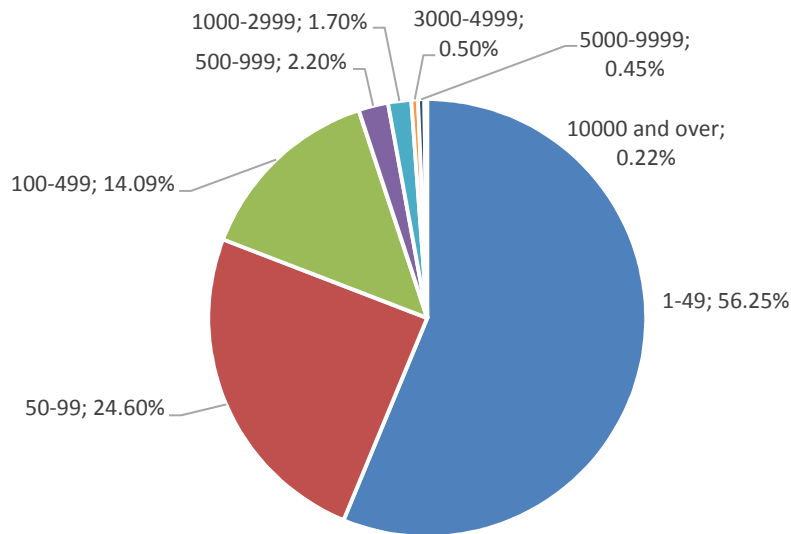


Figure 6. The distribution of hogs industry in Beijing in 2012

Total pork consumption has increased strongly as income has grown and the market for pork as a staple food has developed in China (Huang and Rozelle, 1998; Zhang et al., 2005) for example, urban per capita pork consumption increased significantly from 16.7 kg in 2000 to 20.5 kg in 2009 – an increase of 22.8% (CSY, 2010). The role of urbanization can be seen clearly when we consider that the urban population increased from 459.06 million in 2000 to 621.86 million in 2009 and the effect on total urban pork consumption was an increase from 7.67 million metric tones in 2000 to 12.75 million metric tones in 2009, an increase of 66.3%. Furthermore, rural meat consumption may have also increased with income growth and the development of markets see Huang and Rozelle (1998) who found that market development has an impact on food consumption behavior.

But the share of hogs production in Beijing only accounts for 0.44% of total production in the country. In terms of the production, the provinces located in central part of China, such as Hubei (5.99%), Henan (8.18%), Hunan (8.42%), Anhui (4.19%) and Jiangxi (4.37%), are the main areas. In northern China, Shandong and Hebei are the main areas accounting for 6.59% and 4.87%, respectively.

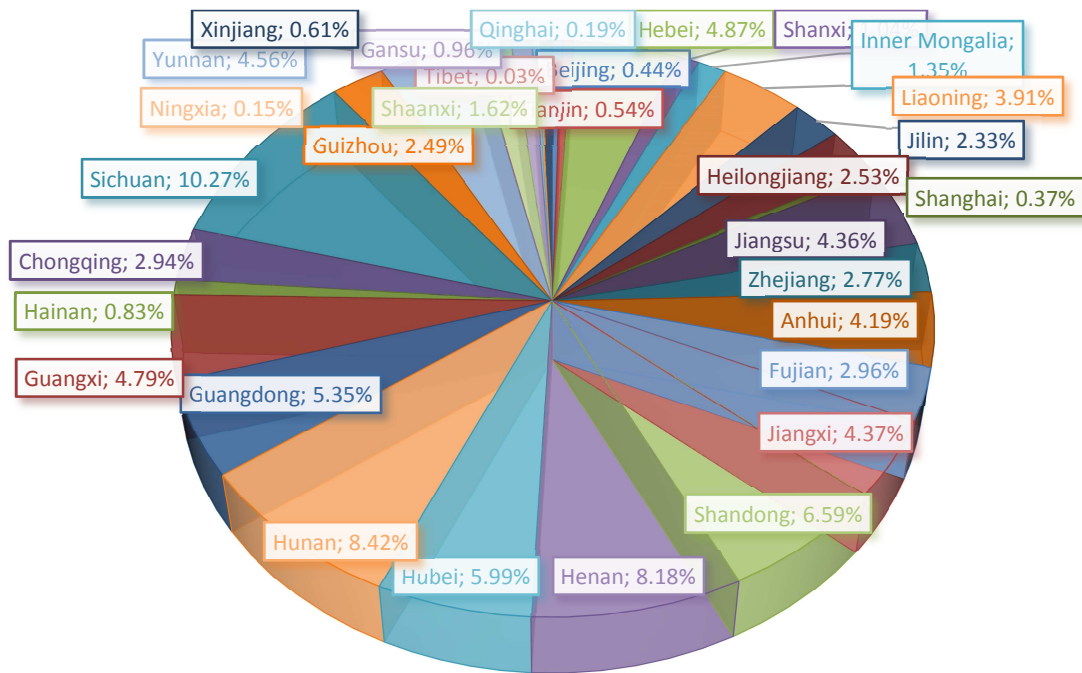


Figure 7. The hogs production by regions in China in 2012

Although feeding food waste to swine has been common in China, especially in rural areas adjacent to major metropolitan areas. This practice has declined tremendously in recent years because of stricter federal, state, and local laws regulating animal health, transportation, and the feed usage of food waste. No breeder of livestock or poultry may “feed any restaurant or eatery will untreated by high temperature to the livestock” and “raise the livestock or poultry in a refuse dump or feed the substances of refuse dump to the livestock or poultry” (Article 43 of the Stock-breeding Law of the People’s Republic of China, July 1<sup>st</sup>, 2006). In the end of 2012, we have investigated 237 farmers engaged in hogs feeding in five districts of Beijing, i.e. Fangshan, Daxing, Pinggu, Tongzhou and Shunyi. The scale of hogs sales in 2012 ranges from 36 pigs to over 40,000 pigs. No single farmer and officer agreed that there is still feeding in Beijing due to the strict regulations and policy.

In the catering business in Beijing, Juan et al. (2014) conducted a survey and interviewed 218 business units in the catering industry in 2013. The results show that 42.2% of the catering units interviewed conducted classification for the food waste and 46.7% disposed the food waste safely following the regulations and requirements. However, still 31.7% of the units discharged the food waste directly with the garbage. 49.5% of the units have their own food waste management regulations and only 28.9% with food waste ledger system.

Among the administrative managers being interviewed, 62.8% of them knew the hazards of the food waste without correct treatment, 66.5% of them paid attention to the news or report on the issue of food waste and 39.9% of them participated and/ or organized the program on food waste management. The managers in large-scale business units have better knowledge and more serious attitude about food waste management and its effects.

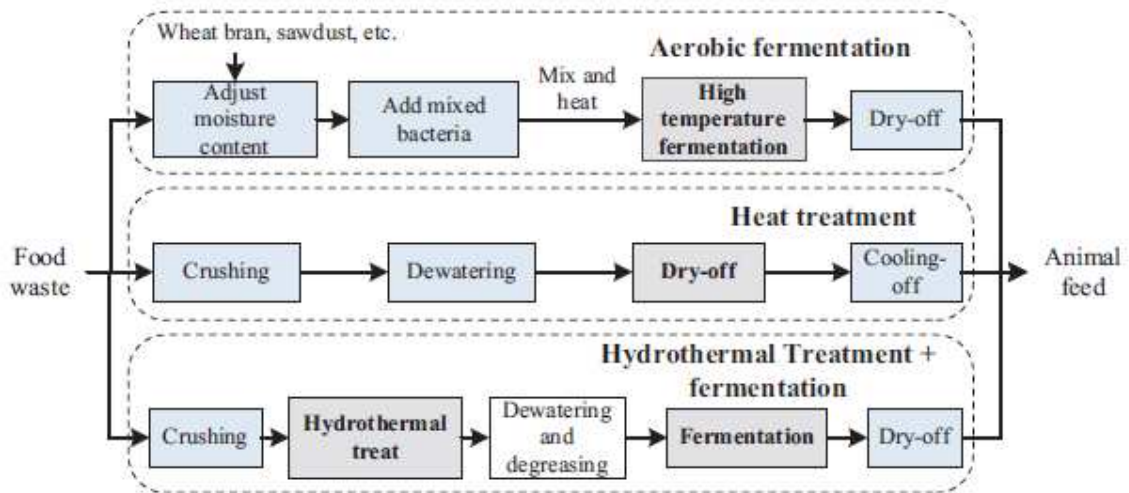


Fig. 1. Three typical conversion techniques for food waste-derived animal feeds.

In the present study, the selected conversion techniques for food waste-derived animal feeds production include aerobic fermentation, heat treatment, and coupled hydrothermal treatment and fermentation.



## Swill feed's quality and animal health hazards in China

Food waste is very conducive for the breeding of microorganisms with high organic content and high moisture content, resulting in quick rotting, easy to carry breed bacteria that can lead to foot and mouth disease, salmonella, toxoplasmosis, swine fever virus, etc., and the direct use of food waste and improper handling can cause the spread of pathogens and infection. Thus, microbiological safety is another important issue that affects the use of food waste-derived animal feed.

It is prohibited to feed the animals using the food waste without innocent treatment. However, the traditional way to treat the food waste by farmers is hours boiling. Another concern is mental pollution in the food waste which would contaminate hogs if the food waste is not properly treated. Subsequently, human will be probably contaminated by the polluted meat and it will decrease the immunologic function of the liver, kidney system. It is said that over 90% of epidemic disease of hogs occurred in the swill feeding in the last decades in Zhengzhou city, Henan province (Zhang 2011).

But to our knowledge, there is no empirical study in China to estimate the effect of using food waste feeding animals systematically and quantitatively.

To avoid and reduce the effect of swill feeding, the government has prohibited the swill feeding, particular in the intensified farming. In the urban areas, the enterprises are more and more active in processing food waste. It is somehow easier to control, collect and process the food waste in the big cities due to the better system. Simultaneously, it is easier and more effective for the government to inspect and monitor the intensified hogs feeding in the cities. The details have described above taking the Golden Beetles as an example.

In the rural areas, the biogas system is one of the methods to reduce the swill feeding. The famous mechanism of biogas system in the rural areas includes "pig – biogas – fruit", "pig – biogas – fish" and "pig – biogas – paddy". Although the name is different, the operation and maintenance of the system is almost same.

The animal and human manure is flushed into the biogas tank that is built under ground, associated with the food waste, for fermentation. Then the methane gas produced can be used for cooking, lighting and fruit fresh keeping. The residues, i.e. biogas slurry and residue, can be used for agricultural production. It is shown that biogas slurry could improve the quality of fruits. Influence of seeds treated with biogas fluid to growth. The following figure shows the mode of the mode and its flow. There are also studies on treating food waste using biogas system in the urban areas now.

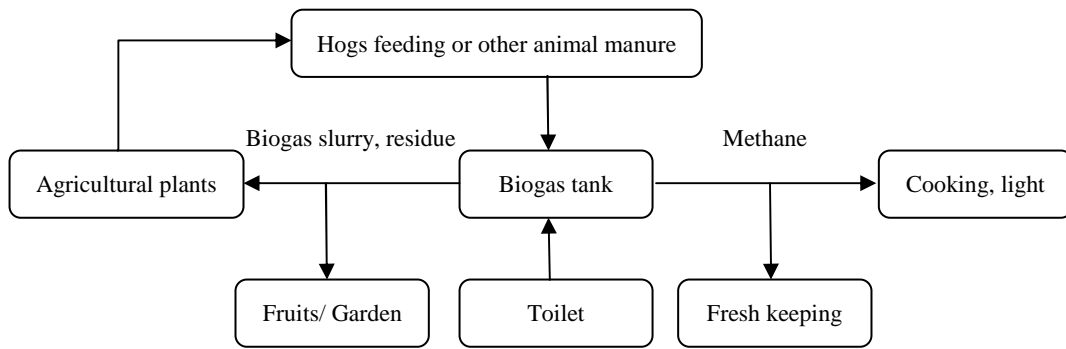


Figure 9. The mode of “pig – biogas – fruit” and its flow

## Conclusion

- Food waste management has been an increasingly important issue in China as the amount is huge due to the population, habit and out of date processing technology.
- Taking food waste as a recycled resource, there is a tremendous potential in China. The technologies of food waste processing have been developed and improved by the scientists. But there is few study on their adoption and impact.
- As the raising concern on food safety and regulations being issued, not only public departments and authorities but also private sectors are involved in food waste collection and processing.
- The regulations and laws as well as implementation is much better in big cities. It is somehow indicated that the gap between developed areas and developing areas may be still significant, i.e. swill feeding probably exist in the developing areas.
- In the big cities such as Beijing, there is still certain number of catering business units not managing the food waste properly.
- Chinese used to feed animals using food waste. However, swill feeding is prohibited in the relevant laws and regulations. But there is still news related to swill feeding being exposed from time to time.
- We did not find the swill feeding case in the household survey in Beijing. But due to the personal communication and observations, swill feeding may still exist in the peri-urban and rural areas in the small counties which lack of studies.

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