

FOOD WASTE USED AS ANIMAL FEED IN ENVIRONMENTAL PROTECTION AND SUSTAINABILITY CONTEXTS

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Abstract: The use of food waste as animal feed represents an important step in reducing negative environmental impacts and contributes to the sustainable development of agriculture. This study explores how utilizing food leftovers for animal feed can decrease the demand for conventional animal feed production, thereby reducing resource consumption and greenhouse gas emissions. Using food waste also helps reduce landfill waste, which positively impacts environmental protection. Economically, such practices can lower costs for farmers. The study also addresses challenges related to animal feed safety and the necessary measures for the proper processing of food waste, contributing to the sustainable development of agricultural systems and environmental protection.

Key words: food waste, animal feed, environmental protection, sustainable development

1. INTRODUCTION

Food waste represents the loss of food occurring at the end of the supply chain. This loss results in the waste of resources such as labor, water, energy, and land invested in production, as well as financial losses for retailers and consumers [1]. In developed countries, the majority of this waste occurs at the end of the food chain, in sectors that directly interact with consumers (supermarkets, stores, distribution centers, restaurants, food service institutions) and within households [2].

Variations in food production, distribution, and consumption have led to an increase in the amount of food waste worldwide. Continuous waste generation, coupled with the migration of people from rural to urban areas, further exacerbates this situation. Researchers predict that by 2050, approximately 68% of the global population will reside in urban areas, while only about 30% of people will be responsible for supplying large quantities of fruits, vegetables, and meat products to themselves and urban populations [3]. According to UNEP estimates, in 2022, 1.05 billion tons of food waste were generated globally across the retail, food service, and household sectors. The average amount of food waste per person in 2022 was 132 kg, with 79 kg originating from households [4].

The use of food waste as an alternative source of animal feed holds significant potential for overcoming the current unfavorable situation, marked by high costs and insufficient supply of animal feed [1]. For centuries, farmers have fed animals with food leftovers, which in turn provide food for humans, keeping food waste within the human food supply chain. Feeding animals with food waste reduces the amount of conventional animal feed that needs to be produced and processed, thereby lessening the environmental impact associated with its production. Converting food waste into animal feed saves money for both farmers and companies, as it can be cheaper than sending food waste to landfills. Companies can supply food leftovers to manufacturers producing feed for livestock or pets.

2. USE OF FOOD WASTE IN ANIMAL FEED PRODUCTION

2.1. Advantages and disadvantages of use of food waste in animal feed production

To assist selecting food waste disposal technologies, the EU provides guidelines on preferred disposal technologies. The food waste management hierarchy outlines that governments should prioritize efforts (in order from most to least desirable) to [4]:

- reduce food waste,
- redistribute food waste (e.g. to homeless people),
- recycle food waste as animal feed,
- compost, transform into energy through anaerobic digestion, and finally,

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- dispose of the remainder in the landfill.

This legislation is currently not applied in relation to the use of food waste as animal feed, as it is illegal to use most food waste as animal feed in the EU [4].

Farmers can increase their income by using food waste leftovers to reduce animal feed costs. Another important advantage is the reduction of environmental issues caused by the decomposition of such waste. However, the use of food waste from industry as animal feed also has several drawbacks, in addition to the previously mentioned advantages. These disadvantages include safety concerns, an unpredictable nutritional profile, and high production costs. Due to their high water content, food waste leftovers are more prone to spoilage during collection, transportation, and storage. As a result, the quality of animal feed produced from food waste may be compromised during these processes. Additionally, commercial food waste (especially from the food service and retail sectors) varies in quantity and homogeneity, and its nutritional composition is inconsistent. Manufacturers of recycled animal feed face these challenges by using innovative solutions and successfully recycling food waste into animal feed at relatively low costs [1].

The conversion of food waste into animal feed is minimal in relation to the amount produced in most countries for several reasons [5]:

- The negative historical perception of "feeding waste" to pigs and consuming products from animals that were fed food waste.
- Historical epidemics of animal diseases associated with feeding raw food waste and the severe economic consequences.
- Current concerns about the spread of African swine fever virus due to feeding pigs on farms with raw or insufficiently heat-treated food waste from households in countries where the virus is endemic.
- Legal restrictions and regulations that prohibit feeding animals certain types of food waste due to the potential transmission of diseases.
- Lack of economic and government incentives to encourage entrepreneurship and facilitate entry into the business.
- Lack of infrastructure for the collection, processing, storage, and use of different types and forms of food waste for animal feed.
- General lack of public awareness regarding the scale of the food waste problem and its ecological and economic consequences.
- Differences in cultural attitudes and economic status regarding waste reduction and related environmental benefits across different societies and countries.

2.2. Legal restrictions on the use of food waste for animal feed production

Although there are technological and logistical challenges in converting food waste into animal feed, the biggest barrier is the laws and regulations that prohibit or significantly restrict feeding animals various types of food waste, especially those containing animal remains. These laws were adopted several decades ago to prevent the transmission of diseases from raw food waste or waste originating from ruminants. However, these measures were implemented before thermal processing methods in the processing industry and animal plasma were developed, which effectively deactivate endoparasites, bacteria, and viruses that pose a risk [5].

One of the main reasons for regulating food waste that contains animal products is the risk of transmitting bovine spongiform encephalopathy (BSE), a fatal degenerative disease in ruminants (such as cattle). As a result, laws that restrict or prohibit the use of food waste containing animal products are the primary reason for the lack of incentives and infrastructure for processing food waste into animal feed [5].

2.3. Methods of turning food waste into animal feed

Different processing methods are used to increase the nutritional value, digestibility, feeding efficiency, removal of toxins, sanitation of pathogens, elimination of inedible components, long-term storage capability, portability, and market value of food waste. Converting food waste into a value-

added product, such as animal feed, can improve feeding efficiency by reducing animal feed costs, leading to greater profitability for farmers and reducing the environmental impact caused by food waste disposal. Food processing, which alters its physical (and occasionally chemical) properties, is a key step in the process of converting food waste into animal feed in order to improve food quality, dietary stability for animals, and reduce losses during feeding. Food waste processing techniques mainly focus on conversion efficiency, increased food intake, and livestock health, while reducing digestive diseases. Various processing techniques, such as dehydration and/or drying, pelleting, extrusion, fermentation, silage production, and others, can be used to convert food scraps into animal feed (Figure 1). To transform certain types of food waste into acceptable animal feed, these processing technologies can be used alone or in combination [1].

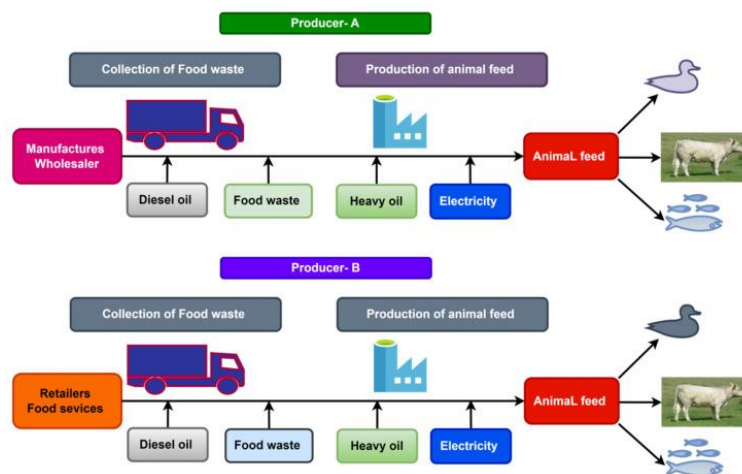


Figure 1- Utilization of FWs to animal feeding by producers (A,B) [1]

Lam Tak Group is one of the leaders in creating innovative and sustainable solutions for converting food waste into valuable animal feed. One such solution is shown in Figure 2 and includes five steps [6]:

- Collection – The process begins with the systematic collection of food waste from various sources, including restaurants, supermarkets, and food processing facilities. The waste is then categorized into organic and inorganic types, with the inorganic waste being disposed of appropriately.
- Pre-processing – In this phase, the food waste is thoroughly checked for any remaining inorganic materials and sorted based on its suitability for different types of animal feed. This step ensures that only high-quality organic waste proceeds to the next stage of the process.
- Thermal processing – The waste is then subjected to thermal treatment or sterilization. The goal is to reduce moisture, eliminate harmful substances, kill disease-causing agents and pathogens, and break down complex nutrients into a form that is easier for animals to digest, thus preventing any health risks for the animals and, subsequently, for humans.
- Conversion – The conversion process may involve several methods, including fermentation, dehydration, and grinding, which help increase the nutritional value of animal feed and facilitate handling, transportation, and extended shelf life. Fermentation can improve the digestibility of the feed and its nutrient content through the action of microbes, but it requires proper control of fermentation conditions.
- Quality control and distribution – Quality control is critical throughout the entire processing phase to ensure that the final product meets safety and nutritional standards.

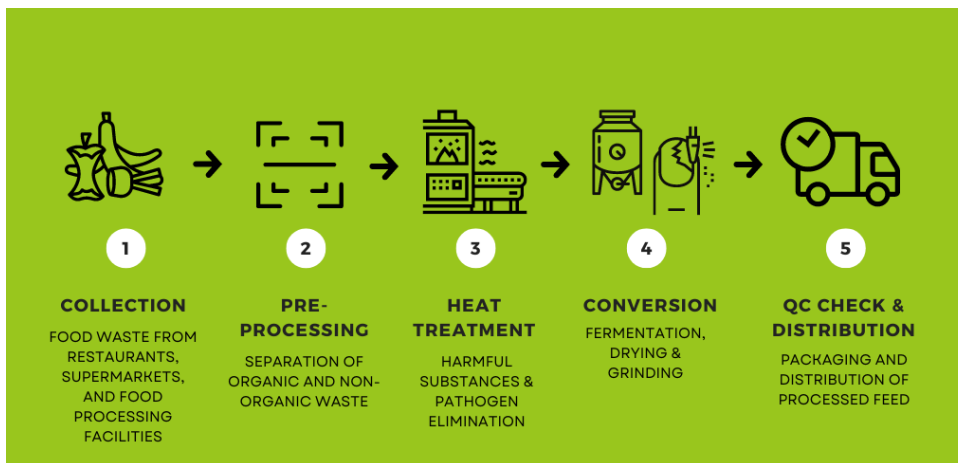


Figure 2 - The Process of Food Waste Conversion to Animal Feed [6]

2.4. Turning food waste into animal feed and impact on the environment

Although converting food waste into animal feed presents a more valuable alternative with a smaller environmental impact compared to composting, anaerobic digestion, and disposing in landfills, no extensive or comparative studies have been conducted on disposal methods. Some of the studies that have been conducted mainly show that using food waste as animal feed is more environmentally favorable compared to other disposal methods. These studies have primarily focused on assessing the impact on global warming using greenhouse gas (GHG) emissions as indicators, while analyses of resource use such as energy, land, and water have been limited. Some researchers have emphasized that the results obtained within specific scenarios and assumptions of each study may not be applicable to broader situations, and it has been recommended that further research be conducted using harmonized approaches to assessment. It has been found that the nutritional composition of food waste affects the extent of GHG emission reduction. The nutritional composition also determines whether recycling certain types of waste into animal feed is the most favorable option. For example, bread waste showed the greatest potential for reducing GHG emissions. This was followed by chicken, beef, and bananas, while lettuce had the least potential. These results indicate that food waste sources with high energy content and dry matter content are more suitable for use as animal feed compared to nutritionally less rich sources [7].

Using food waste for animal feed production is not completely carbon-neutral, as the processes of collection, transport, and processing of waste require energy consumption, which leads to carbon dioxide (CO₂) emissions. Through the application of life cycle assessment, several studies have attempted to measure the carbon footprint of these activities under real-world conditions of animal feed production. Dou and colleagues (2024) pointed out that the collection, transport, and processing of one ton of food waste in South Korea resulted in an emission of 61 kg of CO₂ for raw food production, while for dry food production, this footprint was 200 kg of CO₂. In comparison with the emissions of 1,010 kg of CO₂ that would occur if the waste were disposed of in landfills, this shows a significant difference in carbon footprint. Estimates made in Japan showed that the carbon footprint was 3.5 kg of CO₂ per ton of food waste for liquid food production (12% dry matter), while for dry food production (90% dry matter), the footprint was 272 kg of CO₂. Landfill emissions vary depending on the type of waste, processing methodology, and other factors [8].

In the case of food waste being landfilled, the carbon footprint can range between 1,260 and 1,400 kg of CO₂ per ton of food waste if landfill gas is not collected and treated [8].

Overall, the carbon footprint of converting food waste into animal feed is significantly lower, approximately 5 to 20% compared to landfilled waste. These findings provide an important foundation for decision-makers and experts, as they can contribute to the development of more sustainable practices in waste management and animal feed production [8].

3. CONCLUSION

Using food waste for animal feed production represents a sustainable alternative in terms of reducing negative environmental impacts, as it helps reduce the amount of waste sent to landfills and decreases the need for the production of new resources. This process can have a significant impact on sustainable development, as it helps reduce greenhouse gas (GHG) emissions, thereby mitigating global warming. Additionally, converting food waste into animal feed reduces the need for importing conventional feed ingredients, lowering the economic and ecological costs associated with their production and transportation, which further contributes to sustainable development.

When food waste is used for animal feed production, it helps prevent the loss of nutrients that would otherwise be discarded, while simultaneously providing valuable nutrients for animals, increasing the efficiency of production of meat, milk, and other animal products. This approach has the potential to create a closed-loop system where resources are reused, reducing the need for new agricultural products, which positively impacts the preservation of land and water.

In urban areas, food waste could be used as fertilizer or compost for urban agriculture due to strict legal restrictions related to animal feed production.

Although using food waste for animal feed offers numerous benefits, there are challenges in its implementation. One of the main issues is legal barriers, such as bans on using food waste containing animal by-products, which can hinder the broader application of this practice. Additionally, appropriate technological processes and infrastructure need to be developed to ensure safe waste processing, reducing the risk of disease transmission and food contamination.

Despite these challenges, using food waste in animal feed production is a significant step towards more sustainable food production and efficient waste management, with great potential to deliver economic, ecological, and social benefits.

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