Journal of Energy Bioscience 2025, Vol.16, No.4, 172-181
http://bioscipublisher.com/index.php/jeb

Case Study Open Access

Case Study on Energy Crop Development: Sweet Potato for Biogas in Rural China

Zhang Qian, Wenzhong Huang
Biomass Research Center, Hainan Institute of Tropical Agricultural Resouces, Sanya, 572025, Hainan, China
Corresponding email: wenzhong.huang@hitar.org

Journal of Energy Bioscience, 2025, Vol.16, No.4 doi: 10.5376/jeb.2025.16.0017
Received: 22 May, 2025
Accepted: 30 Jun., 2025
Published: 11 Jul., 2025

Preferred citation for this article:
Qian Z., and Huang W.Z., 2025, Case study on energy crop development: sweet potato for biogas in rural China, Journal of Energy Bioscience, 16(4): 172-181 (doi: 10.5376/jeb.2025.16.0017)

Abstract This study mainly talks about how sweet potatoes are used as energy in rural China, especially for biogas production. In addition to being a common food and industrial raw material, sweet potatoes can actually be used as energy crops. Studies have found that different varieties of sweet potatoes vary greatly in their gas production and methane production capabilities. Some varieties, such as Laranjeiras and BRS Cuia, can produce more biogas, which shows that sweet potatoes are still reliable as energy. In southern China, people can rotate sweet potatoes with corn. This method can bring energy benefits, economic benefits and environmental benefits at the same time. In this way, you can increase net energy output, make more money, and reduce greenhouse gas emissions. If sweet potatoes are fermented with animal manure, more biogas will be produced, which is more cost-effective. This is very helpful for the development of a circular economy in rural areas. If the sweet potato waste is treated with heat treatment before fermentation, it can also produce a lot more gas. This also makes the fermentation process faster and shorter. As an energy crop in rural areas, sweet potatoes not only allow farmers to use their own energy, reduce damage to the environment, but also increase income. For promoting sustainable development in rural China, sweet potatoes are a promising choice.

Keywords Sweet potato; Energy crops; Biogas; Rural sustainable development; China

1 Introduction

As the demand for energy in rural China grows, it is important to find a sustainable and cost-effective energy solution. In many rural areas, the supply of traditional energy cannot keep up, pollution is serious, and the cost of energy is high. Therefore, it is particularly urgent to develop local renewable energy, which can not only improve the living conditions of farmers, but also help drive economic development (Tang et al., 2022). Biogas is a relatively clean energy source. It can not only solve the problem of insufficient energy in rural areas, but also make good use of agricultural waste, reduce environmental pollution, and reduce greenhouse gas emissions. This is very helpful for achieving sustainable development in rural areas (Tang et al., 2022; Montoro et al., 2025).

Sweet potato (*Ipomoea batatas* L.) is a common food and industrial crop in China, and its production is also high worldwide (Liu, 2011). In recent years, sweet potatoes have been considered suitable for energy production, especially for biogas production, due to their high yield, strong adaptability and rich biomass (De Paula Batista et al., 2019; Tang et al., 2022). Studies have found that different sweet potato varieties and planting methods perform well in terms of biomass yield, energy efficiency and reduction of greenhouse gas emissions. Especially in southern China, the economic and environmental benefits of growing sweet potatoes are obvious (Tang et al., 2022). In addition, if sweet potato waste is first treated by thermochemical methods, it can produce more biogas and methane, which also makes the energy value of sweet potatoes higher (Catherine and Twizerimana, 2022).

This study mainly wants to systematically see whether sweet potatoes can be promoted as a biogas energy crop in rural China. We will do several things: first, evaluate the gas production capacity and energy efficiency of different sweet potato varieties and sweet potato waste; second, see if it has any benefits in terms of economy, environment and emission reduction; third, study how to optimize the sweet potato biogas production process and how to promote this practice. We hope that these analyses can provide some scientific support for the development of renewable energy in rural China and give policymakers some useful suggestions.

2 Energy Crop Development in China: Background and Policy Context

2.1 National energy strategy

China's energy structure has always been dominated by coal. With the continuous development of the economy and the growing population, the demand for energy is also increasing. This has also brought about energy security issues and greater environmental pressure. In order to reduce the impact of climate change, China has proposed the goals of "carbon peak" and "carbon neutrality", and actively promoted the adjustment of energy structure and strived to increase the proportion of renewable energy use. Among various renewable energy sources, biomass energy is a very important one. It is rich in resources, renewable, and basically does not emit carbon. These characteristics make it a good choice to replace fossil energy such as coal and oil, and also help reduce greenhouse gas emissions (Wang et al., 2024). The development of biomass energy is not only helpful for carbon reduction, but also protects the ecological environment and enhances energy security (Sang and Zhu, 2011; Wang et al., 2024).

2.2 Policy support for biogas and bioenergy

The Chinese government has always attached great importance to the development of bioenergy and has issued many relevant policies. The Renewable Energy Law implemented in 2005 is a very important starting point. It provides legal support for the development of biomass energy and explicitly encourages the use of methods such as biogas, biopower generation, and biofuels (Wang et al., 2024). The national and local governments also promote rural biogas projects and other bioenergy construction through subsidies, tax cuts, and technical research. These policies also encourage the good use of straw, energy crops, etc. to improve utilization efficiency (Zhang and Lis, 2020; Wang et al., 2024). These practices not only promote the development of bioenergy, but also help improve the rural energy structure and increase farmers' income (Zhang and Lis, 2020).

2.3 Role of energy crops in rural development

In rural China, energy crops play many important roles. First, these crops can be grown on marginal land or unused arable land, which will not affect food planting and improve land use efficiency (Wang et al., 2017; Fu et al., 2022; Wang et al., 2024). Planting energy crops can bring new sources of income to rural areas, allowing farmers to earn more and is also conducive to adjusting the agricultural structure (Zhang and Lis, 2020; Fu et al., 2022). Furthermore, the development of energy crops can also reduce straw burning, reduce greenhouse gas emissions, and benefit the rural ecological environment (Sang and Zhu, 2011; Fang et al., 2024; Wang et al., 2024). When these crops are combined with renewable energy technologies such as biogas and power generation, they become a key force in promoting green and low-carbon development in rural areas (Fu et al., 2022; Fang et al., 2024; Wang et al., 2024).

3 Biogas Technology and Feedstock Dynamics

3.1 Principles of biogas production

The production of biogas mainly relies on a technology called "anaerobic digestion" (AD). This process is carried out in the absence of oxygen, and microorganisms decompose organic matter and finally produce gases such as methane and carbon dioxide. This decomposition process is generally divided into several stages, including hydrolysis, acidification, acetic acid production and methane production. In the end, not only usable biogas can be obtained, but also a "digestion residue" can be obtained, which can be used as fertilizer (Catherine and Twizerimana, 2022; Montoro et al., 2025) (Figure 1). This technology can process a lot of agricultural waste, such as feces, straw, kitchen waste, etc. It can not only reduce environmental pollution, but also turn waste into energy and resources, realizing "turning waste into treasure" (Zhang et al., 2015; Liu et al., 2023).

3.2 Common feedstocks in China

In rural China, the raw materials used to produce biogas are mainly some common agricultural wastes, such as cow dung, pig dung, corn stalks and kitchen garbage (Zhang et al., 2015; Li et al., 2021; Liu et al., 2023). Among them, livestock and poultry manure is more common, mainly because it contains a lot of organic matter and is easier to decompose. However, the source of this type of raw material is affected by the scale of breeding and the season, and it is not always available stably (Li et al., 2021). Although there are a lot of corn stalks, they contain a high amount of cellulose and lignin, which are difficult to decompose and produce gas slowly. Moreover, this kind of stalk is troublesome to collect and transport, and the cost is high (Zhang et al., 2015; Sun et al., 2022; Liu et al., 2023). Kitchen garbage also has certain potential, but its composition is too complex and the collection system is not perfect, so it is difficult to use on a large scale (Zhang et al., 2015). In addition, the winter in the north is too cold, and the low temperature will reduce the biogas production, which also affects the use effect of traditional raw materials (Yan et al., 2022).

Figure 1 Biogas production setup

3.3 Need for diversification

Because traditional raw materials have many problems, such as low gas production, large seasonal changes, and difficult collection, people began to consider finding some new alternative raw materials. Sweet potato is a very promising choice. It has high yield and strong adaptability, and there are a lot of starch and sugar in the root tubers, which have high energy value and are very suitable for producing biogas (De Paula Batista et al., 2019; Montoro et al., 2025). Studies have found that if sweet potatoes or sweet potato waste are pretreated first, it can not only increase the production of biogas and methane, but also shorten the fermentation time. Moreover, if it is used together with livestock and poultry manure for synergistic fermentation, it will produce more gas and have higher economic benefits (Catherine and Twizerimana, 2022; Montoro et al., 2025). At present, many rural areas in southern China grow sweet potatoes, and the planting foundation is good. If sweet potatoes are promoted as a new biogas raw material, it will not only solve the problem of single type and seasonal shortage of traditional raw materials, but also make rural energy more abundant and sustainable (De Paula Batista et al., 2019; Tang et al., 2022).

4 Agronomic and Economic Suitability of Sweet Potato

4.1 Agronomic characteristics

Sweet potato is a crop suitable for energy production, and it has many obvious advantages. First of all, it has high yield and low soil requirements, and can grow well even on poor land. This makes it easy to promote in rural areas. In addition, its short growth cycle allows it to be planted several times a year, and the land utilization rate is also higher. Through the improvement of breeding technology, as well as scientific fertilization and irrigation methods, sweet potatoes are now performing better and better under difficult conditions such as drought (Tedesco et al., 2023).

4.2 Comparative yield analysis

Studies have found that the biomass yield and biogas production capacity of sweet potatoes are similar to those of other common energy crops, and some varieties even exceed cassava and corn. For example, some sweet potato varieties can produce about 2 900 liters of biogas per hectare, indicating that its methane production is very good .

The reducing sugar and water content in sweet potatoes affect the production of biogas. Some good varieties are more advantageous in converting biomass into energy (De Paula Batista et al., 2019).

4.3 Cost and input analysis

Growing sweet potatoes does not require much labor and fertilizer, which is very suitable for rural areas with more manpower but less funds. If local fertilizers can be used, healthy seedlings can be selected, and some biological and physical methods can be used to prevent insects and diseases, the cost of planting can be further reduced and the income can be increased. Now high-resolution remote sensing technology can also be used to help, which can manage the work in the field more accurately, increase production, and make better use of land (Tedesco et al., 2023).

4.4 Byproduct utilization

In addition to being used for fermentation to produce biogas, sweet potatoes also have many by-products that can be used. For example, its starch can be used as food or industrial raw materials, and the residue after fermentation can also be used to feed livestock. In this way, resources are more fully utilized. This multi-use approach not only increases the overall value of the sweet potato industry, but also contributes to the sustainable development of the rural economy (Tedesco et al., 2023).

5 Environmental and Sustainability Assessment

Sweet potato is a high-yield root crop with low soil requirements. It has great potential for use as biomass energy in rural China. If it is used to produce biogas, whether it is good for the environment needs to be considered from multiple aspects, such as greenhouse gas emissions, land use, biodiversity, water and fertilizer consumption, and the impact of the entire life cycle.

5.1 Greenhouse gas mitigation potential

Using sweet potato fermentation to produce biogas can reduce greenhouse gas emissions. On the one hand, rural energy such as coal, firewood and liquefied gas can be replaced by sweet potato biogas, reducing dependence on carbon energy. On the other hand, biogas residue and biogas liquid can be returned to the fields, which can reduce the use of chemical fertilizers and reduce N_2O emissions caused by nitrogen fertilizers. Some studies have estimated that each ton of sweet potato can produce about 60 to 80 cubic meters of biogas. If a farmer uses 1 ton of sweet potato to produce biogas per year, it can reduce about 180 to 250 kilograms of carbon dioxide equivalent. Compared with straw, sweet potatoes are more suitable for small-scale household use and have higher fermentation efficiency (Hou et al., 2017; Sun et al., 2022).

5.2 Land use and biodiversity considerations

Sweet potatoes are often planted on sloping land, dry land, or in the gaps between crop rotations. This way, they will not compete with major food crops for land, and both food and energy can be obtained. It can also have a good yield on marginal land, and is suitable for promotion in some mountainous areas in southwest and central China, which is very helpful for the development of rural ecological agriculture. It should also be noted that sweet potatoes should not be planted too intensively. If they are planted too singly, biodiversity may be affected. Therefore, it is recommended to use mixed cropping or crop rotation when planting sweet potatoes, and also consider combining them with local ecological protection plans, so that the agricultural system can be more stable (Zhang and Qiu, 2018; Li et al., 2025).

5.3 Water and nutrient requirements

Compared with water-intensive crops such as corn, sweet potatoes require less water. It also has strong adaptability to rainfall and soil, and is a relatively water-saving energy crop. It does not require high fertilizers, mainly phosphorus and potassium, and has less demand for nitrogen, which can also reduce water pollution caused by too much nitrogen fertilizer. Some studies have put forward several suggestions, such as: the water consumption per hectare of sweet potato planting should not exceed 3 500 cubic meters; organic fertilizer substitution should reach at least 40%; nitrogen fertilizer use should be controlled at no more than 80 kilograms per hectare. These practices can turn sweet potato biogas production into a "low-input, high-efficiency" green circular agricultural system.

5.4 Lifecycle assessment (LCA): Summary of existing LCA studies on sweet potato-based biogas.

Many studies have used the life cycle assessment (LCA) method to analyze the environmental impact of sweet potato biogas systems. From sweet potato planting to transportation, fermentation and final utilization, the carbon emissions in the whole process are much lower than those of corn and wheat straw. Chen et al.'s study in Hunan found that the carbon emissions per unit energy of biogas made from sweet potatoes were 17.6 grams CO_2-eq/MJ, which is 85% lower than coal and 65% lower than liquefied gas. Moreover, its energy return ratio (EROEI) is also over 1.8, indicating that it is also cost-effective in terms of energy utilization. Other studies have pointed out that if some optimization measures are added to the system, such as returning biogas residue to the fields or improving water-saving irrigation technology, carbon emissions can be further reduced by 20%. These results show that LCA is very sensitive to management methods and can bring more benefits if used properly (Yang et al., 2024).

6 Technology Integration and Processing Chain

6.1 Harvesting and storage: post-harvest handling challenges

Sweet potato is a good raw material for biogas production, but its tubers contain a lot of water and reducing sugars. These components affect the yield of biogas. Different sweet potato varieties have different water absorption, decay speed, yield and quality. These differences also make post-harvest storage and processing difficult. Varieties with high water and sugar content are more likely to deteriorate. Therefore, after the sweet potato is harvested, appropriate methods should be adopted for storage and transportation to reduce losses and maintain the quality of the raw materials (De Paula Batista et al., 2019).

6.2 Pretreatment techniques: crushing, hydrolysis, ensiling

The structure of sweet potato tubers is relatively complex, and it also contains a lot of starch, especially high content of amylopectin, which will affect its hydrolysis efficiency during anaerobic fermentation. To solve this problem, some thermochemical pretreatment methods can be used, such as alkali solution (NaOH), heating treatment, and controlling the treatment time. Studies have found that after this pretreatment, the gas production of sweet potato waste can be increased by 33.88%, and the methane ratio increased from 42% to 64%. At the same time, the time required for fermentation was shortened from 22 days to 16 days. In addition to heat treatment, physical or biological treatments such as crushing and silage can also make sweet potatoes easier to decompose and extend their shelf life (Catherine and Twizerimana, 2022).

6.3 Co-digestion opportunities: sweet potato mixed with manure or other substrates

If sweet potatoes and livestock and poultry manure are fermented together, it will be more efficient than fermenting them separately. This "co-digestion" method not only increases gas production, but also makes the entire system more cost-effective. Studies have shown that co-digestion can increase gas production by 12.65%, organic matter degradation rate by 15.48%, and methane content can reach 61.92%. At the same time, the fertilizer produced by fermentation is also more nutritious, with nitrogen, phosphorus, and potassium contents of 1.24%, 3.09%, and 3.11%, respectively. In terms of economics, co-digestion can also increase profits by 60%, greatly improving the return on investment (Montoro et al., 2025).

6.4 Biogas yield efficiency: performance metrics from trials and pilot plants

Different sweet potato varieties vary greatly in gas production. Some varieties, such as BRS Cuia and BRS Rubissol, can produce 2 906.5 liters of biogas per hectare. But varieties like Bela Vista only produce 398.2 liters/hectare. If combined with optimized pretreatment and co-digestion, the methane content can be stabilized at 61.92%. The gas production efficiency per unit of volatile solids can also reach 0.449 cubic meters/kilogram (De Paula Batista et al., 2019; Catherine and Twizerimana, 2022; Montoro et al., 2025).

7 Socioeconomic Impacts

7.1 Farmer adoption and incentives: analysis of barriers and motivators

Whether farmers are willing to participate is directly related to whether the use of sweet potatoes as energy can be promoted. Although the planting technology of sweet potatoes is very mature and the efficiency of producing biogas is also good, many farmers still have concerns about this. Some common problems include: not knowing how to use biogas, not knowing whether it can make money, the equipment is too expensive, the payback time is too long, and the market is unstable (Shi et al., 2025). However, if the government provides subsidies, technical guidance, or there are cooperatives in the village to help, farmers' willingness to participate will be significantly improved. Especially when they find that using biogas residues and liquid biogas in the fields can reduce the use of fertilizers, save money and be environmentally friendly, many people gradually begin to accept sweet potatoes as energy crops, and believe that this method is more cost-effective in the long run (Tang et al., 2022) (Figure 2).

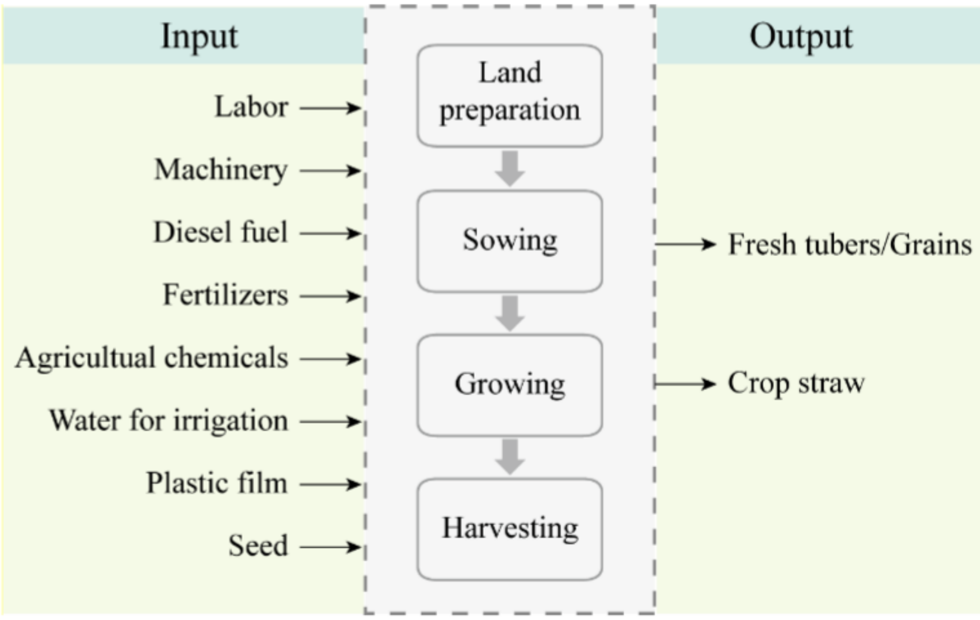

Figure 2 System boundary of sweet potato and reference crops (i.e., rice, maize, and potato) production

7.2 Job creation and income diversification: from cultivation to processing

The sweet potato biogas project has brought many job opportunities to rural areas and made income more diverse. Sweet potato planting requires manpower, and harvesting, storage, transportation, maintenance of biogas equipment, and treatment of biogas residue can also provide non-agricultural jobs. Some surveys have found that if there are 100 households in a village, 10 to 20 stable jobs can be added just by the sweet potato biogas chain. In addition, some places have developed side businesses such as sweet potato flour, alcohol, and feed to make the rural economy more active. In terms of gender, women actually do a lot of work in this system. Planting sweet potatoes, cutting sweet potatoes, and maintaining the biogas digester at home are all done by women. They prefer clean, trouble-free and energy-saving energy methods. However, in some key links, such as cooperative management, technical training and project design, women's participation is not high enough. If there are more "female demonstration households" and more agricultural technology courses specifically for women, it will not only improve their acceptance of technology, but also help families use biogas faster, and promote gender equality and the unity of rural communities (Montoro et al., 2025).

7.3 Gender and equity considerations: roles of women in energy crop systems

Combining the sweet potato energy system with local cooperatives is a key to its long-term operation. Many places now adopt the "farmers + cooperatives + enterprises" approach. Farmers are responsible for growing sweet potatoes, cooperatives are responsible for management and technology, and enterprises are responsible for selling biogas or processing by-products. This division of labor not only improves overall efficiency, but also makes it easier for farmers to organize themselves. Cooperatives can also help apply for loans, coordinate government subsidies, provide technical services, etc., which is very useful. To make this system smoother, it is also necessary to clearly define the rights and responsibilities of each party and how to divide the benefits. Only in this way can farmers have a greater sense of participation and trust, and cooperatives can cooperate better and move towards standardization (Sheikha and Ray, 2017; Iqbal et al., 2021).

8 Case Study: Rural Biogas Deployment Using Sweet Potato

8.1 Location and demographics: brief description of the study site.

This case study was selected from a rural area in China. Most people here are engaged in agriculture, and most farmers are family units. The labor force is mainly middle-aged and elderly people, the population density is neither high nor low, and the crops are mainly food and cash crops, sweet potatoes are one of them (De Paula Batista et al., 2019; Montoro et al., 2025).

8.2 Project design: who led the initiative (government, NGO, private).

This biogas project is led by the local government. The government provides policy and technical support, and the agricultural cooperative is responsible for organizing everyone to participate and collecting raw materials. Farmers grow sweet potatoes themselves and process part of the raw materials (Montoro et al., 2025).

8.3 Sweet potato cultivation model: contract farming, subsidies, or cooperative growing.

Here, the "cooperative + farmer" approach is adopted to grow sweet potatoes. Farmers and cooperatives sign contracts, the price is set in advance, and the cooperatives also provide planting training. Some places also have planting subsidies to encourage everyone to grow more sweet potatoes and ensure a stable source of raw materials (Montoro et al., 2025).

8.4 Technology used: digesters, pre-treatment, energy use (cooking, lighting).

The project uses anaerobic digesters, also known as biogas digesters. Sweet potato waste is first treated with thermochemical treatment before use, such as using NaOH to improve the fermentation effect. The biogas produced is mainly used in farmers' homes, such as cooking and lighting, and some is used to drive some small agricultural machinery (Catherine and Twizerimana, 2022; Montoro et al., 2025).

8.5 Results and lessons learned:

8.5.1 Biogas output vs expectations

After thermochemical treatment, the gas production of sweet potato waste increased by about 33.88%, and methane increased by 22%. In addition, the fermentation cycle was shortened from the original 22 days to 16 days. Compared with using only livestock and poultry manure, if it is fermented with sweet potatoes, the gas production can be increased by 12.65%, and the methane ratio can reach 61.92% (Catherine and Twizerimana, 2022; Montoro et al., 2025).

8.5.2 Farmer feedback

Most farmers said that the biogas production was relatively stable and sufficient for cooking and lighting. They said that now they no longer had to burn coal or chop wood at home, and life was more convenient (Montoro et al., 2025).

8.5.3 Economic and environmental outcomes

This project has greatly increased farmers' income. Using the "co-digestion" method, profits can be increased by 60%. The return of biogas residue and liquid to the fields as fertilizer not only saves money on fertilizers, but also makes the soil better and more environmentally friendly (Montoro et al., 2025).

8.5.4 Key bottlenecks (supply chain, policy, knowledge gaps)

However, the project also has some problems. For example, sweet potatoes are seasonal crops, and the supply of raw materials is not stable. Some farmers are not very skilled, and it is difficult to repair biogas equipment when it breaks down. In addition, some subsidy policies are slow to implement, and technical training is not enough, and support in this regard needs to be strengthened (Catherine and Twizerimana, 2022; Montoro et al., 2025).

9 Comparative Insights and Challenges

9.1 Comparison with other energy crops and sites

Sweet potato is a good biomass energy crop that performs well in producing biogas and methane. Compared with common energy crops such as cassava and corn, the effect of sweet potato is basically the same. Studies have found that when sweet potato and cassava are fermented together, the unit gas production is similar, 0.449 cubic meters/kg for sweet potato and 0.457 cubic meters/kg for cassava. The methane content of both is about 61%, with little difference (Montoro et al., 2025). The reducing sugar and moisture content of sweet potato are higher than that of corn, which is beneficial for anaerobic fermentation (De Paula Batista et al., 2019). However, there are still great differences between different sweet potato varieties. For example, the Laranjeiras variety has a particularly high gas production (De Paula Batista et al., 2019). Moreover, sweet potatoes can provide nutrition and energy at the same time, and have good adaptability in different regions, which also makes it more advantageous in rural energy systems (Tedesco et al., 2023).

9.2 Technical limitations

Although sweet potatoes are used to produce biogas, they also have some technical difficulties. First, it contains a lot of water and sugar, which helps to produce gas, but its starch structure is complex, especially amylopectin, which is not easy to decompose, and the fermentation time will be longer (Catherine and Twizerimana, 2022). Sweet potatoes are seasonal crops, with concentrated harvest time, and storage is not easy. They are easy to rot, affecting the continuous supply of raw materials (De Paula Batista et al., 2019; Catherine and Twizerimana, 2022). To improve efficiency and shorten the fermentation cycle, pretreatment, such as heating or adding alkali, is also needed to optimize substrate stability and equipment operation time (Catherine and Twizerimana, 2022).

9.3 Institutional and financial barriers

Sweet potato biogas projects have also encountered many difficulties in terms of policies and funds. Currently, policy support is not enough, and the investment payback time is long. Although joint fermentation can improve economic benefits and make money in many cases, the project requires a lot of investment in the early stage and maintenance is not cheap. Farmers and enterprises do not have so much money and lack technical support (Montoro et al., 2025). Some local policies are not perfect and lack specific incentive mechanisms. These problems limit the promotion and long-term development of sweet potato biogas projects (Tedesco et al., 2023; Montoro et al., 2025).

9.4 Adoption constraints

Many farmers are not familiar with the technology of sweet potato biogas production and are not very receptive. The main reason is that people do not understand this new technology and lack training and follow-up service support. In addition, sweet potatoes are important food and cash crops. Some farmers think that they are more suitable for eating or selling rather than fermenting. This contradiction between "eating and using" will also affect promotion (Tedesco et al., 2023). The current technical service system is not perfect enough, and there is no efficient promotion mechanism. These have become the main obstacles to the popularization of sweet potato biogas technology in rural areas (Tedesco et al., 2023; Montoro et al., 2025).

10 Conclusion and Recommendations

Different varieties of sweet potatoes vary greatly in yield and composition. Some varieties, such as Laranjeiras and BRS Cuia, produce more biogas, which has a lot to do with the amount of reducing sugars and water they contain. This shows that sweet potatoes are promising as energy crops. From a technical point of view, if sweet potato waste is treated with thermochemical methods, such as sodium hydroxide (NaOH), and then fermented, not only can the production of biogas and methane be increased, but the methane content can also be increased from 42% to 64%, and the fermentation time will be shortened, and the efficiency of energy conversion will also be improved. In rural areas, sweet potatoes are abundant and easy to obtain. Using them to develop biogas can not only reduce the waste of agricultural waste, but also bring clean energy to farmers, which is suitable for large-scale promotion.

In order to better promote the application of sweet potato biogas, several aspects can be taken into consideration. First of all, in terms of planting, those sweet potato varieties with high yield and high sugar content should be promoted first, so that it is easier to increase biogas production. Secondly, rural areas should be encouraged to adopt some new pretreatment methods, such as thermochemical treatment, which can greatly improve fermentation efficiency and methane production. At the same time, the government also needs to introduce some subsidy policies to help farmers and enterprises reduce the initial cost of building biogas digesters, so that projects are easier to implement. In addition, it is also important to incorporate sweet potato biogas into the rural energy system, which can not only improve the utilization rate of agricultural waste, but also enhance the rural energy supply capacity.

In the future, efforts can be made in sweet potato breeding, such as cultivating new varieties that are more suitable for gas production and drought-resistant and disease-resistant, so as to fundamentally improve the benefits of energy crops. At the same time, suitable construction models for different regions can be explored, such as a combination of centralized and distributed methods, so that resource allocation is more reasonable. It is also possible to consider fermenting sweet potatoes with other agricultural waste, such as with livestock manure, which can not only increase biogas production, but also increase overall economic benefits. If these measures can be implemented, they will be of great help in promoting rural energy development.

Acknowledgments
We would like to express our gratitude to the two anonymous peer reviewers for their critical assessment and constructive suggestions on our manuscript.

Conflict of Interest Disclosure
The authors affirm that this research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

References
Catherine C., and Twizerimana M., 2022, Biogas production from thermochemically pretreated sweet potato root waste, Heliyon, 8(9): e10376.
https://doi.org/10.1016/j.heliyon.2022.e10376

De Paula Batista S., Guerra E., Resende J., Gueri M., Carvalho G., Crestani J., and Silva I., 2019, Potential for biogas generation from sweet potato genotypes, Ambiente e Agua - An Interdisciplinary Journal of Applied Science, 14(2): e2317.
https://doi.org/10.4136/AMBI-AGUA.2317

Fang Y., Hossain M., Peng S., Han L., and Yang P., 2024, Sustainable energy development of crop straw in five southern provinces of China: Bioenergy production, land, and water saving potential, Renewable Energy, 224: 120134.
https://doi.org/10.1016/j.renene.2024.120134

Fu T., Xu Y., Li M., Xue S., Duan Z., and Xie G., 2022, Bioenergy production potential of 16 energy crops on marginal land in China, BioEnergy Research, 15: 998-1016.
https://doi.org/10.1007/s12155-021-10380-3

Hou J., Zhang W., Wang P., Dou Z., Gao L., and Styles D., 2017, Greenhouse gas mitigation of rural household biogas systems in China: a life cycle assessment, Energies, 10: 239.
https://doi.org/10.3390/EN10020239

Iqbal N., Sakhani M., Khan A., Ma A., Ajmal Z., and Khan M., 2021, Socioeconomic impacts of domestic biogas plants on rural households to strengthen energy security, Environmental Science and Pollution Research, 28: 27446-27456.
https://doi.org/10.1007/s11356-021-12633-2

Li Y., Qing C., Zhou W., and Xu D., 2025, Exploring the role of environmental regulations in biogas development in China, from the perspective of peer effect, Energy, 315: 134393.
https://doi.org/10.1016/j.energy.2025.134393

Li Y., Yan B., Qin Y., Shi W., and Yan J., 2021, Analysis of the types of animal husbandry and planting that influence household biogas in rural China, Journal of Cleaner Production, 332: 130025.
https://doi.org/10.1016/j.jclepro.2021.130025

Liu Q., 2011, Sweet potato omics and biotechnology in China, Plant Omics, 4: 295-301.

Liu T., Ferrari G., Pezzuolo A., Alengebawy A., Jin K., Yang G., Li Q., and Ai P., 2023, Evaluation and analysis of biogas potential from agricultural waste in Hubei Province, China, Agricultural Systems, 205: 103577.
https://doi.org/10.1016/j.agsy.2022.103577

Montoro S., Santos D., and De Lucas J., 2025, Exploring new alternative energy for sustainable food production, Circular Economy and Sustainability, 5: 1923-1947.
https://doi.org/10.1007/s43615-024-00497-w

Sang T., and Zhu W., 2011, China's bioenergy potential, GCB Bioenergy, 3(2): 79-90.
https://doi.org/10.1111/j.1757-1707.2010.01064.x

Sheikha A., and Ray R., 2017, Potential impacts of bioprocessing of sweet potato: review, Critical Reviews in Food Science and Nutrition, 57: 455-471.
https://doi.org/10.1080/10408398.2014.960909

Shi F., Meng X., Li J., Yang D., Liu J., Liu X., Xiang M., and Zhu Y., 2025, Impact of nitrogen fertilization on soil microbial diversity, its mediated enzyme activities, and stem nematode population in sweet potato fields, Frontiers in Microbiology, 16: 1528575.
https://doi.org/10.3389/fmicb.2025.1528575

Sun Y., Yang B., Wang Y., Zheng Z., Wang J., Yue Y., Mu W., Xu G., and Ying J., 2022, Emergy evaluation of biogas production system in China from perspective of collection radius, Energy, 265: 126377.
https://doi.org/10.1016/j.energy.2022.126377

Tang C., Jiang B., Ameen A., Mo X., Yang Y., and Wang Z., 2022, Life-cycle energy, economic, and greenhouse gas emissions of diversified sweet-potato-based cropping systems in South China, Agronomy, 12(10): 2340.
https://doi.org/10.3390/agronomy12102340

Tedesco D., Moreira B., Júnior M., Maeda M., and Da Silva R., 2023, Sustainable management of sweet potatoes: a review on practices, strategies, and opportunities in nutrition-sensitive agriculture, energy security, and quality of life, Agricultural Systems, 210: 103693.
https://doi.org/10.1016/j.agsy.2023.103693

Wang J., Gao M., He X., Zhang Q., Leo N., and Xu C., 2017, Evaluation of potential productivity of woody energy crops on marginal land in China, Chinese Geographical Science, 27: 963-973.
https://doi.org/10.1007/s11769-017-0916-4

Wang T., Zhou T., Li C., Song Q., Zhang M., and Yang H., 2024, Development status and prospects of biomass energy in China, Energies, 17(17): 4484.
https://doi.org/10.3390/en17174484

Yan B., Li Y., Qin Y., Shi W., and Yan J., 2022, Spatial-temporal distribution of biogas production from agricultural waste per capita in rural China and its correlation with ground temperature, The Science of the Total Environment, 817: 152987.
https://doi.org/10.1016/j.scitotenv.2022.152987

Yang B., Jia W., Yu Y., and Zhang H., 2024, Sustainability assessment of agricultural waste biogas production system in China based on emergy and carbon evaluation methods, Agriculture, 14(11): 1912.
https://doi.org/10.3390/agriculture14111912

Zhang C., and Qiu L., 2018, Comprehensive sustainability assessment of a biogas-linked agro-ecosystem: a case study in China, Clean Technologies and Environmental Policy, 20: 1847-1860.
https://doi.org/10.1007/s10098-018-1580-9

Zhang T., Yang Y., and Xie D., 2015, Insights into the production potential and trends of China's rural biogas, International Journal of Energy Research, 39: 1068-1082.
https://doi.org/10.1002/er.3311

Zhang Z., and Lis M., 2020, Modeling green energy development based on sustainable economic growth in China, Sustainability, 12(4): 1368.
https://doi.org/10.3390/su12041368