

Feature Review

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The Potential of Sweet Potato in Bioethanol and Biogas Production

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Abstract This study explores how sweet potatoes can be used to produce bioethanol and biogas, making them clean and renewable energy sources. Sweet potatoes have a high starch content, are adaptable to various types of soil, and have weak competitiveness with food crops. These characteristics make it an excellent raw material for the production of biofuels. This study reviewed the agronomic and biochemical characteristics of sweet potatoes and how these characteristics affect fuel production and energy efficiency. In addition, this study also explored the main production methods, such as low-temperature enzymatic hydrolysis and anaerobic digestion, which are conducive to converting sweet potatoes and their waste into ethanol and methane. Several cases from China, Africa and Brazil have demonstrated how sweet potato bioenergy can function in real life. In China, rural factories use simple fermentation systems to produce ethanol. In Africa, families use sweet potato waste to produce biogas for cooking. In Brazil, large farms operate integrated biorefineries that simultaneously produce ethanol, biogas, animal feed and fertilizers. These cases demonstrate that sweet potato energy projects can increase farm income, create job opportunities and reduce pollution. This article also points out related challenges, such as the high cost of enzymes, storage issues, and limited policy support. Even so, with the improvement of breeding levels, technological innovation and the application of digital tools, the prospects for sweet potato bioenergy are very bright. The development of this industry helps reduce the use of fossil fuels and supports green and low-carbon growth.

Keywords Sweet potato; bioethanol; biogas; renewable energy; sustainable development

1 Introduction

The use of fossil fuels has greatly increased greenhouse gas emissions and environmental pollution. To deal with climate change and achieve sustainable development, many countries are developing renewable energy. Biofuels, such as bioethanol and biogas, are key alternatives because they are renewable, carbon-neutral, and can reduce dependence on fossil fuels (Wang et al., 2013; Costa et al., 2018).

Bioethanol is made by fermenting starch or cellulose materials and is widely used in transportation, helping reduce carbon monoxide and particulate emissions (Lareo et al., 2013; Wang et al., 2013). Biogas is produced by anaerobic digestion of organic waste to form methane, which can be used for power and heat, while also treating agricultural waste (Wang et al., 2016). With better technology and policy support, both bioethanol and biogas are growing fast in global energy use.

Sweet potato (*Ipomoea batatas*) has become a strong candidate crop for biofuel production due to its high starch content, strong adaptability and high yield. It grows well in poor soil and requires almost no watering or fertilization (Lareo et al., 2013; Rizzolo et al., 2021). Unlike crops such as corn or wheat, sweet potatoes do not directly compete with the food supply. Sweet potatoes have a higher ethanol yield per unit area, and their by-products such as vines and residues can also be used to produce biogas (Wang et al., 2016; Gou et al., 2023). Optimizing enzymatic and fermentation processes can enhance conversion efficiency and save energy (Wang et al., 2013; Carvalho et al., 2023).

This study reviewed the potential of sweet potatoes in the production of bioethanol and biogas, and analyzed the latest progress in terms of raw material characteristics, process optimization, energy efficiency and environmental impact. In addition, this article also explores key technologies, new methods, and the role of sweet potato biofuels

in emission reduction and resource recycling. Finally, this paper puts forward the research and policy directions for the future sustainable industrial development.

2 Agronomic and Biochemical Traits of Sweet Potato

2.1 Agronomic traits

Sweet potatoes (*Ipomoea batatas*) grow well in tropical, subtropical and even some temperate regions. It is adaptable to various types of soil, including sandy soil, loam and clay, and only requires good drainage. Compared with major grains, it requires less water and fertilizer, and has strong drought resistance, growing well even on poor soil (Tedesco et al., 2023). Many varieties are resistant to pests and diseases, especially those improved through breeding (Vieira et al., 2015).

Most varieties mature in 120–180 days, faster than sugarcane or maize. High-yield types can reach over 30 tons per hectare under good conditions. The vines and leaves grow vigorously, offering materials for feed or biogas (De Paula Batista et al., 2019).

2.2 Biochemical composition

Sweet potato roots are rich in starch (15%~30%) and sugars, easy to hydrolyze for bioethanol (Wu et al., 2021a; 2021b). The high water content (60%~80%) supports anaerobic digestion, improving biogas yield (De Paula Batista et al., 2019). With high carbohydrate and moisture levels, sweet potato is an efficient biofuel feedstock (De Paula Batista et al., 2019; Wu et al., 2021a).

The vines contain proteins and fibers, suitable for feed or biogas use (Vieira et al., 2015; Sheikhha and Ray, 2017). Peels and residues are rich in organic matter and trace elements, useful for compost or soil improvement. Proper use of all parts supports “whole-plant utilization” (Sheikha and Ray, 2017; De Paula Batista et al., 2019).

2.3 Comparison with other crops

Compared with cassava, sugarcane or corn, sweet potatoes are more adaptable to specific soil and climatic conditions (Vieira et al., 2015; Tedesco et al., 2023). Sweet potatoes grow rapidly, have high yields, and do not compete with staple food crops (Sheikha and Ray, 2017). Its starch content is comparable to that of cassava, and it is easy to be converted into ethanol with low energy consumption (Hariharan et al., 2020). Unlike sugarcane, sweet potatoes do not require complex juicing processes, and compared with corn, their by-products have higher feed and fiber values.

Sweet potato residues perform better in biogas fermentation than corn stalks or bagasse (De Paula Batista et al., 2019). It shows strong advantages in energy conversion, adaptability, and resource use (Tedesco et al., 2023).

3 Sweet Potato Bioethanol Production

3.1 Starch conversion technology

Sweet potatoes have a high starch content, so the first step is to convert the starch into fermentable sugar. This process involves liquefaction and saccharification using α -amylase and glucoamylase. Recent studies have shown that hydrolysis can proceed well at 28 °C~42 °C, and the use of simultaneous saccharification fermentation (SSF) can shorten the reaction time and increase the yield. For high-viscosity residues, cellulase and pectinase help release glucose and reduce viscosity (Wang et al., 2016). The optimized process can achieve nearly 80% ethanol production within approximately 22 hours (Carvalho et al., 2023). The combined use of enzymes can also increase the release of sugar in the residue (Gou et al., 2023).

3.2 Fermentation process

Common microbes include *Saccharomyces cerevisiae* and *S. diastaticus* (Abdullah et al., 2015; Rizzolo et al., 2021). Factors such as temperature, yeast concentration, and pH affect ethanol yield. The best results are at 35 °C ~37 °C and 40%~45% (v/v) yeast (Abdullah et al., 2015). SSF technology is widely used because it reduces sugar loss and viscosity, improving efficiency (Zhang et al., 2011; Hariharan et al., 2020). Ethanol yield can reach over 91% at both lab and industrial scales (Zhang et al., 2011). Adding xylanase can further improve fermentation of thick materials (Wang et al., 2016).

3.3 Ethanol output and efficiency

The output of ethanol depends on the variety, starch content and process parameters. Each kilogram of dry sweet potato residue can produce 210-226 grams of ethanol with a concentration of 79-113 grams per liter (Wang et al., 2016; Gou et al., 2023). The theoretical yield can reach 4 800~10 000 liters per hectare (Lareo et al., 2013; Rizzolo et al., 2021) (Figure 1). The net energy ratio can reach 1.48, and the energy gain is 6.55 megajoules per liter (Wang et al., 2013). The key factors include starch content, enzyme type, strain activity and pH value. Cleaner energy use and better crop management can enhance energy and environmental efficiency (Costa et al., 2018).

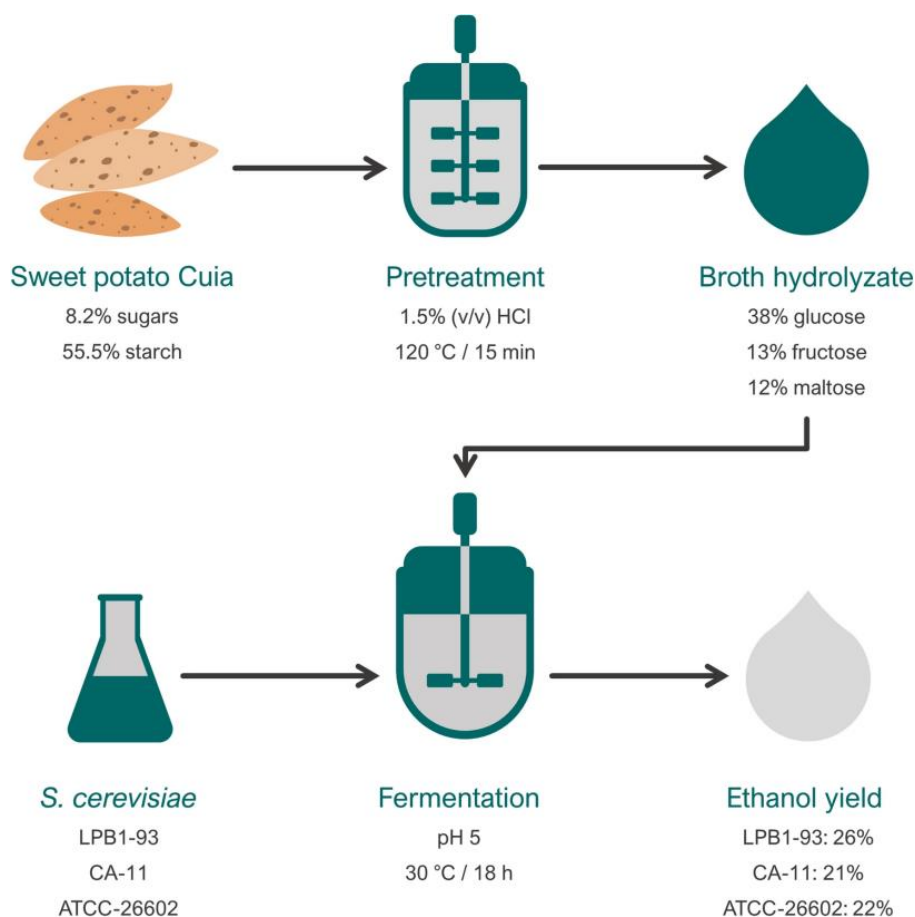


Figure 1 Conversion process of sweet potato into ethanol (Adopted from Rizzolo et al., 2021)

3.4 Pilot and commercial applications

China has built several pilot projects and commercial chemical plants for sweet potato ethanol, promoting the energy transition in rural areas (Zhang et al., 2011; Wang et al., 2016). Brazil and India are also carrying out similar work, with a focus on breeding and technological innovation (Rizzolo et al., 2021). The key to success lies in stable raw materials, simplified production processes and the utilization of by-products. Although sweet potato ethanol has a lower environmental impact than some fuels, problems such as water eutrophication and gas emissions still exist (Wang et al., 2013; Costa et al., 2018). Centralized production, green planting and policy support will contribute to the sustainable development of this industry.

4 Sweet Potato Residue Produces Biogas

4.1 Anaerobic digestion potential

Sweet potato residue is an agricultural waste rich in starch, cellulose and soluble sugar, and has huge potential for biomass energy. There are differences in the contents of moisture, reducing sugar and organic matter among different varieties of sweet potato roots and residues, which will affect the ease of decomposition and gas production during anaerobic digestion (De Paula Batista et al., 2019).

Because sweet potatoes have a high sugar content and are rich in water, microorganisms can easily decompose the residue of sweet potatoes and produce methane. Some varieties, such as Laranjeiras and BRS Cuia, have higher biomethane potential (BMP), with gas production exceeding 2,900 liters per hectare (De Paula Batista et al., 2019). However, complex starch structures, especially amylopectin, can reduce enzyme activity and prolong digestion time (Catherine and Twizerimana, 2022) (Figure 2).



Figure 2 Biogas production setup (Adopted from Catherine and Twizerimana, 2022)

In practical applications, sweet potato residue can be used alone or mixed with livestock and poultry manure for anaerobic digestion. Co-digestion helps balance the carbon-nitrogen ratio, enhance microbial activity and system stability (Montoro et al., 2025). After co-digestion with livestock and poultry manure, biogas production can be increased by approximately 12.65%, methane content can reach 61.92%, and organic matter degradation and nutrient recovery rate are also improved.

4.2 Process optimization

Pretreatment is crucial for increasing biogas production because the complex starch structure makes its digestion more difficult. Thermochemical pretreatment (such as using NaOH solution) can break down starch and cellulose, making the material more digestible (Catherine and Twizerimana, 2022). Under the optimal conditions (NaOH 2.9 g/L, 82 °C, 102 min), biogas production increased by 33.88%, methane content rose from 42% to 64%, and digestion time was shortened from 22 days to 16 days (Catherine and Twizerimana, 2022). Other pretreatment methods, such as grinding, hot water treatment and enzyme pretreatment, are also very common.

Both intermittent and continuous anaerobic digesters can be used. Batch reactors are suitable for small-scale or laboratory applications, while continuous stirred tank reactors (CSTR) are more suitable for industrial production with stable output (Catherine and Twizerimana, 2022; Montoro et al., 2025). New systems such as multi-stage reactors and anaerobic membrane bioreactors can further increase methane production and system performance. Process optimization also includes precise control of temperature, pH value and carbon-nitrogen ratio.

4.3 Biogas production and utilization of by-products

The biogas production and methane content of sweet potato residue depend on the substrate composition, pretreatment and process parameters. After optimization, the yield can reach 37.8 mL/g (in terms of dry matter), and the methane content can reach 64%, which is much higher than that of untreated sweet potato residue (Catherine and Twizerimana, 2022). Co-digestion further improved these results and demonstrated stable energy conversion (Montoro, Santos, and De Lucas, 2025). Although the biogas production varies among different sweet potato varieties, on the whole, its potential for sustainable utilization is huge (De Paula Batista et al., 2019; Montoro et al., 2025).

In addition to biogas, anaerobic digestion can also produce nutrient-rich digestion products and liquid by-products. These by-products can be used as bio-organic fertilizers to recycle nutrients and improve the soil (Montoro et al., 2025). Liquid digests are rich in nitrogen, phosphorus and potassium, making them suitable for crops or gardens. Solid residues can be composted or used to increase soil organic matter and fertility.

5 Environmental and Economic Benefits

5.1 Environmental sustainability

Life cycle assessment (LCA) shows that the net energy ratio of sweet potato bioethanol is 1.48, and the net energy gain is 6.55 MJ/L. This means it uses energy more efficiently than fossil fuels (Wang et al., 2013; Sanni et al., 2022). The use of sweet potato ethanol and biogas can help cut greenhouse gases and lower the need for oil and other nonrenewable energy. Compared with corn or cassava, sweet potato makes better use of land. It can still grow well on poor soil or marginal land, so it does not take land away from food crops (Sheikha and Ray, 2017; Sanni et al., 2022).

Sweet potato waste can also be reused. After anaerobic digestion treatment, the residue can be converted into organic fertilizer and energy (Weber et al., 2020; Montoro et al., 2025). This not only reduces waste but also helps to recycle useful materials.

Even so, the production of sweet potato biofuel still brings some environmental problems, such as eutrophication and acidification. The use of fertilizer and pesticide, and the steam used in production, may cause water and air pollution. Studies show that steam use, crop yield, and fertilizer input are key factors that affect the environmental results (Wang et al., 2013). To make the process greener, we can replace coal with clean energy and promote precise fertilization in farming. The liquid and solid leftovers from biogas production can also go back to the fields as organic fertilizer, reducing chemical fertilizer use (Montoro et al., 2025).

5.2 Economic opportunities

The sweet potato industry brings jobs and supports other related industries like energy and environmental protection (Weber et al., 2020). In places such as Brazil and China, making bioethanol and biogas from sweet potatoes increases the value of crops and helps improve rural areas and technology (Montoro et al., 2025). Farmers can earn money not just from selling the roots but also from using vines and residues to make other products (Sheikha and Ray, 2017).

A sweet potato biorefinery can make ethanol, biogas, and liquor at the same time. This brings more income sources. In many cases, the projects show good net present value (NPV) and internal rate of return (IRR). Some projects can get back the investment in only one year (Weber et al., 2020). Using co-digestion can increase biogas output and raise profits by about 60% compared to using only animal manure (Montoro et al., 2025). These projects not only make money but also create new jobs and improve local economies.

5.3 Cost-benefit analysis

Economic studies show that sweet potato ethanol factories can reach a return on investment (ROI) of 41.96% when working at 80% of capacity. This is higher than sorghum and only slightly lower than cassava. The break-even price is about \$3.27 per gallon. When the selling price is higher, the project makes a profit (Sanni et al., 2022). If the factory produces ethanol and liquor together, profits can grow even more. In some cases, the net present value goes over \$1 million, and the internal rate of return reaches 51%, with the payback period just over one year (Weber et al., 2020).

For biogas projects, using co-digestion and by-products helps improve cost-effectiveness. Over half of these projects can reach a positive net present value (Montoro et al., 2025).

The main factors that affect cost and profit include the price of raw materials, yield, energy use, process efficiency, and the sale of by-products (Wang et al., 2013; Sanni et al., 2022; Montoro et al., 2025). Steam use and the type of energy are also very important. Using clean energy and better technology can lower costs (Wang et al., 2013). Using sweet potato residues and vines adds extra income and spreads the cost of materials and treatment (Weber et al., 2020; Montoro et al., 2025).

Compared with sugarcane, sweet potato projects may have lower profit per unit, but they are better for the environment and for society.

6. Challenges and Limitations

6.1 Technical bottlenecks

The high moisture and high sugar content characteristics of sweet potatoes and their residues make them extremely prone to spoilage and deterioration, resulting in severe loss of raw materials during harvesting, transportation and storage, and affecting the subsequent processing efficiency and product quality (Costa et al., 2018; Tedesco et al., 2023). Especially in regions with hot climates or high humidity, the storage period of sweet potato tubers and waste is extremely limited. They have to rely on cold chain or rapid processing systems; otherwise, they are prone to mold and spoilage, increasing raw material management and logistics costs. The structure of sweet potato starch is complex, and it has a high dependence on enzyme preparations during hydrolysis and saccharification. Moreover, efficient enzyme preparations are expensive, which has become an economic obstacle restricting large-scale promotion (Lyu et al., 2021). At present, although the advancements in enzyme engineering and biotechnology have led to some cost reductions, further breakthroughs are still needed in the research and application of efficient and low-cost enzyme preparations (Okoro et al., 2022).

The starch content, fiber structure and resistance characteristics of different varieties vary greatly, making it difficult to unify the process parameters of hydrolysis, fermentation and anaerobic digestion, which affects the utilization rate of raw materials and product consistency (Lyu et al., 2021; Tedesco et al., 2023). The presence of amylopectin and cellulose in sweet potato residue will reduce the enzymatic hydrolysis efficiency, prolong the reaction period, increase energy consumption and the difficulty of by-product treatment (Costa et al., 2018). In biogas production, the high moisture content and high organic load of the substrate can easily cause operational problems such as acidification, foaming and clogging of the reactor, which puts forward higher requirements for the stability of the anaerobic digestion system.

6.2 Infrastructure and market shortcomings

The collection, transportation and preliminary processing of sweet potatoes and their residues lack an efficient and low-cost logistics and processing network, resulting in an unstable raw material supply chain and affecting the continuous production and economies of scale of the factory (Costa et al., 2018). In many major sweet potato production areas, raw materials are mostly grown in a scattered manner, lacking centralized purchasing and standardized pretreatment facilities, which increases raw material loss and transportation costs, and also limits the large-scale expansion of the industry (Tedesco et al., 2023). The downstream markets of bioethanol and biogas are not yet fully mature. There is a lack of a complete product distribution, storage and terminal utilization system, resulting in limited product sales channels, large fluctuations in market prices, and affecting the investment enthusiasm of enterprises and the stability of the industrial chain.

The upstream and downstream of the sweet potato biofuel industry chain are not well connected, and there is a lack of efficient value chain integration and diversified product development capabilities. Processing enterprises in many regions are limited to the production of a single product (such as ethanol or biogas), and fail to achieve the high-value utilization of by-products (such as digestive juices, organic fertilizers, feed, etc.), resulting in resource waste and a decline in economic benefits (Okoro et al., 2022; Tedesco et al., 2023). The lack of professional technical services and industrial alliances has restricted the promotion of new technologies and industrial collaborative innovation.

6.3 Policy and institutional obstacles

Although some countries and regions have introduced biofuel development plans and subsidy policies, the overall policy system is still imperfect and lacks specific support measures for non-grain biomass raw materials such as sweet potatoes (Tedesco et al., 2023). In practice, biofuel projects often encounter problems such as cumbersome approval processes, difficult land transfer, and inadequate implementation of tax incentives, which increase the institutional transaction costs of enterprises (Costa et al., 2018). There is considerable uncertainty in the market access, price mechanism and subsidy policy of biofuel products. The investment risk for enterprises is high, which affects the continuous investment of capital and technology (Tedesco et al., 2023).

From a regulatory perspective, the biofuel industry involves multiple sectors such as agriculture, energy, and the environment, but coordinated regulation remains weak (Costa et al., 2018; Tedesco et al., 2023). In addition, the lack of stable financial support has hindered technological research and development, infrastructure construction and market growth. Uncertainty and a weak support system have made the sweet potato biofuel industry less competitive compared with traditional energy and other biomass energy sources.

7 Case Studies

7.1 Case 1: bioethanol production in Rural China

Many rural cooperatives and small agricultural companies in China adopt advanced processes such as low-temperature enzymatic hydrolysis and synchronous fermentation. These methods help to convert sweet potatoes into ethanol more efficiently. They use conventional amylase to break down starch at a temperature of about 28 °C~42 °C and carry out fermentation simultaneously. This saves energy, shortens production time, and increases ethanol output (Carvalho et al., 2023). In practice, some companies have improved the sequence of enzyme usage and fermentation conditions, increasing the ethanol output to 79.7% and reducing the reaction time by 8.6 hours. This has greatly enhanced efficiency and profits.

Sweet potato ethanol performs better in energy use than ethanol made from corn or wheat. Its life-cycle energy efficiency is higher (Ren et al., 2014). Building and running bioethanol plants also create local jobs and help farmers earn more income. Using sweet potato ethanol helps reduce fossil fuel use and greenhouse gas emissions, supporting China's carbon peak and neutrality goals (Costa et al., 2018).

7.2 Case 2: biogas projects in Sub-Saharan Africa

In sub-Saharan Africa, sweet potato waste is often used in small household or community biogas systems. These projects help solve the problem of energy shortage in rural areas and reduce pollution. Many families build simple anaerobic digesters to convert sweet potato peels, vines and other organic waste into biogas for cooking, lighting and heating (Sheikha and Ray, 2017). The remaining liquid and solid substances in the biogas production process are used as organic fertilizers.

Local cooperatives and community groups are responsible for managing and maintaining these biogas systems, creating new job opportunities. This has also enhanced the participation of women and vulnerable groups in the rural economy. These projects transform agricultural waste into useful resources, reduce pollution and decrease the spread of diseases. Although there are still technical, financial and management challenges, these sweet potato biogas projects offer a practical approach to improving rural energy utilization and protecting the environment.

7.3 Case 3: integrated bioenergy farms in Brazil

Some farms and companies in Brazil have built integrated bioenergy plants. They process sweet potato roots, residues, and vines together to produce ethanol, biogas, animal feed, and organic fertilizer (Costa et al., 2018). These biorefineries use techniques like simultaneous hydrolysis and fermentation and combined anaerobic digestion. This not only improves energy conversion but also cuts waste and environmental pollution. Compared with traditional corn or sugarcane ethanol, sweet potato ethanol in Brazil performs better in reducing carbon emissions and making good use of land.

Through a circular economy model, these farms earn money from energy products and also use by-products like organic fertilizer to improve soil and crop yields. Large-scale operation of these biorefineries creates jobs, promotes technology use, and supports rural infrastructure and local economic growth.

8. Future Outlook and Innovation

8.1 Advances in genetics and breeding

Through traditional hybridization and molecular breeding methods, researchers have cultivated sweet potato varieties with high starch content, strong stress resistance and suitable for mechanical harvesting. These varieties not only increase the yield per unit area, but also optimize the bioconversion efficiency of raw materials (De Paula Batista et al., 2019). Some new varieties have both high carotene and anthocyanin contents, which can not only

meet the nutritional requirements but also be suitable for bioethanol and biogas production, reducing the contradiction of "grain energy competing for land" (Tedesco et al., 2023). Adaptive breeding for marginal lands such as arid and infertile ones enables sweet potatoes to grow efficiently on non-high-quality cultivated land.

In the future, emerging biotechnologies such as gene editing are expected to further accelerate the targeted improvement of sweet potato varieties. By regulating the genes related to starch synthesis, the accumulation rate and proportion of starch can be increased, or the content of degradable components such as cellulose and hemicellulose can be enhanced (Wang et al., 2024). For biogas production, choosing varieties with high reducing sugar content and easy degradability can significantly increase methane output (De Paula Batista et al., 2019).

8.2 Biorefining and cascade utilization

Sweet potatoes can not only be used for starch conversion to ethanol, but also their residue, vines and other by-products can be used as raw materials for biogas fermentation, animal feed, microbial protein and organic fertilizer (Sheikha and Ray, 2017; Weber et al., 2020; Rizzolo et al., 2021). After extracting starch from sweet potato residue, it is still rich in fermentable carbon sources. By optimizing the enzymatic hydrolysis and fermentation processes, it can be efficiently converted into ethanol or biogas (Wang et al., 2016; Wang et al., 2024). Under the integrated production mode, multiple products such as ethanol, distilled spirits, feed and organic fertilizers are output in a coordinated manner, significantly enhancing economic benefits and resource utilization (Weber et al., 2020).

In the future, sweet potato biorefining will place greater emphasis on process integration and energy cascade utilization. Efficient conversion of raw materials and stepwise utilization of by-products were achieved by adopting technologies such as simultaneous saccharification and fermentation (SSF), solid-liquid separation, and waste heat recovery (Zhang et al., 2011; Wang et al., 2016; Carvalho et al., 2023). Flexibly adjust the product structure based on market demand, such as dynamically switching among ethanol, distilled spirits, feed, etc., to enhance the industry's risk resistance capacity (Weber et al., 2020).

8.3 Technological innovation

The application of high-resolution remote sensing, Internet of Things sensors and artificial intelligence (AI) technologies has enabled precise monitoring and remote optimization in the links of sweet potato planting, harvesting and processing (Tedesco et al., 2023). Through satellite remote sensing and unmanned aerial vehicle (UAV) monitoring, farmers can grasp the growth conditions, pests and diseases, and soil moisture in the fields in real time, and adjust irrigation, fertilization, and pest and disease control strategies in a timely manner (Tedesco et al., 2023). During the processing stage, AI algorithms can dynamically optimize fermentation parameters, energy consumption and product quality, reducing energy consumption, minimizing losses and enhancing production efficiency (Carvalho et al., 2023).

In the future, intelligent decision-making platforms based on big data and cloud computing will further enhance the management level of the sweet potato energy industry. By integrating meteorological, soil, crop growth and market information, full-process digital management from the field to the factory is achieved, supporting precise planting, intelligent logistics and flexible production (Tedesco et al., 2023). Emerging technologies such as blockchain can be used for raw material traceability and product quality tracking, enhancing consumer trust and market competitiveness. Intelligent and digital technological innovations will inject strong impetus into the efficient and sustainable development of sweet potatoes in the fields of bioethanol and biogas (Sheikha and Ray, 2017).

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Conflict of Interest Disclosure

The author affirms that this research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

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