



# Strategies and Challenges of Hydrogen Production from Food Processing Wastes

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## DESCRIPTION

The global energy landscape is undergoing a rapid transformation as nations strive to reduce their carbon emissions and transition towards sustainable energy sources. Hydrogen has emerged as a component candidate for a clean and versatile energy carrier. While various methods of hydrogen production exist, some of the most innovative and sustainable approaches involve harnessing the potential of food and food processing wastes. This article explores the strategies and challenges associated with hydrogen production from these organic waste sources. Food waste is a major global issue with severe environmental, economic, and social implications. According to the United Nations, approximately one-third of all food produced for human consumption, which amounts to 1.3 billion tons annually, is wasted. This wastage not only squanders valuable resources such as water and land but also contributes significantly to greenhouse gas emissions when food decomposes in landfills. Turning this problem into an opportunity, researchers and innovators have begun to explore how food waste can be converted into valuable resources like hydrogen.

### Strategies for hydrogen production from food waste

**Anaerobic digestion:** One of the most established methods for extracting hydrogen from food waste is anaerobic digestion. This biological process involves the breakdown of organic matter by microorganisms in the absence of oxygen. During this process, organic waste, such as food scraps and leftovers, is broken down into biogas, which consists of methane and carbon dioxide. However, by modifying the anaerobic digestion process, researchers have successfully produced hydrogen-rich biogas instead. This hydrogen-enriched biogas can then be separated and purified to obtain pure hydrogen gas.

**Fermentation:** Fermentation is another captive approach for hydrogen production from food waste. Certain microorganisms can metabolize organic materials in food waste and produce hydrogen gas as a metabolic by-product. This biological process, known as dark fermentation, can be optimized to enhance

hydrogen production. Researchers are actively investigating different strains of microorganisms and process conditions to maximize the efficiency of dark fermentation for hydrogen generation.

**Thermal gasification:** Thermal gasification is a high-temperature process that can convert food waste into a mixture of hydrogen, carbon monoxide, and methane. This method involves heating the organic waste to a high temperature in the presence of a controlled amount of oxygen or steam. The resulting gas can be further processed to obtain high-purity hydrogen. Thermal gasification has the advantage of being able to handle a wide range of organic materials, including food scraps and agricultural residues.

### Challenges in hydrogen production from food waste

While the potential for hydrogen production from food waste is advantageous, several challenges must be addressed to make this approach economically viable and environmentally sustainable.

**Feedstock variability:** Food waste is highly variable in composition, depending on factors such as location, culture, and consumer habits. This variability poses challenges for consistent and efficient hydrogen production processes. Researchers and engineers must develop flexible and adaptable systems that can handle a wide range of feedstock compositions.

**Energy intensity:** Some hydrogen production methods from food waste, such as thermal gasification, require significant energy input to reach the necessary process temperatures. This energy demand may offset the environmental benefits of using food waste as a feedstock. Developing more energy-efficient processes or integrating renewable energy sources into the production chain is essential to mitigate this issue.

**Technological innovation:** Innovations in hydrogen production technologies are needed to increase efficiency and reduce costs. Study efforts should focus on improving the catalysts and reactor designs used in processes like dark fermentation and thermal gasification. Additionally, developing scalable and modular

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systems will enable widespread adoption of food waste-based hydrogen production.

**Resource competition:** The use of food waste for hydrogen production must be balanced with other essential applications, such as composting or animal feed. Striking the right balance between these competing uses is crucial to ensure that food waste is utilized optimally to minimize environmental impacts. Implementing large-scale hydrogen production from food waste requires navigating regulatory and safety concerns. Hydrogen is a highly flammable gas, and its production and storage must adhere to stringent safety protocols.

Ensuring compliance with regulations while maintaining cost-effectiveness is a significant challenge for industry stakeholders. Hydrogen production from food and food processing wastes

represents a capable pathway for addressing both the global food waste crisis and the transition to a low-carbon energy economy. By harnessing innovative strategies like anaerobic digestion, fermentation, and thermal gasification, researchers and engineers are unlocking the potential of organic waste to produce clean hydrogen. However, significant challenges remain, including feedstock variability, energy intensity, technological innovation, resource competition, and regulatory concerns. Overcoming these challenges will require collaboration among scientists, policymakers, and industry associates to provide a sustainable and efficient food waste-to-hydrogen value chain. Ultimately, the success of this endeavor could not only mitigate the environmental impacts of food waste but also contribute to a cleaner and more sustainable energy.