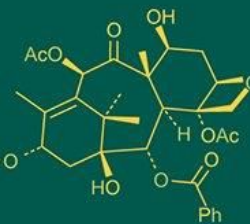


International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
IJABR 2024; 8(8): 1522-1524
www.biochemjournal.com
Received: 25-05-2024
Accepted: 30-06-2024

Chetan Kumar DS
Department of Sericulture,
College of Agriculture, UAS,
GKVK, Bengaluru,
Karnataka, India

B Gowthami
Department of Biosciences and
Sericulture, Sri Padmavati
Mahila Visvavidyalayam,
Tirupati, Andhra Pradesh,
India

V Pavani Naga Durga
Department of Genetics and
Plant Breeding, Shahid
Gundadhar College of
Agriculture and Research
Station, Jagdalpur,
Chhattisgarh, India

Mulberry biomass as a renewable source for bioenergy production

Chetan Kumar DS, B Gowthami and V Pavani Naga Durga

DOI: <https://doi.org/10.33545/26174693.2024.v8.i8s.3781>

Abstract

The increasing demand for renewable energy sources has led to biomass being recognised as a viable alternative to fossil fuels. Among the various biomass sources, mulberry trees (genus *Morus*) offer a promising solution due to their fast growth, high biomass yield, and adaptability to diverse environmental conditions. This review examines the potential of mulberry biomass for bioenergy production, including its applications in biofuels generation, and the environmental and economic benefits associated with its use. The paper also addresses the challenges and future directions in harnessing mulberry biomass for sustainable energy systems.

Keywords: Mulberry biomass, bioenergy, biofuels, renewable energy, sustainability, environmental benefits

Introduction

The growing need for sustainable energy solutions to mitigate the environmental impact of fossil fuels and reduce greenhouse gas emissions has directed attention towards biomass as a renewable resource for bioenergy production. Among the promising biomass sources, mulberry trees are particularly noteworthy. These trees are fast-growing, capable of producing substantial biomass, and adaptable to various climates, making them an ideal feedstock for bioenergy applications. Mulberry biomass can be processed into different forms, such as wood chips, pellets, or even used directly for biofuels, biogas, and bioelectricity generation.

In addition to its biomass potential, mulberry trees are highly resilient and require relatively low inputs, such as water and nutrients, compared to other bioenergy crops. This quality makes mulberry a suitable candidate for cultivation on marginal lands or in regions unsuitable for conventional agricultural practices. Furthermore, the lignocellulosic composition of mulberry biomass makes it an ideal feedstock for conversion into biofuels like ethanol or biobutanol through advanced biochemical and thermochemical processes.

Utilising mulberry biomass for bioenergy production offers multiple benefits: it strengthens energy security, provides economic opportunities, particularly in rural areas, and contributes to carbon sequestration, which can help offset carbon emissions. As the global community strives to transition from non-renewable energy sources, biomass energy, particularly from mulberry, holds promise as a sustainable alternative. This article explores the characteristics of mulberry biomass and its potential applications in renewable energy production.

Mulberry Biomass Characteristics

Mulberry trees, especially *Morus alba*, are known for their rapid growth, with some species capable of reaching 3-5 meters in height within the first year. This rapid growth translates into a high biomass yield, making mulberry an efficient source of organic matter. The tree's lignocellulosic biomass, consisting of cellulose, hemicellulose, and lignin, is suitable for conversion into various biofuels (Fatma *et al.*, 2018) [4]. The high cellulose content of mulberry biomass is particularly beneficial for biofuel production, as cellulose plays a crucial role in the production of bioethanol and biobutanol (Wang *et al.*, 2020; Haykir *et al.*,

Corresponding Author:
Chetan Kumar DS
Department of Sericulture,
College of Agriculture, UAS,
GKVK, Bengaluru,
Karnataka, India

2023)^[14, 6]. Additionally, mulberry trees are known for their adaptability to a wide range of climates and soil types, thriving even in areas with low rainfall and minimal nutrient input. This characteristic makes them ideal for cultivation on marginal lands, reducing competition for fertile agricultural land and promoting the use of otherwise unproductive areas (Jiang *et al.*, 2017)^[8].

Applications in Bioenergy Production

Mulberry trees show great potential in fuel and energy production. In India, annual mulberry shoots, available after the silkworm breeding season, are cut, dried, and used as a renewable fuel source (Chinnaswamy & Hariprasad, 1995)^[3]. Mulberry's high cellulose content (57.4%), hemicellulose (16.3%), and lignin (24.6%) (Sharma and Madan, 1994)^[13], alongside its resistance to disease and pests, make it an excellent candidate for bioenergy applications. Mulberry plantations require low soil inputs and can be cultivated on degraded or marginal land, offering a low-cost biomass source for generating heat, electricity, and liquid or gaseous fuels. Biomass yields of 14-17 tonnes/ha have been reported for mulberry cultivation (Sharma and Madan, 1994)^[13], making it more efficient than other energy crops, such as energy willow (*Salix viminalis*) and kenaf (*Hibiscus cannabinus*).

Lu *et al.* (2009)^[9] explored the use of marginal agricultural lands for cultivating mulberry as a sustainable feedstock for biomass energy production. Their study highlights mulberry's suitability for thermochemical processes (e.g., combustion, gasification, pyrolysis) and biochemical processes (e.g., fermentation, anaerobic digestion), all of which can yield biofuels, biogas, or bioelectricity. Mulberry's rapid growth and high yield make it a promising crop for sustainable energy production. Additionally, mulberry cultivation on marginal lands can help prevent soil erosion, improve soil quality, and sequester carbon, contributing to environmental sustainability.

Ajaya *et al.* (2022)^[1] demonstrated the potential of paper mulberry fruit juice, rich in fermentable sugars, as a substrate for bioethanol production. Their study found that *Morus* fruit juice yields competitive ethanol outputs, comparable to traditional bioethanol feedstocks like sugarcane and corn, while offering an alternative use for an otherwise underutilised resource. Despite the promising results, challenges such as scalability, economic feasibility, and year-round availability remain, and these need to be addressed to fully harness the potential of paper mulberry.

Calorific Value and Higher Heating Value (HHV)

The calorific value of mulberry biomass significantly affects its energy content. According to Lu *et al.* (2009)^[9], the calorific value of mulberry branches was found to be 17.053 MJ/kg. Comparable findings were reported by Mithilashri (2022)^[11] and Goswami and Das (2020)^[5], further supporting the viability of mulberry as a high-energy feedstock.

Fuel Value Index (FVI)

The fuel value index (FVI) is a critical measure for assessing the combustion quality of biomass. Bhatt *et al.* (2010)^[2] and Nabi *et al.* (2017)^[12] obtained similar FVI values for other fuelwood species, supporting the use of mulberry as an efficient biomass resource.

Thermal Conversion Efficiency

Thermal conversion efficiency, which assesses the energy output in relation to the input calorific value, is another critical factor for biomass gasification. Goswami and Das (2020)^[5], who reported a thermal conversion efficiency of 68.45% for *Morus rubra*. High thermal conversion efficiency is essential for the economic viability of mulberry biomass in gasification processes, making it an effective and efficient energy source.

Environmental Benefits

Mulberry biomass offers numerous environmental benefits. As carbon sinks, mulberry trees absorb carbon dioxide from the atmosphere and store it in their biomass, helping to mitigate climate change. Moreover, mulberry cultivation requires minimal water and fertilisers, making it a more environmentally friendly option compared to other bioenergy crops. Using mulberry residues in bioenergy production also helps reduce waste by diverting tree residues (leaves, branches, and trunks) from landfills or open burning, thus contributing to sustainable forest resource management (Hazarika, 2021; Mir *et al.*, 2019)^[7, 10].

Economic Impact

The cultivation and processing of mulberry biomass for bioenergy production can bring significant economic benefits, particularly in rural areas. By promoting mulberry cultivation on marginal lands, bioenergy production creates new income opportunities for farmers and communities. Furthermore, the value-added products derived from mulberry biomass—such as biofuels, biogas, and bioelectricity—can reduce reliance on imported fossil fuels, enhancing energy security and economic stability, especially in regions with limited access to conventional energy resources (Mir *et al.*, 2019)^[10].

Challenges and Limitations

Despite the promising potential of mulberry biomass, several challenges hinder its widespread adoption as a bioenergy feedstock. Economic feasibility remains a key issue, as the initial investments required for plantation establishment, infrastructure, and processing technologies can be substantial. Additionally, the logistics of transporting mulberry biomass from rural or marginal lands to processing facilities can be costly and inefficient, impacting the overall economic viability of mulberry-based bioenergy systems. Furthermore, the scalability of bioethanol and biogas production from mulberry remains uncertain, and more research is needed to optimise fermentation processes and improve yield consistency.

Conclusion and Future Directions

Mulberry biomass holds significant promise as a renewable resource for bioenergy production due to its high biomass yield, rapid growth, and environmental benefits. Its potential applications in biofuels, biogas, and bioelectricity offer opportunities for sustainable energy systems. However, challenges such as economic feasibility, scalability, and transportation logistics must be addressed to realise its full potential. Future research should focus on improving conversion technologies, enhancing yields, and overcoming the limitations of mulberry-based bioenergy systems. With

continued research and development, mulberry biomass could play a crucial role in the global transition towards a more sustainable energy future.

References

1. Ajayo PC, Huang M, Zhao L, Tian D, Jiang Q, Deng S, *et al.* Paper mulberry fruit juice: A novel biomass resource for bioethanol production. *Bioresources and Bioprocessing*. 2022;9(1):3. <https://doi.org/10.1186/s40643-022-00489-5>
2. Bhatt BP, Sarangi SK, De LC. Fuelwood characteristics of some firewood trees and shrubs of Eastern Himalaya, India. *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*. 2010;32(5):469-474. <https://doi.org/10.1080/15567030903110539>
3. Chinnaswamy KP, Hariprasad KB. Fuel energy potentiality of mulberry. *Indian Silk*. 1995;34(4):15-18.
4. Fatma S, Hameed A, Noman M, Ahmed T, Shahid M, Tariq M, *et al.* Lignocellulosic biomass: A sustainable bioenergy source for the future. *Protein and Peptide Letters*. 2018;25(2):148-163. <https://doi.org/10.2174/0929866524666171012111257>
5. Goswami R, Das R. Energy cogeneration study of red mulberry (*Morus rubra*)-based biomass. *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*. 2020;42(8):979-1000. <https://doi.org/10.1080/15567036.2020.1771383>
6. Haykir NI, Zahari SMSNS, Harirchi S, Sar T, Awasthi MK, Taherzadeh MJ. Applications of ionic liquids for the biochemical transformation of lignocellulosic biomass into biofuels and biochemicals: A critical review. *Biochemical Engineering Journal*. 2023;193:108850. <https://doi.org/10.1016/j.bej.2023.108850>
7. Hazarika M. Mulberry: An entrepreneurial opportunity for the sericulture industry. In: Naresh RK, editor. *Agroforestry for climate change mitigation and livelihood security*. Apple Academic Press; 2021. p. 159-172.
8. Jiang Y, Huang R, Yan X, Jia C, Jiang S, Long T. Mulberry for environmental protection. *Pakistan Journal of Botany*. 2017;49(2):781-788.
9. Lu L, Tang Y, Xie JS, Yuan YL. The role of marginal agricultural land-based mulberry planting in biomass energy production. *Renewable Energy*. 2009;34(7):1789-1794. <https://doi.org/10.1016/j.renene.2008.12.017>
10. Mir MR, Khan IL, Baqual MF, Banday M, Raja R, Khursheed S. Mulberry-based agroforestry system: An effective way of maintaining livelihood security and climate change mitigation. In: *Agroforestry and Climate Change*. Apple Academic Press; 2019. p. 299-318.
11. Mithilasri M. Clonal evaluation, wood and leaf quality characterization of mulberry genetic resources (Ph.D. Thesis). Tamil Nadu Agricultural University, Coimbatore, India; 2022.
12. Nabi S, Qaisar KN, Rather SA, Khan PA, Nabi B. Fuelwood characteristics of some important tree species in prevalent agroforestry systems of District Budgam, Kashmir Valley, India. *International Journal of Current Microbiology and Applied Sciences*. 2017;6(11):3801-3806. <https://doi.org/10.20546/ijcmas.2017.611.449>
13. Sharma S, Madan M. Potential of mulberry (*Morus alba*) biomass. *Journal of Scientific and Industrial Research*. 1994;53:710-714.
14. Wang Z, Ning P, Hu L, Nie Q, Liu Y, Zhou Y, *et al.* Efficient ethanol production from paper mulberry pretreated at high solid loading in fed-non-isothermal-simultaneous saccharification and fermentation. *Renewable Energy*. 2020;160:211-219. <https://doi.org/10.1016/j.renene.2020.06.019>