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PRODUCTION OF BIOETHANOL FROM INDIGENOUS ARTEMISIA BIOMASS

Madarova Surayyo Uralovna

2nd-Year Basic Doctoral Student, University of "New Uzbekistan", Tashkent, Uzbekistan
E-mail: s.madarova@newuu.uz
ORCID ID: 0009-0007-8815-3552

Abstract. *This paper analyzes the potential of Artemisia biomass, widely distributed in the arid regions of Uzbekistan, for bioethanol production based on a review of the scientific literature. The main technological stages of bioethanol production and the effects of hydrolysis and fermentation on bioethanol yield were evaluated. A systematic literature review, comparative analysis, and synthesis methods were employed. The results showed that the cellulose and hemicellulose fractions of Artemisia biomass are important carbohydrate sources for bioethanol production. Fermentation temperature was found to have a significant effect on bioethanol yield, with 30 °C identified as the optimum temperature. In addition, the Separate Hydrolysis and Fermentation (SHF) process was shown to have the potential to improve process efficiency. The findings indicate that Artemisia biomass is a promising indigenous lignocellulosic feedstock for future bioethanol production. Further research should focus on optimizing pretreatment, hydrolysis, and fermentation conditions, as well as evaluating the techno-economic feasibility of the process.*

Keywords: *Artemisia diffusa, bioethanol, hydrolysis, fermentation, Saccharomyces cerevisiae, renewable energy, biofuel, Uzbekistan.*

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ПРОИЗВОДСТВО БИОЭТАНОЛА ИЗ МЕСТНОЙ БИОМАССЫ ARTEMISIA

Мадарова Сурайё Ураловна

2-й годовой базовый докторант Университета «Новый Узбекистан», Ташкент, Узбекистан

Annotatsiya. *В данной статье на основе анализа научной литературы рассмотрен потенциал биомассы Artemisia, широко распространённой в засушливых регионах Узбекистана, для производства биоэтанола. Оценены основные технологические стадии производства биоэтанола, а также влияние процессов гидролиза и ферментации на выход биоэтанола. В исследовании использованы методы систематического обзора литературы, сравнительного анализа и обобщения. Результаты показали, что целлюлоза и гемицеллюлоза, содержащиеся в биомассе Artemisia, являются важными источниками углеводов для производства биоэтанола. Установлено, что температура ферментации оказывает существенное влияние на выход биоэтанола, при этом оптимальной является температура 30 °C. Кроме того, показано, что технология раздельного гидролиза и ферментации обладает потенциалом для повышения*

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эффективности процесса. Полученные результаты свидетельствуют о том, что биомасса Artemisia является перспективным местным лигноцеллюлозным сырьём для производства биоэтанола. Дальнейшие исследования должны быть направлены на оптимизацию предварительной обработки, гидролиза и ферментации, а также на оценку технико-экономической эффективности данного процесса.
Ключевые слова: *Artemisia diffusa, биоэтанол, гидролиз, ферментация, Saccharomyces cerevisiae, возобновляемая энергия, биотопливо, Узбекистан.*

MAHALLIY ARTEMISIA BIOMASSASIDAN BIOETANOL ISHLAB CHIQARISH

Madarova Surayyo Uralovna
"Yangi O'zbekiston" universitetining 2-bosqich tayanch doktoranti, Toshkent, O'zbekiston

Annotatsiya. *Mazkur maqolada O'zbekistonning qurg'oqchil hududlarida keng tarqalgan Artemisia biomassasining bioetanol ishlab chiqarishdagi salohiyati ilmiy adabiyotlar asosida tahlil qilindi. Tadqiqotda bioetanol ishlab chiqarishning asosiy texnologik bosqichlari, gidroliz va fermentatsiya jarayonlarining bioetanol hosildorligiga ta'siri baholandi. Tizimli adabiyotlar tahlili, qiyosiy tahlil va umumlashtirish metodlaridan foydalanildi. Natijalar Artemisia biomassasi tarkibidagi sellyuloza va gemisellyulozaning bioetanol ishlab chiqarish uchun muhim uglevod manbai ekanligini ko'rsatdi. Fermentatsiya haroratining bioetanol hosildorligiga sezilarli ta'sir ko'rsatishi aniqlanib, 30 °C optimal harorat sifatida belgilandi. Shuningdek, alohida gidroliz va fermentatsiya texnologiyasi jarayon samaradorligini oshirish imkoniyatiga ega ekanligi qayd etildi. Olingan natijalar kelajakda Artemisia biomassasi bioetanol ishlab chiqarish uchun istiqbolli mahalliy lignosellyulozali xomashyo ekanligini ko'rsatadi. Kelgusida dastlabki ishlov berish, gidroliz va fermentatsiya parametrlarini optimallashtirish hamda texnik-iqtisodiy samaradorlikni baholash bo'yicha kompleks tadqiqotlar o'tkazish maqsadga muvofiqdir.*
Kalit so'zlar: *Artemisia diffusa, bioetanol, gidroliz, fermentatsiya, Saccharomyces cerevisiae, qayta tiklanuvchi energiya, bioyoqilg'i, O'zbekiston.*

Introduction. In recent years, growing global energy demand, the depletion of fossil fuel reserves, and increasing environmental concerns associated with fossil fuel consumption have intensified interest in renewable energy sources [1]. Among the various biofuels considered for the transportation sector, bioethanol has emerged as a promising alternative fuel because of its renewable nature, relatively low environmental impact, and compatibility with existing gasoline engines [2].

Preliminary data for 2020 indicate that Uzbekistan remained dependent on imports to satisfy part of its domestic demand for petroleum products. Imports accounted for approximately 30% of diesel fuel consumption, 19% of motor gasoline consumption, and 35% of fuel oil consumption [3]. These figures highlight the importance of exploring alternative and locally available energy resources.

At present, bioethanol is predominantly produced from food crops such as sugarcane, corn, and wheat [4]. However, the extensive use of food crops for fuel production may create competition with food production and raise concerns regarding food security. Consequently, increasing attention has been directed toward the development of bioethanol production technologies based on lignocellulosic biomass [5]. Unlike conventional food-based feedstocks, lignocellulosic biomass does not directly compete with food resources, is renewable, and contains substantial amounts of cellulose and hemicellulose, making it a promising raw material for sustainable bioethanol production [6,7].

Species of the genus *Artemisia* are widely distributed in the natural flora of Uzbekistan and are well adapted to arid and semi-arid environmental conditions. Their tolerance to unfavorable climatic factors and availability as indigenous plant biomass make them a potentially valuable local feedstock for biofuel production [8,9]. The lignocellulosic

composition of *Artemisia* biomass further increases its potential for conversion into fermentable sugars and, subsequently, bioethanol.

Despite this potential, the available scientific information concerning the technological stages of bioethanol production from *Artemisia* biomass—including pretreatment, hydrolysis, and fermentation conditions, as well as the factors affecting bioethanol yield—has not yet been sufficiently systematized. Therefore, a comprehensive analysis of the available scientific literature is scientifically relevant for assessing the suitability of *Artemisia* biomass as a feedstock for bioethanol production and for identifying the technological parameters that determine process efficiency.

The aim of this study is to evaluate the potential of indigenous *Artemisia* biomass for bioethanol production through a comprehensive analysis of the available scientific literature. Particular attention is given to the principal technological stages of the production process, including biomass pretreatment, hydrolysis, and fermentation, as well as to the key factors influencing bioethanol yield, with specific emphasis on fermentation temperature. In addition, the study examines the prospects of utilizing locally available *Artemisia* biomass as a sustainable lignocellulosic feedstock for biofuel production in Uzbekistan and identifies potential directions for further research aimed at improving process efficiency and facilitating its practical implementation.

Methods and Materials. This study is devoted to the analysis of the technological stages involved in bioethanol production from indigenous Artemisia biomass based on a comprehensive review of the scientific literature. A systematic literature review, comparative analysis, data synthesis, and graphical data evaluation methods were employed.

Artemisia diffusa, which is widely distributed in the natural rangelands of Uzbekistan, was selected as the study feedstock. The biomass was harvested in July, air-dried under natural conditions for two weeks, and then ground to a particle size of 0.5 mm. The biomass preparation procedure is presented in Fig.1. (a) fresh biomass, b) air-dried biomass, c) ground biomass.

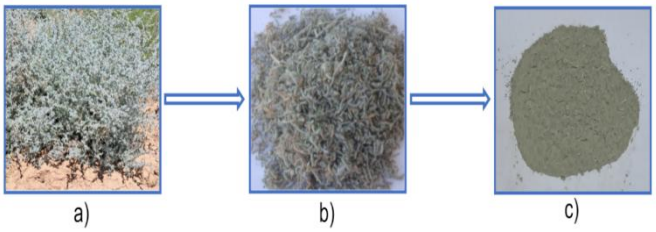

Fig.1. Collection and drying of Artemisia biomass sample.

The main stages of bioethanol production, including pretreatment, hydrolysis, and fermentation, were analyzed based on the available scientific literature. During the hydrolysis stage, the applicability of dilute sulfuric acid (H_2SO_4) and alkaline solutions for the disruption of the lignocellulosic structure was evaluated. In the fermentation stage, the advantages of using *Saccharomyces cerevisiae* as the fermenting microorganism were assessed, and the characteristics of the Separate Hydrolysis and Fermentation (SHF) process were comparatively analyzed.

The effect of fermentation temperature on bioethanol yield was evaluated based on the graphical data presented in the reviewed literature.

Results and Discussion. The analysis of the scientific literature revealed that the cellulose and hemicellulose fractions of *Artemisia diffusa* biomass constitute important carbohydrate sources for bioethanol production. The widespread distribution of this species in the arid regions of Uzbekistan highlights its potential as a promising indigenous feedstock for sustainable biofuel production.

The analysis further demonstrated that the efficiency of bioethanol production is strongly influenced by biomass composition, pretreatment method, hydrolysis conditions, and fermentation parameters. The Separate Hydrolysis and Fermentation (SHF) process was identified as one of the most effective approaches because it allows the hydrolysis and fermentation stages to be carried out independently, thereby enabling the optimization of temperature and pH conditions for each process.

The effect of fermentation temperature on bioethanol yield was analyzed based on the data presented in Fig. 2.

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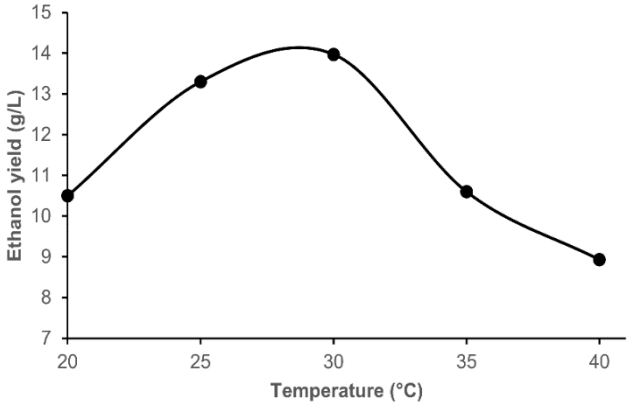

Fig.2. Effect of fermentation temperature on bioethanol yield.

As shown in Fig.2, increasing the fermentation temperature from 20°C to 30°C resulted in an increase in bioethanol yield from 10.5 g/L to 14.0 g/L. However, a further increase in temperature to 35–40°C led to a decline in bioethanol yield. This reduction can be attributed to the decreased metabolic activity of *Saccharomyces cerevisiae* cells at elevated temperatures.

The findings indicate that *Artemisia diffusa* biomass is a promising lignocellulosic feedstock for bioethanol production. Nevertheless, further improvements in bioethanol yield require the optimization of biomass pretreatment methods, hydrolysis conditions, and fermentation parameters. Comprehensive experimental investigations are also needed to enhance process efficiency and support the practical application of *Artemisia* biomass for sustainable biofuel production.

Conclusion. Based on the analysis of the scientific literature and graphical data, *Artemisia diffusa* biomass was identified as a promising indigenous lignocellulosic feedstock for bioethanol production.

The analysis demonstrated that fermentation temperature has a significant influence on bioethanol yield. According to the evaluated data, 30 °C was identified as the optimum fermentation temperature for maximizing bioethanol production.

The Separate Hydrolysis and Fermentation process was found to have considerable potential for improving the efficiency of bioethanol production.

Future research should focus on the experimental validation of bioethanol production from indigenous *Artemisia* biomass under practical operating conditions, as well as on optimizing hydrolysis and fermentation parameters and developing strategies for the large-scale implementation of the technology.

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