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OPINION PAPER

Utilization of corn for ethanol production: An analysis of production, economy, and grain type requirements

Bijender Pal

Introduction

Corn ethanol production has gained significant traction as a renewable and environmentally friendly alternative to fossil fuels. Ethanol, a biofuel derived from corn, holds the promise of reducing greenhouse gas emissions, promoting energy security, and bolstering rural economies (Padhan *et al*., 2023). This note aims to delve into the process of corn ethanol production, the economic implications, and the specific grain type requirements involved. Government of India has launched programs on ethanol blending patrols (EBP) in the year of 2003. 10% (E10) of the blended targets so far has been are met from the sugarcane and broken rice. In order to achieve E20 target, we need nearly 14 million liters bio-ethanol by 2025-26. A call has been taken up to use water efficient crop "Corn" for bioethanol. Scientific community hears need to be geared up to develop the high yielding corn hybrids with preferred grain types for various segments. It is critical to start developing or introducing the germplasm which can enable to develop the hybrid with the grain texture referred by the ethanol industry. The product concept notes and trait prioritization has to be relooked and given equal emphasis of the grain types suitable for the ethanol production. In this article, efforts have been made to put some of the important facts which can be considered by the Breeders and policymakers for better use of corn as feedstock in ethanol production.

✉ Bijender Pal: bijendrapal127@gmail.com

Bioseed Research India, Hyderabad-500033, Telangana, India

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Corn ethanol production process

The production of corn ethanol involves several stages, beginning with the cultivation of corn, harvesting, and then it undergoes milling, where it is ground into a fine powder (Kurambhatti *et al*., 2019). The next step is the conversion of starch into sugar, achieved through the process of enzymatic hydrolysis. Enzymes break down the corn starch into simple sugars, mainly glucose. Fermentation is the subsequent crucial step. Yeast is added to the sugar-rich liquid, and under controlled conditions, it consumes the sugars and produces ethanol and carbon dioxide. Distillation follows fermentation, concentrating the ethanol and removing impurities, resulting in a high-purity ethanol product. Lastly, dehydrating the ethanol to remove any remaining water content is necessary to achieve the required fuel grade.

Economic significance

The production of corn ethanol has significant economic implications, both on a regional and national scale. The industry provides job opportunities across the supply chain, from farmers growing corn to workers in ethanol production plants. This contributes to the overall economic growth of rural areas and helps support local communities. Moreover, the reduction in dependence on fossil fuels through the use of ethanol can positively impact energy security. As a renewable resource, corn can be continuously grown, unlike finite fossil fuels. Furthermore, domestic production of ethanol may reduce reliance on foreign oil.

Grain type requirements

While corn is the primary feedstock for ethanol production, not all corn varieties are equally suitable. The

most commonly used type is dent corn, known for its high starch content. Starch is the primary component that gets converted into sugar during the production process. Other types of corn, such as sweet corn or popcorn, are less suitable for ethanol production due to their lower starch content. In recent years, there has been growing interest in developing advanced technologies to produce ethanol from other parts of the corn plant, such as corn stover (leaves, stalks, and cobs) and even corn kernel fiber. These advancements could potentially increase overall ethanol production efficiency and reduce the pressure on using high-quality grain for fuel purposes. As technology and research continue to advance, there are ongoing developments in the field of corn ethanol production, aiming to enhance efficiency, sustainability, and cost-effectiveness.

Breeding and product developments

Breeding corn for better ethanol productivity is a very important activities of this mission. Till now, starch content was not a targeted trait in the most of the breeding programs in India, that is why the starch content in most of the breeding materials in India as below 70%. Low starch content and hard grain texture may be the undesirable and uneconomical for ethanol production. Breeding groups need to work and accumulate the Germplasm which has high starch content and developing the product accordingly. This is a long process (explained below) and also so critical to develop the hybrids with grain type and textures which is required for ethanol production (Gong *et al*., 2022).

1) Germplasm collection – introduction of temperate material
2) Characterization of germplasm
3) Understanding heritability of traits
4) Trait introgression in the local Germplasm
5) Developing the trait base gene pools as pre breeding activity
6) Line development
7) Hybrids development / identification of the high yielding hybrids with high starch contents.

Other considerations

1) Second-Generation Ethanol Production: Second-generation ethanol production involves using the non-food parts of the corn plant, such as corn stover (leaves, stalks, and cobs). These non-grain components contain cellulose and hemicellulose, which can be broken down into sugars and further converted into ethanol (Li *et al*., 2016). This approach allows for better resource utilization and reduces the competition between food and fuel production.
2) Improved Fermentation and Yeast Strains: Research is ongoing to develop more efficient and robust yeast strains for ethanol fermentation. These new strains are engineered to withstand higher ethanol concentrations, tolerate contaminants, and have higher conversion rates, resulting in increased ethanol yields and faster production processes.
3) Energy-Efficient Processing: Scientists and engineers are continually seeking ways to improve the energy efficiency of corn ethanol production. This includes optimizing the use of water, electricity, and other resources during various stages of the production process. Energy-saving measures not only reduce the environmental footprint but also improve the economic viability of ethanol production.
4) Co-Products Utilization: Corn ethanol production generates several valuable co-products, such as distillers' dried grains with soluble (DDGS). DDGS is a protein-rich byproduct that is used as livestock feed. Researchers are exploring ways to further enhance the value of these co-products, such as refining them for human consumption or developing novel applications in other industries.
5) Sustainable Farming Practices: Sustainable farming practices are being promoted to reduce the environmental impact of corn cultivation. These practices include precision agriculture techniques, improved irrigation methods, and reduced chemical usage (Nisar *et al*., 2021). Sustainable farming not only benefits the environment but also supports the long-term viability of corn as a biofuel feedstock.
6) Integrated Bio-refineries: Integrated bio-refineries represent an innovative approach where multiple bio-based products are produced from a single feedstock, such as corn. Alongside ethanol, these facilities may produce bio-chemicals, bio-plastics, and other renewable materials. This integrated approach maximizes resource utilization and diversifies revenue streams, making ethanol production more economically viable.

Conclusion

The use of corn for ethanol production has emerged as a vital component of the renewable energy landscape. The process of producing ethanol from corn involves various stages, from cultivation to fermentation and distillation, with the specific grain type requirements emphasizing the need for high-starch varieties like dent corn. The economic benefits of corn ethanol production are multi-faceted, ranging from job creation to energy security and reduced greenhouse gas emissions. However, continuous research and technological advancements will play a crucial role in further improving efficiency, sustainability, and the overall viability of corn-based ethanol as a significant energy source. The development and implementation of new technologies and practices are transforming corn ethanol production, making it more sustainable, economically viable, and efficient. From the use of second-generation feedstock like corn stover to advanced fermentation techniques and integrated bio-refineries, these developments hold the promise of further reducing the environmental impact of bio-fuel production and contributing to a greener, more sustainable energy future. Continuous research and innovation will play a vital role in unlocking the full potential of corn-based ethanol and other renewable fuels.

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