Bioethanol production from Horticultural waste

Gouthami Y[1]., Praveen Gidagiri [2]., Bhuvaneshwari G[1]., Geetha Lekshmi P R[2] and Shameena S[2]

[1.] Department of Post Harvest Technology, College of Horticulture, Bagalkot, Karnataka

[2.] Department of Post Harvest Management, College of Agriculture, Vellyani, Thiruvananthapuram, Kerala

1. INTRODUCTION

In India, an annual agricultural waste production of approximately 350 million tonnes. According to the Ministry of New and Renewable Energy's estimates, this waste holds the potential to be transformed into green fertilizer for agricultural purposes (Goel *et al.,* 2022), and it has the capacity to generate over 18,000 MW of power on an annual basis. On a global scale, a staggering 1.3 billion tonnes of food meant for human consumption goes to waste or is lost each year. For example, the worldwide discard of potatoes is estimated to reach 12 million tonnes annually, with India contributing 2 million tonnes (Anon., 2020).

A multitude of technologies have been explored to convert agricultural waste into valuable resources, thus creating bio-based products like bioethanol with potential market demand (Panda *et al.,* 2017). Moreover there is a growing interest in transitioning towards renewable energy sources to meet energy needs, produce fuels, electricity, and various other products (Uihlein and Schbek, 2009; Ballesteros *et al.,* 2006). Renewable biomass fuels, such as bioethanol, biodiesel, and bio-hydrogen, represent promising alternatives to petroleum-based fuels. These sustainable fuels can be derived from sources like sugarcane, corn, algae, agricultural waste, and residues from fruits and vegetables, offering a potential solution to the environmental issues stemming from excessive fossil fuel consumption.

2. BIOETHANOL: A SUSTAINABLE BIOFUEL

Bioethanol is a liquid biofuel which is generated through the microbial fermentation of various feedstocks, including corn, soybeans, wheat straw, woodchips, fruit and vegetable wastes, and more recently, microalgae. Waste materials rich in cellulose, lignin, and lignocellulosic components have the potential to be converted into bioethanol. Biofuels offer numerous advantages as a bioenergy source. They are considered carbon neutral since the carbon dioxide released during combustion is offset by the amount of carbon dioxide absorbed by the plants during their growth. This characteristic contributes to mitigating global warming. Furthermore, biofuel production like bioethanol supports farm income, reduces energy costs, and fosters rural development, all while garnering support from environmental advocates. The production of bioethanol serves as a sustainable alternative to high-priced petroleum, reducing dependence on costly fossil fuels and promoting a more environmentally friendly and economically viable energy future. Regions like North America and Brazil have already made substantial strides in producing bioethanol as a viable transportation fuel. There is a compelling need to further expand the production and adoption of bioethanol as an alternative to petroleum-based fuels.

BIOETHANOL PRODUCTION

The production process of bioethanol is categorized into three generations as follows:

2.1 First-generation bioethanol
2.2 Second-generation bioethanol
2.3 Third-generation bioethanol

2.1 First-generation bioethanol

Initially, first-generation ethanol was primarily sourced from the sugars and starches in food crops like corn, wheat, and sugarcane. Notably, sugarcane was a key feedstock for sugar-based ethanol in Brazil, while corn and grains were commonly used for starch-based ethanol, particularly in the USA. This trend extended to other countries involved in ethanol production, including China, Canada, France, Germany, and Sweden, as highlighted by Arifin *et al*. (2014).

Brazil stood out for its dominant sugar-based ethanol production from sugarcane, making up a significant portion of the global output. Conversely, the USA was a major player in starch-based ethanol production, accounting for the largest share at 58%. Brazil followed with 28%, while China, Canada, and Thailand contributed smaller amounts (3%, 2%, and 1% respectively). Moreover, within the European Union, France and Germany were leading contributors, collectively contributing 6% to global ethanol production, according to Niphadkar *et al*. (2017)

As a result, there is a growing search for more efficient and effective alternatives. Plant waste biomass, primarily consisting of lignocellulosic materials, offers potential for the development of advanced biofuels known as second-generation biofuels.

Challenges and current status

In united states corn is commonly used as primary source of ethanol production, where a significant portion—40% or more—of the corn crop is allocated for this purpose.

However, this reliance on corn is compounded by its status as a staple food in various countries, leading to a worldwide surge in food prices and exacerbating hunger-related issues. This same predicament arises when sugarcane is utilized as a feedstock for ethanol production.

The cultivation of these crops necessitates the application of pesticides and fertilizers, incurring substantial costs while also contributing to the contamination of soil and water resources. Consequently, environmental hazards present an additional constraint in the production process. Furthermore, ethanol production from corn faces challenges such as a sluggish production rate and relatively low energy yield, with a net yield of around 20%.

2.2 Second-generation bioethanol

The production of second-generation bioethanol involves the use of "plant biomass," which is notably more cost-effective, abundant, and free from conflicts related to food consumption (Gomez et al., 2008). This approach to ethanol production was strategically developed to address the debatable issue of food versus fuel. It also focus on utilizing agricultural residues and forest waste, primarily consisting of various forms of lignocellulosic materials (Lennartsson *et al.,* 2014).

Advancements in bioprocess techniques, cost reduction measures, and the availability of sustainable resources have turned second-generation bioethanol production into a lucrative endeavor for select manufacturers. For example, the Borregaard Company in Norway is frequently acknowledged as the foremost producer of second-generation ethanol (Rodsrud *et al.*, 2012).

Limitations or production challenges in second-generation bioethanol

A notable challenge linked to second-generation bioethanol production was the degradation of sugars and the considerable energy consumption during pretreatment operations, resulting in increased overall process expenditures (Palacios-Bereche *et al.,* 2013; Dias *et al.,* 2014). Another obstacle was the need for efficient microorganisms capable of simultaneously fermenting both C5 and C6 sugars into bioethanol. Furthermore, the enzymes employed in the saccharification process were costly, adding to the overall production expenses.

2.3 Third-generation bioethanol

Third-generation bioethanol utilizes carbon-rich biomass for its production. Biomass sources such as seaweed and marine algae, such as the Enteromorpha species with a carbohydrate content of around 70% on a dry weight basis, can be harnessed for bioethanol production (Nahak *et al.*, 2011). Borines *et al.* (2013) successfully produced ethanol (at levels of 10–15%) from polysaccharides derived from Sargassum spp. by optimizing the pretreatment conditions for glucose and reducing sugar. Given the significant potential for biomass conversion (ranging from 46,760 to 140,290 liters per hectare), there is a growing emphasis on advancing research for the production of third-generation biofuels, particularly from macro or microalgae (Chaudhary *et al*., 2014).

Limitation

A significant challenge in algal biorefining was the direct absence of fermentable sugars. To address this, further optimization of pretreatment methods was necessary.

Table 1. Estimated ethanol production quantities from various feedstock sources.

Generation	Source of biomass	Yield of ethanol (L/t)	Reference
First generation	Sugar beet Sugar cane Cassava Maize Rice Wheat	110 (L/t) 70–75 (L/t) 137–180 (L/t) 400 (L/t) 430 (L/t) 340 (L/t)	FAO, 2008
Second generation	Corn stover Wheat straw Sugarcane bagasse Juice from *Agave americana* leaves Rice straw	362–456 (L/t) 406 (L/t) 318–500 (L/t) 34 (L/t) 416 (L/t)	Corbin *et al.*, 2015
Third generation	Microalgae Brown seaweeds (macroalgae) Seagrass (macroalgae) Green seaweeds (macroalgae) Red seaweeds (macroalgae)	167–501 (L/t) 12–1128 (L/t) 747 (L/t) 72–608 (L/t) 12–595 (L/t)	Ramachandra and Hebbale, 2020

Within the three-generation bioethanol production process, the second-generation method encompasses a diverse array of innovative biofuels derived from emerging feedstocks composed of lignocellulosic materials. These materials encompass agricultural residues (e.g., straw), energy crops (e.g., Miscanthus, poplar), forestry byproducts and waste, as well as components of municipal solid waste. Therefore, the second-generation (2G) bioethanol production process presents an appealing option for the efficient utilization of biowaste (Niphadkar *et al.*, 2017).

3. BASIC MATERIALS USED FOR PRODUCTION OF BIOETHANOL

Raw materials suitable for bioethanol production can be categorized according to their chemical composition, specifically, carbohydrate sources can be classified into three distinct groups:

(i) Sugar-containing materials: sugarcane, sweet sorghum, molasses, whey, sugar beet

(ii) Starch-containing materials: grains such as wheat corn, tubers such as cassava

(iii) Lignocellulosic materials: agricultural waste like straw, crop and wood residues, etc. (Mussatto *et al*., 2010).

First-generation feedstocks (containing sugars and starch) compete with their utilization as food or animal feed, which can impact their availability. As a result, lignocellulosic biomass, classified as second-generation feedstock, emerges as a viable alternative for bioethanol production. These resources are easily accessible, cost-effective, widely distributed, and do not compete with food and feed crops. (Tomas-Pejo *et al*., 2011).

4. PRETREATMENT OF BIOMASS FOR PRODUCTION OF BIOETHANOL

The primary challenge in biofuel production revolves around the pretreatment of biomass. Lignocellulosic biomass consists of three key components: hemicellulose, lignin, and cellulose. Pretreatment techniques encompass processes that facilitate the dissolution and separation of one or more of these constituent parts within the biomass. This process aims to make the solid biomass residue more receptive to subsequent chemical or biological treatments (Demirbas, 2005). Effective pretreatment process will aids in production of sugars, prevent loss and deterioration of sugars, minimize of inhibitory substances, reduction of energy requirements and cost reduction. Pretreatment methods include physical, chemical, physicochemical, and biological, and combinations thereof.

4.1 PHYSICAL PRETREATMENT

4.1.1 Mechanical size reduction

The first step in ethanol production from agricultural solid wastes involves comminution, which includes actions like milling, grinding, or chipping. The objective is to reduce cellulose crystallinity (Sun and Cheng, 2002) thereby improving the efficiency of subsequent processing stages. Several methods like, wet milling, dry milling, vibratory ball milling, and compression milling is used for this purpose. While size reduction can lead to better results, excessive reduction to achieve very fine particle sizes can have adverse effects on subsequent processes, such as pretreatment and enzymatic hydrolysis.

4.1.2 Pyrolysis

Pyrolysis is an endothermic procedure that demands relatively lower energy input. In this process, materials undergo treatment at temperatures exceeding 300 ºC, causing the rapid decomposition of cellulose and the generation of gaseous products such as H_2, CO, and residual char. The residual char is subsequently subjected to leaching with water or a mild acid solution. The water leachate contains sufficient carbon sources to support microbial growth for bioethanol production, with glucose being the primary constituent of the water leachate. On average, about 55% of the total biomass weight is lost during the water leaching process (Das *et al.,* 2004).

4.2 PHYSICOCHEMICAL PRETREATMENT

4.2.1 Steam explosion or autohydrolysis

Steam explosion is a highly promising pretreatment method that enhances the accessibility of biomass to cellulase enzymes (Neves *et al*. 2007). This catalyst-free pretreatment approach is particularly notable, resulting in the fractionation of biomass to produce levulinic acid, xylitol, and alcohol. In the autohydrolysis method, biomass is subjected to high-pressure steam (ranging from 20 to 50 bar) at elevated temperatures (between 160 and 290 ºC) for a brief period, followed by an abrupt decompression to atmospheric pressure, as described by Sanchez and Cardona (2008). The steam expansion within the lignocellulosic matrix effectively separates individual fibers (Balat *et al.*, 2008).

4.2.2 Liquid hot water method

This approach employs pressurized hot liquid water to hydrolyze hemicellulose, operating at temperatures ranging from 170 to 230 ºC and at pressure exceeding the saturation point (5 MPa)for a duration of 20 minutes (Neves *et al.,* 2007).

4.2.3 Ammonia fiber explosion

The Ammonia Fiber Explosion (AFEX) pretreatment combines liquid ammonia and steam explosion techniques (Balat *et al.* 2008) that subjects lignocellulosic materials to high-temperature and high-pressure treatment, followed by a rapid release of pressure.

4.2.4 CO_2 explosion

The CO_2 explosion method operates in a manner similar to the steam and ammonia explosion techniques, achieving higher conversion yields (Hamelinck *et al.*, 2005). CO_2 explosion is more cost-effective than ammonia explosion and does not result in the formation of inhibitors, as seen in the case of steam explosion. (Prasad *et al*., 2007).

4.3 CHEMICAL PRETREATMENT

This method involves the use of dilute reagents such as acid, alkali, ammonia, organic solvent, SO_2, CO_2, or other chemicals. Easy to operate and have good yields in a short period.

4.3.1 Acid pretreatment

It is one of the most essential method and targets for higher yields of sugars from lignocellulosic material. It is usually conducted at temperatures between 130 ºC and 210 ºC. Moiser *et al*. (2005) reported higher hydrolysis yield from lignocellulose pretreated with diluted H_2SO_4 than other acids. H_2SO_4 (sulphuric acid) is broadly used for pretreatment among various acid types (Cardona et al., 2009). When wheat straw treated with 0.75 per cent H_2SO_4 at 121 ^{o}C for 1 hour period, a saccharification yield of 74% was attained (Saha *et al*., 2005).

4.3.2 Alkaline pretreatment

Alkali treatment disrupts lignocellulose cell wall by degrading hemicelluloses, lignin and silica, hydrolyzing uronic and acetic esters and causing cellulose to swell. Pretreatment with alkali degrades the lignin matrix and makes hemicellulose and cellulose available for enzymatic degradation (Pandey *et al*., 2000a). NaOH will boost hardwood digestibility from 14% to 55% by lowering the lignin level from 24-55% to 20% (Kumar and Wyman, 2009).

4.3.3 Wet oxidation

In wet oxidation process, the feedstock material is subjected to water and either air or oxygen at temperatures exceeding 120 ºC (Martin *et al.*, 2007). The biomass is mixed with water at a ratio of 1 liter per 6 grams.

4.3.4 Organosolv pretreatment

Organic solvents pulping processes serve as viable alternatives for the de-lignification of lignocellulosic materials (Sain, 2020). It involves usage of organic solvent/water blends, removing the need for liquor incineration and enables for the isolation of lignins through solvent distillation. Noteworthy examples of such pretreatment techniques involve usage of 90 per cent formic acid mixed with pressurized CO_2 (50% alcohol/water mixture and 50% carbon dioxide). Additionally, various other organic solvents that can be suitable for delignification include methanol, ethanol, acetic acid, performic acid, peracetic acid, and acetone (Zhao *et al*., 2009).

4.4 BIOLOGICAL PRETREATMENT

Biological pretreatments offer an environmentally friendly approach compared to other methods since they circumvent the use of chemicals, demand minimal energy, generate no waste streams or corrosion issues, and produce fewer inhibitors. In this technique, microorganisms such as brown, white, and soft rot fungi play a pivotal role in breaking down lignin and hemicellulose. (Sanchez, 2009).

4.4.1 Enzymes hydrolysis

Enzymatic hydrolysis is a process that employs enzymes to break down raw lignocellulosic materials (Sain, 2020). Cellulases, a class of enzymes, play a vital role in enzymatically breaking down cellulose, allowing yeast or bacteria to ferment the resulting reducing sugars into ethanol (Sun and Cheng, 2002). During the cellulose hydrolysis process, three primary categories of cellulases are involved: endoglucanases, which target less crystalline areas within the cellulose structure to generate unbound chain ends; exoglucanases/cellobiohydrolases, which further break down the molecule by eliminating cellobiose units from these unbound chain ends; and β-glucosidases, which catalyze the conversion of cellobiose into glucose (Prasad *et al*., 2007).

Two main stages:

Primary Hydrolysis: In this stage, endoglucanases and exoglucanases act on a solid substrate, releasing oligosaccharides (short chains of glucose units, typically up to 6) into the liquid phase.

Secondary Hydrolysis: This stage involves the continued hydrolysis of the released oligosaccharides. Cellobiohydrolases further break down the oligosaccharides into cellobiose, and β-glucosidases convert cellobiose into glucose.

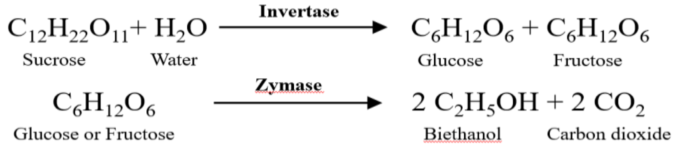
Lignin, tightly bound to cellulose, is often inaccessible to cellulases. Therefore, the primary mechanism for breaking down lignin involves peroxidases. Lignin peroxidase/ligninase and manganese peroxidase/Mn-dependent peroxidase are the most crucial peroxidase enzymes in this process. Laccase, synthesized by various types of white rot fungi, can also be utilized for this purpose (Binod *et al*., 2010).

Enzymatic hydrolysis is considered more environmentally friendly than acid hydrolysis of lignocellulose due to its high selectivity and milder reaction conditions (pH around 5 and temperatures below 50°C). Additionally, it produces more glucose with minimal byproduct production, which is advantageous for the subsequent fermentation of the hydrolysate.

5. BIOETHANOL PRODUCTION PROCESS

Bioethanol production can derive from a diverse range of carbohydrates, including monosaccharides, disaccharides, and polysaccharides. Polysaccharides are typically structured as chains of linked monosaccharides formed through dehydration syntheses. The process generally involves breaking down polysaccharides and disaccharides into monosaccharides, which are further converted into bioethanol and CO_2.

Yeast fermentation is a widely recognized natural metabolic procedure in which specialized yeast strains convert intricate carbohydrates into simple sugars, followed by the conversion of these sugars into either alcohol or acid. Cellulose conversion into bioethanol generally involves a dual process encompassing enzymatic hydrolysis and fermentation.



Bioethanol production largely depends on fermentation processes, which are,

- Simultaneous saccharification and fermentation (SSF)
- Simultaneous saccharification and co-fermentation (SSCF)
- Separate hydrolysis and fermentation (SHF)
- Solid-state fermentation (SSF)

5.1 Simultaneous saccharification and fermentation (SSF)

An enzyme complex is used in this procedure to hydrolyze cellulose and produce sugars. Later, these sugars are utilized by microbes and transformed into value-added products. SSF is superior to other fermentative procedures in many ways. Employing a single vessel for both fermentation and saccharification minimizes residence times and lowers the capital costs associated with the process and the reduction of inhibitory compounds from enzymatic hydrolysis, which improves the process' overall performance, are a few advantages when compared to separate enzymatic hydrolysis and fermentation (SHF). These benefits have led to extensive research on using SSF to make biofuels like ethanol and butanol from butanol from lignocellulosic and starchy raw materials (Das-Neves *et al.*, 2007). The ideal temperature for enzymatic hydrolysis is often more critical than the fermentation temperature, so finding an equilibrium point of pH and temperature at which the process functions properly is also a prerequisite (Niphadkar *et al*., 2017)

5.2 Simultaneous saccharification and co-fermentation (SSCF)

It is another substitute process to SSF, which simultaneously allows hexose and pentose fermentation. In this process configuration, microorganisms used for fermentation should have similar pH and temperature. SSCF offers the potential of streamlined processing while reducing capital costs (Cardona and Sanchez, 2007).

5.3 Separate hydrolysis and fermentation (SHF)

The starch based ethanol production method is known as SHF (separate hydrolysis and fermentation) process. Which involves initial step as catalysing the starch by enzymes-amylolytic enzyme (alpha amyalase) for the liquefaction process and glucoamylase for saccharification purpose. Further. Fermentation takes place in separate vessel. (Das-Neves *et al*., 2007).

5.4 Solid-state fermentation (SSF)

SHF (Solid-state fermentation) is a cost effective and promising technology that eliminates the need for the extraction of sugar while allowing microorganisms to thrive on solid substance without the presence of free water. This leads to decreased distillation and purification expense. Additionally, SSF is a proven technique for producing a variety of enzymes, making it a viable choice for the enzymatic pretreatment and substrates hydrolysis and subsequent bioethanol production (Pandey *et al*., 2000b).

6. FERMENTATION MODES

6.1 Batch fermentation: A set amount of medium, which includes nutrients and other components, is given to microorganisms. As people ingest nutrients, the culture and environment are continuously changing.

Advantages	Disadvantages
• Inexpensive • Low danger of contamination • Less need for control • Simpler sterilization	• Ethanol production with fewer cells per cell • increased downtime between batches because of vessel setup, cleaning, and sterilization

6.2 Fed-Batch fermentation: Microorganisms are introduced to the media by inoculation, and after growing in a batch environment for a predetermined period, nutrients are gradually added during the fermentation (Yang and Sha, 2019).

Advantages	Disadvantages
• Higher ethanol accumulation • Limited byproduct accumulation • Sustaining of maximum viable cell concentration • Increased lifespan of cell • Control of variables like pH, temperature, and dissolved oxygen	• Operating expensive • Increased inactivity periods between batches due to sterilization, cleaning and vessel setup

6.3 Continuous fermentation: The fermenter continuously replaces the nutrients consumed with a fresh medium. The removal of hazardous metabolites, used media, and ethanol is ongoing (Yang and Sha, 2019).

Advantages	Disadvantages

• Decreased downtime for cleaning of vessel • Increased productivity • Lesser costs; greater degree of control • Potential to automate • Cost-effective • Less prone to human error.	• Long development times can raise the danger of contamination • Aggregation of cell can inhibit the steady growth rate

Table 2. Difference between batch, fed batch, and continuous fermentation

Characteristics	Batch	Fed batch	Continuous
System of Cultivation	Sealed type	Partially enclosed type	Open type
Adding of fresh nutrition	-	Yes	Yes
Culture volume	Unchanging	Elevate	Unchanging
Wastage removal	-	-	Yes
Occurrence of contamination	Minimal	midway	Maximal
Growth stage	Lag, Log, Stationary, and Decline phase	Lag, Log, Stationary, and Decline phase	Lag and Log phase
Log phase	Briefer	Extended	Prolonged and uninterrupted
Product yield	Low	Medium	High

7. BIOETHANOL SEPARATION AND PURIFICATION

Two separation energy-intensive stages are necessary for producing pure ethanol from binary ethanol-water azeotrope (Huang et al., 2008). In the first phase, ethanol is concentrated to a mass concentration of between 92.4 and 94% by conventional distillation. An energy-efficient option with relatively moderate investments is cyclic distillation to purify ethanol.

The process of ethanol dehydration is used in the second phase to create anhydrous ethanol, which has ethanol concentrations higher than those seen in azeotropic composition. That can be accomplished using pressure distillation (Mulia-Soto and Flores-Tlacuahuac, 2011), distillation techniques enclosing liquid solvent, dissolved salt, their mixture, ionic liquids and hyperbranched polymers adjacently azeotropic distillation and their various combinations.

Membrane methods have attained attention as an substitute for conventional distillation because of a variety of benefits that make them appealing for the separation of liquid mixtures. They can separate temperature-sensitive materials because of their excellent separation efficiency, cheap energy, and operational costs, lack of waste streams, and ability to operate at low temperatures (Radocaj and Diosady, 2014).

Parallel to fermentation, pervaporation is a possibility. This technique, which is safe for the working microorganism and allows for in-situ ethanol extraction, shows promise (Kaewkannetra et al., 2011). Gas stripping is an additional method in addition to distillation, for the extraction of ethanol and volatile components from broth of fermentation process. (de Vrije et al., 2013).

According to Marjani et al. (2014), ethanol separation also used the carbon nanotube-integrated polyamide nanocomposite membrane. The silicalite-1, polydimethylsiloxane, and polyvinylidene fluoride hybrid composite membranes were used to ferment sorghum juice and continuous bioprocess. (Cai et al., 2016).

4. Fourth-generation bioethanol (4G)

Genetically modified algae can produce more products and have many other advantages than wild-type algae. CRISPR/Cas9 is a commonly utilized method in genetic engineering because it combines effective transfection and targeted gene disruption.

The successful manufacture of ethanol and other fuel products, including butanol, isobutanol, and modified fatty acids, has been achieved in 4G biofuel methods that depend on genetically enhanced Cyanobacteria.

Asia's First 2G Ethanol Bio-Refinery of Indian Oil Corporation Limited (IOCL) at **Panipat, Haryana (10th Aug 2022).**

Advantages of Bioethanol

- Carbon neutral
- Encourages farm income
- Reduce energy costs
- Replaces the usage of high price petroleum
-

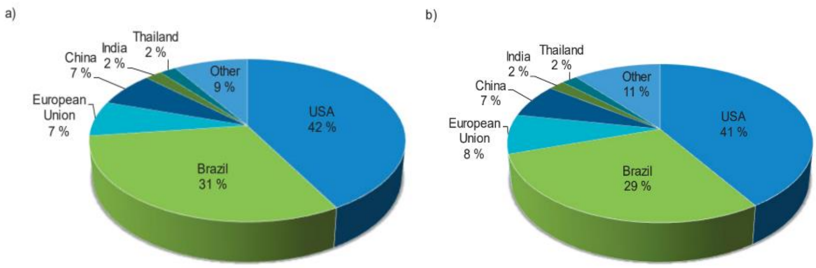


Fig. Predictions of the world bioethanol (a) production and (b) consumption by 2024

State/UT	No. of Molasses Based projects	Installed Capacity (in Cr ltrs p.a.)	No. of Grain Based projects	Installed Capacity (in Cr ltrs p.a.)	Total Installed Capacity (in Cr ltrs p.a.)
Karnataka	33	100.2	6	18.5	118.7

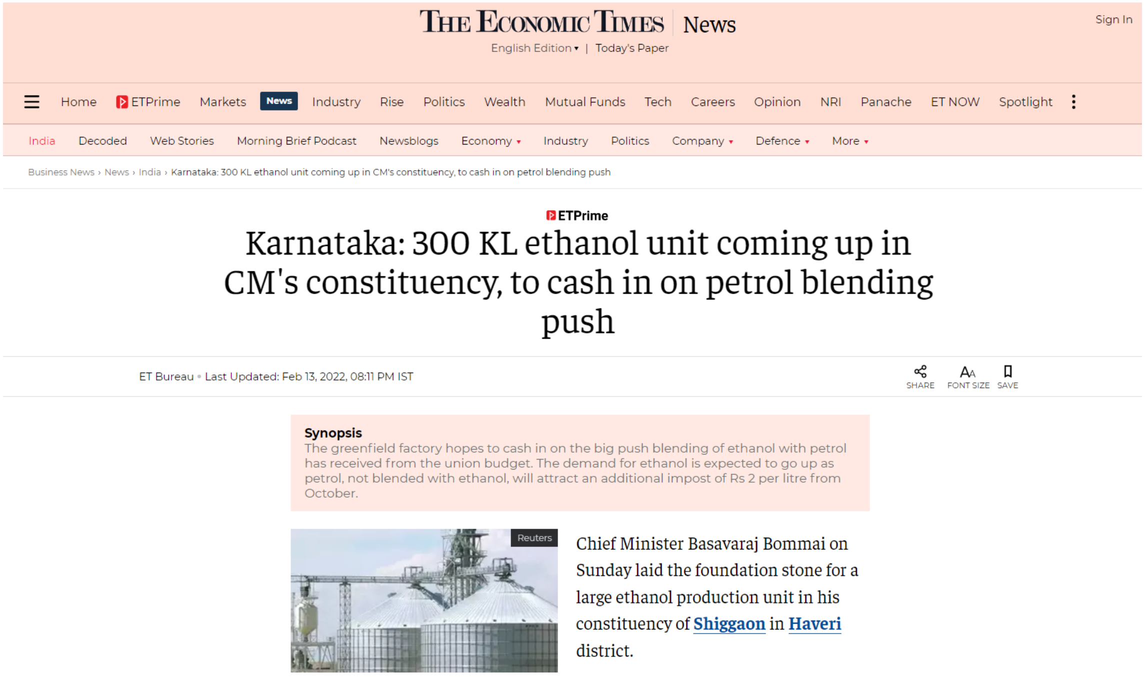
Ministry of Consumer Affairs, Food & Public Distribution

The current ethanol production capacity for ethanol blending with petrol and other uses is about 947 crore litres (which includes 619 crore litres of molasses based production capacity and 328 crore litres of grain based production capacity)

Posted On: 21 DEC 2022 3:35PM by PIB Delhi

The Union Minister of State for Consumer Affairs, Food and Public Distribution, Ms. Sadhvi Niranjan Jyoti in a written reply to a question in Lok Sabha today shared that the current ethanol production capacity in the country for ethanol blending with petrol and other uses is about 947 crore litres (which includes 619 crore litres of molasses based production capacity and 328 crore litres of grain based production capacity).

The state-wise & feed-stock wise details of installed ethanol production capacities in the country are at Annexure.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Karnataka: 300 KL ethanol unit coming up in CM's constituency, to cash in on petrol blending push

ET Bureau • Last Updated: Feb 13, 2022, 08:11 PM IST

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Synopsis
The greenfield factory hopes to cash in on the big push blending of ethanol with petrol has received from the union budget. The demand for ethanol is expected to go up as petrol, not blended with ethanol, will attract an additional impost of Rs 2 per litre from October.

Reuters

Chief Minister Basavaraj Bommai on Sunday laid the foundation stone for a large ethanol production unit in his constituency of Shiggaon in Haveri district.

Ministry of Petroleum & Natural Gas

India has reached 10 per cent ethanol blending by crossing the goal by 5 months . Posted On: 05 JUN 2022 2:11 PM by PIB Delhi.

In june 2021 Hon'ble Prime Minister unveiled "Roadmap for Ethanol Blending in India 2020-25", which comprehensive a detailed pathway for achieving 20 per cent blending ethanol.

Companies

- **Balrampur Chini Mills Ltd.**
- **Triveni Engineering Ind.**
- **Shree Renuka Sugars Ltd.**
- **EID Parry (India) Ltd**
- **Bajaj Hindusthan Sugar Company**
- **Godavari Biorefineries Limited**

- **Dalmia Bharat Sugar and Industries Limited**
- **Simbhaoli Sugars Limited**

Uses of Bioethanol has several applications, including:

Uses of Fuel: It is blended with gasoline to create ethanol fuel (commonly known as E10 or E85, depending on the ethanol-to-gasoline ratio). Ethanol is a renewable and cleaner-burning substitute for fossil fuels, decreasing greenhouse gas emissions.

1. **Industrial Applications:** Ethanol is used as a solvent in the manufacturing of various products, including pharmaceuticals, personal care items and cleaning agents.

2. **Alcoholic Beverages**: Ethanol is the primary alcohol in alcoholic beverages.

Benefits and Challenges: Bioethanol offers several environmental benefits, as it is produced from renewable resources and diminishes net CO_2 emissions compared to fossil fuels. However, there are also challenges associated with its production, including competition with food crops, land-use changes, and potential impacts on water resources.

Researchers and scientists continue improving bioethanol production methods and exploring alternative feedstocks that are less resource-intensive and not compete with food production. Additionally, advancements in second-generation biofuels, such as cellulosic ethanol, aim to use non-food-based feedstocks like agricultural residues and municipal solid waste, further reducing environmental impacts.

Overall, bioethanol remains an essential component of the global effort to transition to more sustainable and environmentally friendly energy sources.

9. CONCLUSION

India produces roughly 350 million tonnes of agricultural waste annually. Uncontrolled agricultural solid waste disposal and burning has led to pollution, a threat to human life, and other environmental issues. These wastes can be managed effectively through various uses, including the manufacture of fuel, fertilizers, animal feed, etc. Transforming agricultural residue into bioethanol holds the potential to maintain environmental cleanliness, and generating bioenergy offers a solution to address the challenges stemming from the decline of fossil fuel resources. The environmentally friendly bioethanol made from agricultural waste is a valuable replacement for fossil fuels. Burning conventional gasoline with a small amount of bioethanol produces less greenhouse gas emissions. Modern automobiles can also run flawlessly on bioethanol blends without modifying their engines, which has improved environmental sustainability and reduced energy use. The need for sustainable energy sources to reduce dependency on imported petroleum oil means that bioethanol is a potential alternative energy source in the future.

- Eco-friendly alternative to non-renewable fuels
- Environment clean
- Reduces greenhouse gas emissions during combustion
- Modern motor vehicles operate smoothly using bioethanol blends without requiring engine adjustments.

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