CONVERSION OF ORGANIC WASTE INTO FUELS, A INNOVATIVE STEP FOR BIOENERGY PRODUCTION

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ABSTRAT

Due to its low carbon dioxide emission, bioenergy conversion using a variety of biofuels is seen as a leading alternative to fossil fuels. Sustainable energy sources, such as organic waste products like wheat straw and maize stover, may be transformed into biofuels. Second-generation cellulosic biofuels provide an answer to the problem of transportation-related carbon emissions while also powering homes and businesses. A strategy for managing agricultural and other organic wastes for the manufacture of fuels like butanol and ethanol was the focus of a recent research. Thus, this research made use of cellulosic materials such as straws from wheat, cotton, and rice, as well as maize stover, fruit waste, and cogon grass. For every substrate, we compared chemical and biological pretreatments. Bacterial enzymes were tested for their efficiency in saccharifying agricultural substrates. We infer that these bacterial enzymes can hydrolyze agricultural waste in addition to pure substrates. The study's findings could encourage biofuel production and lessen the need to import fossil fuels from other nations, which is a strain on foreign currency reserves.

Key words; Organic wastes Biomass, fuels , Fermentation, Innovation

INTRODUCTION

The use of fossil fuels in transportation is a major contributor to greenhouse gas emissions (Bodjui et al., 2019).But using ethanol and butanol instead of fuels made from oil might lessen our negative effects on the environment and have social and economic benefits.

Bioelectricity, biogas, biodiesel, and bioethanol are all examples of biological energy resources. According to Dhamole et al. (2015), bioalcohol has the ability to lessen our reliance on fossil fuels, lower emissions of greenhouse gases, and serve as both a chemical feedstock and a transportation fuel.Biobutanol production has seen tremendous improvement as a result of several nations' efforts to decrease oil imports, enhance air quality, and boost rural economies. According to the Renewable Fuels Association (2007), the world's ethanol output stands at 51,000 million liters. Due to its increased oxygen concentration, ethanol has some benefits as a fuel. A decrease in aromatic compounds and an increase in carbon monoxide emissions result from the enhanced oxidation of hydrocarbons made possible by the increased oxygen content. Thomas and Kwong (2001) found that ethanol has better octane rating attributes.

Pakistan is mostly an agricultural nation, making biomass a crucial energy resource for the country. (Amiri et al., 2014; Chaudhry et al., 2009) Biomass from cattle and agricultural production, including ruminant and cereal grain byproducts. The most abundant organic material on Earth, known as lignocellulosic biomass, is composed of cellulose (35-50%), hemicellulose (20-35%), and lignin (5-30%), according to Huber et al. (2006).Demirbas (2001) lists a variety of agricultural materials that may be used as renewable energy sources, including straws, green leaves, fruit shells, nut shells, and fruit seeds. Apple pomace, maize stover, corn steep liquor, wheat straw, and wheat bran are the most popular feedstocks (Ejezi et al., 2006).Instead of growing energy crops, which compete with food crops, agricultural waste is used to produce biofuels such as biodiesel, bioethanol, biohydrogen, and methane. In order to alleviate the conflict between food production and fuel use, one alternative is to make use of lignocellulosic biomass, which is abundant and has no disposal problems (Mahro and Timm, 2007). The grasses are regarded as a dependable material for ethanol extraction. The usage of long-lived grasses has

several benefits, one of which is the potential reduction in production and fuel costs associated with ethanol (Gomez et al., 2008).

Imperatacylindrica, more often known as cogon grass, is a year-round crop in many parts of the globe, especially in tropical and subtropical regions. Cogon grass is a notorious plant that has been used for fodder and to improve soil stability. It is also considered a nuisance in over 35 crops in over 73 nations. Secondary metabolites found in cogon grass roots have medicinal use. Perennial grasses may thrive in soils that aren't ideal for growing other types of crops. According to Lin and Lee (2011), cogon grass has the potential to be used as a component in renewable energy systems.Coastal Bermuda grass, or Cynodondactylon, is a perennial grass with a high cellulosic content and potential for ethanol generation. Coastal Bermuda grass is a great raw material for ethanol production since it is either sold cheaply or discarded rather often. Bermuda grass has a larger biomass concentration and can convert entire carbohydrates into bioethanol, making it the most promising source for ethanol production when compared to maize. The majority of the world's Bermuda grass may be found in tropical and subtropical regions. Although some of its roots have reached depths of less than 60 cm, the plant may achieve a height of 1-30 cm and a root system that can reach depths of up to 2 meters (Sun and Cheng, 2005).According to Sluiter et al. (2008), certain species of Bermuda grass may reach a height of 15-20 cm, while others can reach heights of more than 1 m.

Because they are among the most common organic waste products in Pakistan, this research included a variety of agrowaste samples, including straws from wheat, cotton, and rice, as well as maize stover, cogon grass, and fruit peels. Corn is third among the three essential cereals, behind wheat and rice. It is planted on 1,130 hectares and produces 4.695 million tons per year. Cotton is the second main crop that is grown every year. Rice, the third most significant crop, is grown on 28,911 hectares and yields 70,05 metric tons per year (PES, 2014–2015). According to many studies, the agricultural area of Sanghar in Pakistan's Sindh province produces 2.7 million tons of garbage each year. This includes rice straw, rice husk, canola straw, wheat straw, cotton stalks, cotton bagasse, and sugarcane remnants. Between seventy-five and eighty-five percent of these feed supplies end up in the fire. According to the UN Environment Program (2011), these materials might be used to generate electricity without compromising food supplies or other domestic resources.There is an abundance of maize (Zea mays), the greatest cereal

stover, and it is also a great feed for cattle. You may graze it off or burn it before planting your next crop in many regions of Pakistan. Plus, there are various uses for every component of the maize plant (Kim and Dale, 2004). The density of microbes in termite stomach is among the greatest on the planet. The termites' ability to break down the wood's complex carbohydrates into smaller molecules is a function of the bacteria living in their digestive system. Bacteria found in termites' digestive tracts break down cellulose, a primary component in wood, into a number of byproducts, including fatty acids and alcohols like ethanol (Kim and Haltzapple, 2005).Soil, water, and the intestines are all home to the rod-shaped gram-positive bacteria that make up the genus Clostridium. Fermentation of sugar by Clostridium acetobutylicum produces a blend of organic solvents, including ethanol, butanol, and acetone. Ethanol and other alcoholic beverages are made by the fermentation of single-celled eukaryotic organisms called Saccharomyces cerevisiae, often called baker's yeast.

MATERIAL AND METHODS

Collection of Agricultural Substrates

Collecting peel wastes and cogon grasses from different regions was done. We used fine plastic bags to gather about 1 kilogram of each sample. After being shad-dried, the samples were sun-dried and then oven-dried for one night at 55 °C. Using an electric grinder, the materials were ground into a fine powder and then passed through a standard size 40 mesh sieve. The samples were kept in little plastic bags that were clearly labeled with their names. They were then placed in the refrigerator at 4°C until they were needed again.

Proximate Analysis of Samples

Each sample was tested for ash content, volatile matter, crude protein, crude fiber, crude fat, and both wet and dry weight according to the guidelines set forth by the AOAC in 1990. After drying the samples at 105 ºC to eliminate moisture, the usual procedures for estimating total solids and moisture contents were followed (Sluiter, 2005).

Chemical analysis of raw biomass

We used the previously described approach to determine the sample's cellulose content. To find the hemicellulose, the differences between acid detergent fiber (ADF) and neutral detergent fiber (NDF) were computed.As previously reported by AOAC (1990), the lignin contents were determined using a conventional technique.

Analytical procedures

According to Haifeng et al. (2015), the aforementioned approach was used to identify the fermentation products, which included hexoses and pentoses as monomer sugars, acetone-butanol, ethanol, and their bioproducts.

Chemical Pretreatment

Two chemicals, including an acid (H2SO4), were utilized for chemical pretreatment. The temperatures ranged from 100 °C to 120 °C, and the durations were 15, 30, and 45 minutes. Throughout the experiment, a solid sample containing 10% (w/v) was used in the reagent bottle. The samples were filtered in each bottle using the vacuum filtration assembly after pretreatment, and the contents were poured onto filter paper. The material rinsed away with 300 cc of distilled water after filtering to neutralize the pH. After being dried at 105 °C, the filter paper was weighed.

Enzymatic Hydrolysis

After undergoing a 5% (w/v) pretreatment, the biomass was subjected to hydrolysis with cellulose and β-glucosidases in a water bath shaker with a 0.05 M buffer (sodium citrate) at a pH of 4.8 for 72 hours. Cellulases with activity of (30FPU g-1). In order to find the sugar content, samples were taken from the reagent bottle every 12 hours. Hydrogen peroxide (µl) was added after the enzymatic hydrolysis. For 10 minutes at 13,500g, the unhydrolyzed material was spun in a centrifuge to separate it. The sugar analysis was done using the dinitrosalicylic acid (DNS) technique, and the supernatant was collected using syringe filters.The p-hydroxybenzoic acid

hydrazide (PAHBAH) technique was used to determine the sugar content. The concentration range of xylose used to generate the standard curve was 1Mm-25mM. To find out how much sugar was in the pretreatment sample, we compared it to the standard sugar concentration. Following the enzymatic hydrolysis procedure, the optimal pretreatment conditions were chosen. To proceed with the fermentation process, only the samples with the highest amounts of released sugar were chosen. The fermentation process made use of the solid biomass, which was kept at 4 °C.

At a temperature of 4°C, the Saccharomyces cerevisiae strain was cultured on YPD agar medium, which consisted of 1% yeast extract, 2% peptone, and 2% glucose. The yeast cells were cultured in a 5-milliliter petri dish with YPD media with 0.9% NaCl (w/v) for 16 hours at 30°C with a rotary shaker set at 100 r.p.m. (Alfenoro, 2002).

A Saccharomyces cerevisiae strain was used in a fermentation experiment. After 48 hours in a medium containing glucose yeast extract, 10% of the inoculum was transferred to 50 mL of fermentation medium that had already been saccharified. The mixture was then left to ferment at room temperature for three days (Jiang et al., 2015).Under anaerobic circumstances, the fermentation experiment was carried out for 72 hours at a temperature of 50ºC and a speed of 120 rpm. Following the conclusion of the fermentation operation, the resulting mixture was fractionally distillated using a boiling point-based equipment to extract acetone, methanol, butanol, and ethanol. The reason butanol can be extracted from water is because it has a higher boiling point (118 ºC) than water (100 ºC). Ethanol may be condensed before water since its boiling point is lower (78.3 ºC) (Kathleem et al., 2018).

HPLC Analysis of Enzymatic Hydrolysate

The technique described by Haifeng et al. (2015) was used to identify the fermentation products, which included hexoses and pentoses as monomer sugars, acetone-butanol, ethanol, and other bio products.

Following enzymatic hydrolysis, HPLC was used to further examine the acidic and alkaline pretreatment samples of wheat, rice, and maize stover. To achieve this goal, we analyzed samples that had previously indicated a greater concentration of glucose under optimal circumstances. The samples were centrifuged at 14,000 rpm, 4 ºC for 15 minutes after being extracted at various times throughout the enzymatic hydrolysis process. A 0.22 µm syringe filter was used to separate the supernatant. The sample concentrations were adjusted to fall within the calibration curve range by diluting 500 µl of the sample with 1 milliliter of methanol. Because the sugars were soluble in methanol, it was used as the solvent. Before analysis, the samples and glucose standard solution were all passed through a 0.22 µm filter. A volume of about 20 µl of agricultural waste was introduced into the HPLC system via the injection loop. The samples were subjected to a 10-minute gradient run in order to assess the glucose (Shields and Cathcart.2010).

Statistical analysis

Data generated through various analysis were statically analyzed for mean, standard deviation etc.,

RESULTS AND DISCUSSION

The next sections provide the results of the bacterial isolation process, the chemical examination of biomass samples, and the fermentation of carbohydrates into acetone, butanol, and ethanol. The potential for the isolates to convert different sugars into alcoholic products is high. Based on this, the present research used termite-based bacterial isolates to manufacture acetone-butanol-ethanol (ABE) from organic waste materials sourced from farms and municipalities. There are bacteria in termite guts that produce more than a thousand different enzymes that may

decompose wood, according to published reports. Proteins that break down cellulose have the potential to be a cost-effective source for making alcoholic fuels.

Biological Pretreatment

Results displayed in tables 1-4, indicates amount of sugar released by different bacteria isolates. It was observed that bacterial isolates has provided higher amount of sugar from wheat straw which was higher than all other substrates analyzed.

Biomass analysis

Data in tables 1-3, represents various parameter found in biomass samples. It was observed that Cogon grass has higher cellulosic contents as compared to other substrates used for analysis.

Table 1. Proximate analysis (%) of biomass samples

Substrate	Dry Matter	Moisture	Crude Protein	Crude Ash	Crude Fiber
Peel(wastes)	92.41±0.48	7.53±0.34	7.93 ±0.23	5.91± 0.45	33.87±0.33
Cogon grass	93.11±0.27	6.89±0.26	5.12 ±0.21	9.18±0.34	35.41±0.42

Analysis of organic wastes samples

Table 2. Chemical analysis (%)of biomass samples

Substrate	NDF	ADF	Hemicellulose	Cellulose	Lignin
Peel(Fruit wastes)	79.6±0.51	52.1±0.31	26.3±0.34	29.6±0.67	21.5±0.43
Cogon grass	82.06±0.72	48.41±0.42	29.6±0.52	34.2±0.83	15.32±0.25

Mean ± standard deviation (n=3) NDF = Neutral Detergent Fiber and ADF=Acid Detergent Fiber

Dilute H_2SO_4 pretreatment

The samples of the various biomass were pretreated with dilute acid 1, 1.5 and 2% concentration, an autoclave at temperature of 105, 120 and 135ºC for the period of 15, 30 and 45 minutes (Table 2). The temperature 120 ℃ is considered best for both the samples while the retention time of 15 minutes was suitable for peel wastes and 30 minutes for cogon grass at the concentration of 1.5% and 1% respectively, these are the optimized conditions that was used for enzymatic experiment

Fermentation

Ethanol yields 10% from cogon grass and 7.4% from peel waste. The concentration of glucose decreased while the concentration of ethanol increased with increasing time, up to a specific point. But the concentration of glucose was insufficient to sustain ethanol synthesis after 72 hours. In comparison to peel wastes, cogon grass has higher cellulose but lower lignin levels, making it a more suitable option for the generation of butanol, ethanol, and other similar product (Tables 3-4).

Table 3. Sugars and other products (%) obtained from grasses

Substrate	Glucose	Xylose	Lignin	Dry matter	Moisture	Ash
Cogon grass	32.36. ±1.14	18.85 ±1.18	6.93 ±0.44	90.33 ±1.85	9.67 ±0.54	5.77 ±0.46
Peal wastes	27.32. ±2.15	15.37 ±1.13	4.75 ±0.54	92.46 ±1.24	8.56 ±0.55	4.89 ±0.58

% age values of various parameters of biomass samples.

Dilute sulfuric acid pretreatment of Peel wastes

The peel waste contained 27.33±2.15% glucose. After the therapy, the glucose concentration rose. After 30 minutes of treatment with a diluted acid concentration of 1.8% at a reaction temperature of 110 °C, the solid portion of the samples produced a higher amount of glucose. Results showed that pretreatment with a combination of moderate temperature and acid concentration significantly increased glucose contents. Talo et al. (2014) also made a similar discovery about the acid hydrolysis of low-temperature orange peel.

Percentage decrease in xylose content in solid fraction of peel wastes after H_2SO_4Pretreatment

According to Table 10, the xylose concentration in the peel wastes was 15.37%±1.13. Following processing, a reduction in this amount was seen. Minimal xylose in the solid fraction was achieved by incubating at 110 °C for 30 minutes with an acid concentration of 1.10% (Figure 11).According to Sun and Cheng (2005), hemicellulose may be completely removed with diluted acid pretreatment. Additionally, Wyman et al. (2005) found that xylose is soluble to its fullest extent at room temperature.

Percentage increase in lignin content in solid fraction after H_2SO_4pretreatment

The results show that the smallest amount of lignin in the solid fraction may be achieved by using an acid dosage of 2.0% for 37 minutes at 125 °C. While the reaction did indeed result in a 7.32 percent rise in lignin content, the actual figures were in a declining sequence. After being pretreated with H2SO4, xylose was greatly removed, leading to an apparent rise in lignin concentration. Solubilization of lignin increases with increasing reaction time to determine maximum value, assuming temperature remains constant.

Table 4. Maximum Sugar yields after enzymatic hydrolysis of substrates at pH 4.8, 50 °C, 120 rpm.

Substrate	Glucose $_{SF}$ (2.5g/50mL)	Glucose $_{SF}$ (50g/L)	Glucose(g/L)	Rate $_{sac}$ (%)	Time $_{OPT}$(hours)

Cogon grass	1.10	22.00	17.72	80.54	72
Peal wastes	0.98	18.5	14.7	78.35	72

* SF = Solid fraction Y = Yield Sac = saccharification Opt = optimum

There was no buildup of sugar like cellobiose, even though cellobiose was present in the reaction mixture, which led to increased saccharification (80.54%). In addition, Xue et al. (2012) noted that celllase efficiency was actually improved (since cellubioses weren't present), leading to more sugar recovery during enzymatic hydrolysis.

Figure 1. Samples of various organic waste

Analysis of Sugar after Pretreatment and Enzymatic Hydrolysis

The experiment included enzymatic hydrolysis of three distinct substrates—corn stover, wheat straw, and rice straw—in a 500 mL Erlenmyer flask at 50 °C for three days in order to produce sugar. The breakdown of lignin and the enhancement of enzyme and microbial accessibility to carbohydrates are two steps in the pretreatment process of lignocellulose that are essential for sugar production. These substrates have been subjected to two distinct pretreatment procedures. The substrates underwent physical preparation by being crushed into a fine powder and then passed through a sieve with a mesh size of 80 to decrease the particle size. Following that, these surfaces underwent chemical preparation. The lignocellulosic biomass was subjected to acidic and basic pretreatment (chemical pretreatment) conditions in order to disrupt its structure.

Dilute Acid Pretreatment

The samples of agricultural waste were pretreated with varying amounts of sulphuric acid H2SO4. The samples were subjected to pretreatment in an autoclave at temperatures of 100, 110, and 120 ºC with a solid loading of 20% (w/v) slurry. Three distinct concentrations of sulphuric acid (0.5, 1, and 1.5%) were used in the reaction, which was carried out at retention times of 10, 15, and 20 minutes. Pretreatment of the substrate with three different concentrations of sulphuric acid was performed at each temperature. Pretreatment of a sample was done in triplicate using the same reaction time and temperature. Each of the nine samples underwent pretreatment in a 100 ml reagent container. In order to determine the optimal conditions for acidic pretreatment, a total of nine tests were conducted, yielding eighty-one treatments on three samples at three distinct temperatures.

High glucose yields were achieved after acidic pretreatment at 120ºC, 1.5% H2SO4, and 15 minutes of reaction time (Figures 13–14). Temperature of 100 ºC, concentration of sodium hydroxide of 1.5%, and retention duration of 20 minutes were the ideal conditions for maize stover under the alkaline pretreatment condition.

HPLC Analysis of Enzymatic Hydrolysate

Further analysis was conducted using HPLC on the acidic pretreatment samples that had been hydrolyzed by enzymes. The samples that demonstrated a larger quantity of glucose under

optimal circumstances were chosen for this reason. After being removed from the enzymatic hydrolysis mixture at various intervals, the samples were spun at 14,000 rpm for 15 minutes at 4 ºC. A 0.22 µm syringe filter was used to separate the supernatant. The sample concentrations were adjusted to fall within the calibration curve range by diluting 500 µl of the sample with 1 milliliter of methanol. Because the sugars were soluble in methanol, it was used as the solvent. Before analysis, the samples and glucose standard solution were all passed through a 0.22 µm filter. The HPLC system was supplied with about 20µl of the agrowaste sample via the injection loop. The samples were subjected to a 10-minute gradient run in order to assess the glucose (Shields and Cathcart.2010).

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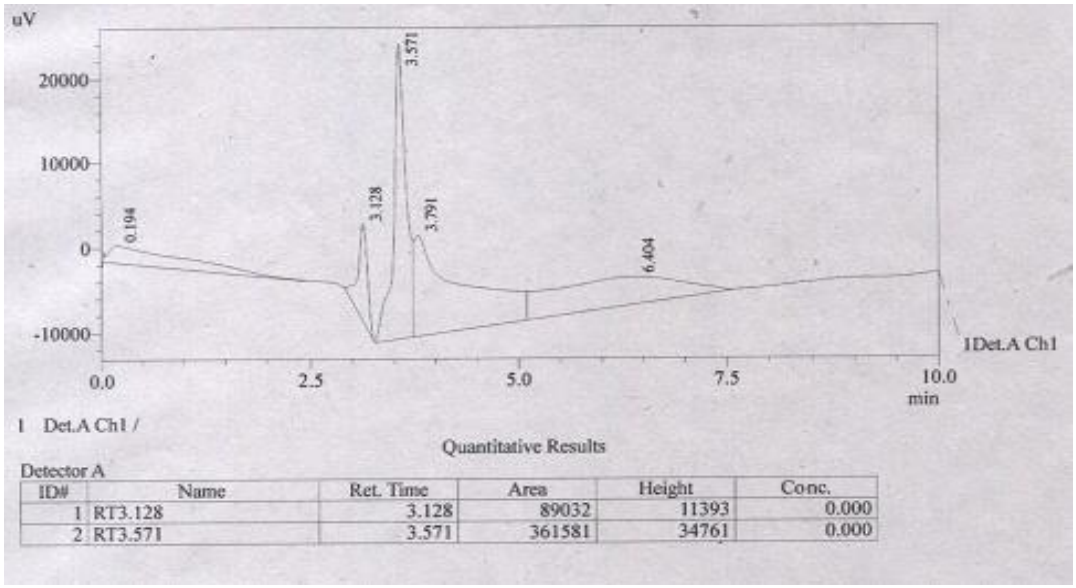

Figure 2.. Chromatogram hydrolysate sugar at acidic pretreatment. Peak of glucose (retention time, 3.128)

Table 6. Analysis of wheat and rice straws samples for sugars with HPLC

Components	**Retention time (min)**	**Concentration (mg/ml) Rice straw**	**Concentration (mg/ml) Wheat straw**

Glucose	8.6	22.52	28.3
Cellobiose	7.1	1.02	1.05
Xylose	11.6	4.3	5.6
Arabinose	12.0	1.4	1.8
Mannose	13.2	1.5	2.8
Galactose	15.5	1.2	1.5
Furfural	42.5	1.4	2.65
HMF	28	1.2	2.84

Analysis of sugar with HPLC

Fermentation with *Clostridium acetobutylicum*

The major product of this type of fermentation is known as ABE (acetone, butanol and ethanol) fermentation. The ratio of the acetone, butanol and ethanol in the fermentation process is mostly 3:6:1 as reported earlier by many authors. It was estimated that *Clostridium acetobutylicum* yields higher butanol quantity at acidic pretreatment conditions as compared to alkaline pretreatment conditions. Although alkaline pretreatment conditions are best for butanol production because the chances for the production of fermentation inhibitors are very low. But in this experiment the reason for low butanol production might be due to low quantity of glucose obtained at alkaline conditions. Among three substrates the yield of butanol was high in wheat straw because of number of factors i.e. the amount of carbohydrate was high in wheat straw as compared to rice straw and corn stover. Low lignin content in wheat straw is responsible for high glucose yield as well as high yield of butanol than other two substrates. Wheat straw contains low lignin contents as compared to rice straw and corn stover. The higher butanol production from wheat straw may be due to its low lignin contents. Among three substrates wheat straw yields highest quantity of butanol at acidic pretreatment conditions. It was estimated from previous studies that wheat straw hydrolysate contain furfural and hydoxymethyl furfural that supported the production of biobutanol by fermentation.. It is concluded that wheat straw is a superior fermentation substrate probably fermentation stimulatory chemicals are present in wheat straw.

***Clostridium acetobutylicum*function for butanol**

The clostridium specie *Clostridium acetobutylicum*was maintained at at -20^{0}C. Enzymatically hydrolysed sample was then used for fermentation. *acetobutylicum*spores were added in 100ml enzymatically hydrolysed solution in reaction bottle for separate hydrolysis and fermentation. These reaction bottles were placed in shaking incubator having 120 rpm at 37^{0}C for 72 hours. The butanol concentration was determined by alcohol meter after 72 hours, and values were expressed as % butanol obtained from wheat straw, from rice straw and from corn stover. Among these three substrates wheat straw produced high yields of butanol .

However, main end products of acidic /alkaline pretreatments and enzymatic hydrolysis are glucose and xylose which can be metabolized by clostridium species during growth and acetone – butanol- ethanol (ABE) fermentation (Qureshi and Blaschek, 2000; Moretti and Thorson, 2008).*C. acetobutylicum* and *C. beijerinckii* are two major microbes normally used in ABE fermentation. However, in recent years research worker from different countries have investigated various strain (s) their parent micorbes, cultivation conditions and growth media for various biomass samples used in batch, fed batch and continuous fermenters to produce ABE

DISCUSSION

It took a number of technical processes, including saccharification, fermentation, and acid or alkali pretreatment, to convert lignocellulosic feedstock into alcoholic fuels like butanol and ethanol. Accurately modifying all system components is crucial to achieve cost-effective biofuel production. Pretreatment, enzymatic hydrolysis, fermentation, and ethanol recovery levels were all greatly enhanced in the past by various nations, allowing them to produce alcoholic fuels at a better standard (Zhao, 2012). Developed nations' well-known examples of biomass fuel generation might serve as useful pointers for less developed nations. Biorefinery and the notion of orientated conversion of categorized composition are only two of the numerous innovative approaches to ethanol production that have been studied. García et al. (2011) and Demirbas (2009) found that butanol can be produced from lignocellulosic biomass using comparable technologies. An efficient combination of these techniques might lead to competitive biofuel production from plant biomass, which is presently underutilized, and further reductions in fuel costs when produced at industrial scale (Talo et al., 2014).

By using the sugars found in cellulosic biomass, valuable byproducts such as acetone, butanol, ethanol, and other comparable alcohols may be produced, which hold great promise as liquid fuels. Wood debris, agricultural crop straws (such as wheat, rice, and cotton), maize stalks, sorghum straws, fruit and vegetable scraps, and similar substrates are the most common sources of carbohydrate-containing biomass (Sajid et al., 2022; Santos, 2019). There is a complex sugar called cellulose found in plant materials, and it is a key ingredient in making alcohol, which is a fuel. Fermentation by bacteria or fungi, in conjunction with acid treatment and enzymatic hydrolysis, reduces this complex cellulose substance to smaller components. Because of their potential usage as fuels, these alcohols are significant. Since biofuels aid in reducing levels of carbon emission release from transportation and other sources, they may provide a solution to (1) the problem of climate change (2). Biofuels are a secure source of energy because they can meet the increasing demand for fossil fuels and energy (3) and mitigate the rising fuel prices (4).Biofuels are a great example of a product that may help solve the problems associated with the circular economy as they reduce waste while making use of natural resources. The present investigation included the production of bioethanol and biobutanol from a variety of cellulosic materials. Consequently, several orders of alcoholic fuels were produced from cellulosic substrates. The results of producing alcoholic fuels from straws have been superior to those from any of the other biomass substrates tested. A number of distillation processes are used after fermentation to purify acetone, butanol, and ethanol, and the kind of cellulosic biomass utilized determines the quantity of alcohols generated.

CONCLUSION

A sustainable and cost-effective method is the bioconversion of lignocellulosic biomass into ethanol and butanol, two alcoholic fuels. However, there has to be persistent effort to fully comprehend the basics of different pretreatment procedures and to create fermentation systems that are both more efficient and less expensive. In addition, there has to be research into more efficient microbial strains for detoxification that doesn't break the bank. In order to replace the presently available fossil fuels, which are already dwindling in supply, the optimization and integration process is being used to decrease energy consumption and boost yields. As a result, researchers throughout the globe are keeping an eye out for new, less expensive ways to generate

energy, particularly from cellulosic biomass. These kinds of studies have the potential to become a major trend in the future of national development via the use of indigenous resources.

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