BUT

Iranica Journal of Energy & Environment
Journal Homepage: www.ijee.net
IJEE an official peer review journal of Babol Noshirvani University of Technology, ISSN:2079-2115

Short Communication

Potential of Ethanol Production Using Molasses Fermentation in a Sugar Plant

P. Sharma[1]*, S. Y. Kumar[2] and A. Shukla[2]

[1] *Department of Energy Technology, RGPV, Bhopal, India*
[2] *College of Engineering and Technology, Mody University of Science & Technology, Lakshmangarh, Dist. Sikar (Rajasthan), India*

P A P E R I N F O

Paper history:
Received 21 November 2018
Accepted in revised form 31 December 2018

Keywords:
Ethanol production
Sugar plant
Fermentation process
Sugarcane
Molasses fermentation

A B S T R A C T

Due to globalization, privatization and liberalization; sugar industry has to face the domestic as well as international competition. Thus, for survival of the industry, cost effectiveness and economics of by-products become very vital. The aim of this work is to assess the potential, in the short term, for fuel ethanol production by using intermediate molasses in a sugar plant in central India. The by-product plant can support the existing plant to improve the general economy, financial viability, economic status of sugarcane growers and workers by way of paying higher prices for sugarcane crop and also create more employment opportunities in the rural areas by setting up industries based on sugarcane by-products. For assessing the amount of Ethanol production an experimental study has been carried out which find out the amount of ethanol production via fermentation process of molasses sample acquired from the plant. It gives more fine results as the quality of sugarcane changes from place to place.

***doi**: 10.5829/ijee.2018.09.04.02*

INTRODUCTION

Worldwide Energy utilization in the last 50 years has quickly expanded and is required to keep on growing throughout the following 50 years, in any case, with noteworthy contrasts. Most overall energy request is provided via carbon-containing fossil sources, for example, coal, oil, and flammable gas [1]. Energy services have always remained in focus of successive Indian governments that has resulted in the expansion of the energy infrastructure within the country and steady expansion in total energy use. Commercial energy use increased 21 times and the power generation capacity went up by 100 times during the past 60 years. The aggregate generation of Energy from ordinary fossil fuel sources expanded from 13400.67 peta joules amid 2013-14 to 14090.50 peta joules amid 2014-15 [2]. Fossil fuels are non-renewable resources reasons global warming and a series of environmental problems. Recent resources are energy resources that are currently generated, for instance, by biological processes. They include, among others, the energy contents of biomass and the potential energy of a natural reservoir.

Biomass can be divided into primary and secondary products. The former are produced by direct use of solar energy through photosynthesis. In terms of energy supply, these are farm and forestry products from energy crop cultivation (i.e. fast-growing trees, energy grasses) or plant by-products, residues, and waste from farming and forestry including the corresponding downstream industry and private households (i.e. straw, residual and demolition wood, organic components in household and industrial waste). Secondary products are generated by the decomposition or conversion of organic substances in higher organisms (e.g. the digestion system of animals); these are for example liquid manure and sewage sludge.

The fast reduction of fossil fuels, mutual with amplified distress surrounding greenhouse gas emissions and an unnatural weather change has made the mission for alternative fuels a great importance. Liquid biofuels are produced from biomass, and hence are believed to be quasi GHG neutral, that is, the biomass takes up the same amount of CO_2 while growing as the amount it releases when the biofuel produced from that biomass is consumed [3].

Biobutanol can act as a substitute for both gasoline and diesel, however it is more usually used as a gasoline substitute [4]. Biobutanol has a higher energy content and more compatible with current automobile engines and gasoline pipelines than ethanol [5]. Fermentation of biomass are another process which gained much attention. Hydrogen production from dark fermentation has increased much consideration in latest years since it has high hydrogen production rate, low energy requirement and process easiness.

* Corresponding author: P. Sharma
E-mail: Pra.sharma30683@gmail.com

Hydrogen gas should be produced from low-cost feedstock such as agricultural wastes and food industry effluents like molasses to increase the commercial profits of biological hydrogen production. At current, ethanol is the maximum and extensively used biofuel [6].

The sugarcane agro-industry have transformed the sugar mill from being just a food producer into anexpanded production plant since it can yields food, energy, and biofuels [7]. The main reason of this modification is the use of sugarcane agro-industrial residues i.e. bagasse, molasses and Press mud as feedstock for energy cogeneration and biofuel production.

The main aim of this paper is to carry out an assessment on sugarcane industry by-product molasses availability and its potential to conversion in biofuel energy in the sugar mill. The trade-off on sugarcane molasses energy use in view of the agro-industrial expansion level, is also examined.

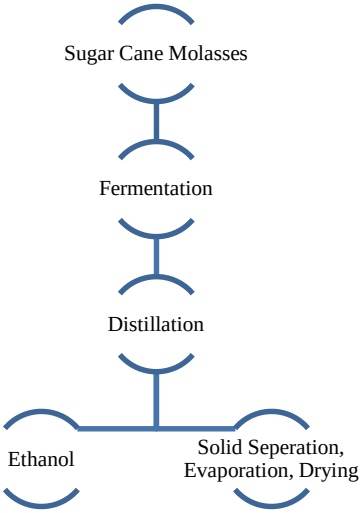

Figure 1. Ethanol production stages from Sugarcane Molasses

SUGARCANE MOLASSES

Sugarcane has high sucrose gratified, and is the by-product that is collected for the generation of sugar. There are three principle by product during the sugar production are Bagasse, molasses and press mud. Molasses is a dark coloured sugary remainder gotten from sugarcane after removal of all commercially profitable sugar. The molasses ingredients depends on the soil, climate, cane type and also sugar refining process. Sugar concentration in molasses is about 50-66 wt% [8]. The chemical composition of molasses samples obtained from the sugar mill is shown in Table 1. Seeing that molasses was one of the first substrates to be used for biobutanol production, there is sufficient literature available on fermentation studies with molasses as. Among another options available for ethanol production molasses has the advantage that it is one of the cheapest carbon sources in the market. It is relatively easy to handle during fermentation (as a liquid, molasses can be pumped) and the molasses mash is relatively easy to sterilize.

PROCESS OF PRODUCING ETHANOL FROM SUGAR CANE MOLASSES

At present, most liquid biofuels are produced from food crops: biodiesel is produced by trans-esterification of extracted neutral lipids, mainly from palm, soybean and oilseed rape, and fuel ethanol is produced by microbial fermentation of sugars from starch crops, such as sugarcane, maize, sugar beet cassava, wheat, and other grains. Sugar refinery by product molasses has been designated as the most inexpensive raw material for traditional ethanol production due to its high efficiency, its high conversion yields and its low production costs. Ethanol and carbon dioxide are produced by yeast fermentation of molasses. This chemical process depends on the ethanol stoichiometric yield, the fermentable sugars content, and the fermentation and distillation yields.

TABLE 1. Composition of the sugar cane molasses used for experiment

Water Content, %	Soluble Solids Content, %	Total Sugar, %	Total Nitrogen Content, %	Mineral Substances Content, %	pH
20.2	79.8	53.7	0.5	6.2	6

EXPERIMENTAL ASSESSMENT OF THE ETHANOL PRODUCTION FROM MOLASSES

For the assessment of ethanol production the molasses sample was collected from Sugar Mill situated in central India. The elemental composition of the molasses was determined using Atomic emission spectroscopy.

Torula yeast (yeast of sedimentary beer) in cooled and chopped condition was used for fermentation analysis. The microorganism is inserted in various stages i.e. activation and growth stage in chemically defined medium, and transformation stage in the sugarcane molasses. For culturing microbes and proper mixing orbital shaker is used. Sugarcane molasses used for the study is a dark viscous fluid with a pH value of about 6, composed by a mixture of glucose (14 wt%), sucrose (76 wt%), fructose (10 wt%). 100 g of molasses along with 500 ml of water has been added with yeast by 5% weight to prepare the mixture for fermentation. The essential nutrients (urea) of changed absorptions 0.15, 0.5, and 0.25%(w/v) were added and the pH value of the mixture was controlled at the level of 5 with the help of concentrated sulphuric acid.

Initially the batch mode process was conducted to find out the amount of ethanol generated. A fermenter with temperature and stirring control was cast-off. Heating for 100 °C for 20 minutes, and, then, cooling up to room temperature i.e. 34 °C has been carried out. The fermentation was carried out at room temperature. At every constant time interval the ethanol amount was recorded.

The yield of ethanol (%) during the fermentation process is measured using an Ebulliometer. Another gas parameters like density, viscosity and purity were determined according to process and standards [9].

In this work the alcoholic batch fermentation was performed at a sugar level generally adopted industrially (200

g/L) [10]. It is observed that approximately 150 g of ethanol, per 2 L of solution, was produced. This means about 375 g approximate of ethanol can be produce using 1kg of molasses [11].

ECONOMIC ANALYSIS OF ETHANOL PRODUCTION FROM MOLASSES

To assess theoretical situations where intermediate molasses are recycled as raw material for fuel ethanol making, it should be calculated that how much molasses is produced as a by-product. The production of molasses can be estimated using the Sugar- Juice-Molasses formula of Deerr [3, 12-15] theoretically but in this study we have find out the production data from the plant.

The most commonly used feedstock for the production of ethanol in the cane sugar industry is final molasses. The production data for final molasses in the sugar mill consider for the study is known for last four years of crushing. Table 2 summarized the production of final molasses, raw sugar and cane harvested for the period 2013-16.

The last four year sugarcane crushing season average for final molasses production is close to 2.9425 lakh M.T. and agrees to a mean of final sugar production rate of 9.6% of total crushing and molasses production rate of 4.73% of cane crushing. It can be estimated that if all the final molasses produced after sugar productionis fermented, the maximum potential for the production of ethanol from final molasses with a mean of last four year production of plant, is about 6.6 million litres per year computed considering the 0.79g/cm^3 density of ethanol [16, 17].

Indian government has fixed the price of ethanol at Rs.40.85/- per litre under Ethanol Blended Petrol (EBP) Programme for resource to the Government Oil Firms.On the above price level the total ethanol can be sell on the approximate price of Rs 2705, 52,960.98approximate per year.

DISCUSSION

The agricultural raw materials direct from fields for ethanol production can affect human and environmental health as well as societal needs in a negative way. For example, because agricultural raw materials are also used to produce food, and other products, the growing demand for biofuels could potentially raise the price of essential food products for consumers.

TABLE 2. Production data of the sugar mill

Year of production	Crushing Capacity (M.T.)	Cane Crushed (Lakh M.T.)	Sugar Produced (Lakh Qtl)	Molasses Produced (M.T.)
2016-17	4500	3.27	3.17	15251
2015-16	4500	2.08	2.00	9380
2014-15	2500	2.86	2.77	14165
2013-14	2500	3.56	3.39	17095
Average of last four years		2.9425	2.8325	13972.75

Indian Government has included sugar in the list of essential commodities and imposed various restrictions like zoning, taxation levy, price of sugar, partial decontrol, release mechanism etc. All these elements affect cost-effectiveness of the sugar industry. In this industry, cane growers insist for better price for the cane they supply to the Mills and the consumers expect the sugar prices at the minimum level, so that they can afford to pay for it. To meet both the ends, the only way is to control and reduce the cost, increase the productivity and increase the performance of by-products. There are three basic by-products in the sugar industry i.e. molasses, bagasse and press mud. This study has been carried out to assess the productivity increment opportunity by using molasses conversion in ethanol by fermentation process, which is at present directly sell out to the other enterprise by the plant in the form of raw material. It has been estimated that on the basis of above calculations the ethanol can be generated of approximate price of Rs. 2705, 52,960.98 per year. The amount of ethanol generation can be vary and depends on the various other factors i.e. yeast, temperature, process adopted, sugar concentrations etc.

India is initiating the use of ethanol as an automotive fuel .With a view to give boost to agriculture sector and reduce environmental pollution, Government of India have been examining for quite some time supply of ethanol-doped-petrol in the country. A move has been made by distilleries in India to use surplus alcohol as a blending agent or an oxygenate in gasoline. Based on experiments by the Indian Institute of Petroleum, a 10 percent ethanol blend with gasoline and a 15 percent ethanol blend with diesel are being considered for use in vehicles in at least one state. The Society for Indian Automobile Manufacturers (SIAM) has established the approval for practice of 5% ethanol-doped-petrol in automobiles [18]. Thus it can be stated that there is a huge demand for Ethanol in the country.

REFERENCES

1. Jung, J.-M., S.-R., Lee, J., Lee, T., Lee, D.C.W., Tsang, E.E., Kwon, 2017. Biodiesel synthesis using chicken manure biochar and waste cooking oil. Bioresource Technology, 244: pp. 810-815.
2. Energy Statics, Central Statistics Office Ministry of Statistics and Programme Implementation, Government of India, New Delhi.
3. Castañeda-Ayarza, J.A. and L.A.B., Cortez, 2017. Final and B molasses for fuel ethanol production and some market implications. Renewable and Sustainable Energy Reviews, 70: pp.1059-1065.
4. Dalle Ave, G. and T.A., Adams, 2018. Techno-economic comparison of Acetone-Butanol-Ethanol fermentation using various extractants. Energy Conversion and Management, 156: pp. 288-300.
5. Van der Merwe, A.B., H., Cheng, J.F. Görgens, and J.H., Knoetze, 2013. Comparison of energy efficiency and economics of process designs for biobutanol production from sugarcane molasses. Fuel, 105: pp. 451-458.
6. Ghosh, S.K., 2016. Biomass & bio-waste supply chain sustainability for bio-energy and bio-fuel production. Procedia Environmental Sciences, 31: pp. 31-39.
7. Pippo, W.A. and C.A., Luengo, 2013. Sugarcane energy use: accounting of feedstock energy considering current agro-industrial trends and their feasibility. International Journal of Energy and Environmental Engineering, 4(10): pp. 1-13.
8. Ruhul Amin, M., M. Saquib Hossain, and M., Sarker, 2013. Simulation of ethanol production by fermentation of molasses. Journal of Engineering (JOE), 1(4): pp. 69-73.

9. Association of Official Analytical Chemists (AOAC), 1993. Official Methods of Analysis of the Association of Official Analytical Chemists, 15th edn. Association of Official Analytical Chemists, Washington DC, USA.
10. Ponce, G.H.S.F., J.M., Neto, S.S., De Jesus, J.C., De Carvalho Miranda, R., Maciel Filho, R.R. De Andrade, and M.R.W., Maciel, 2016. Sugarcane molasses fermentation with in situ gas stripping using low and moderate sugar concentrations for ethanol production: Experimental data and modeling. Biochemical engineering journal, 110: pp. 152-161.
11. Lavarack, B.P., 2003. Estimates of ethanol production from sugar cane feedstocks. In Proceedings-Australian Society of Sugar Cane Technologists, PK Editorial Services Pty Ltd, 25: pp. 69-77.
12. Hamelinck, C.N., G., Van Hooijdonk, and A.P., Faaij, 2005. Ethanol from lignocellulosic biomass: techno-economic performance in short-, middle-and long-term. Biomass and bioenergy, 28(4): pp. 384-410.
13. Ardila, Y.C., J.J., Figueroa, B.H., Lunelli, R., Maciel Filhoand, M.W., Maciel, 2014. Simulation of ethanol production via fermentation of the synthesis gas using aspen plus TM. Chemical Engineering Transactions, 37: pp. 637-642.
14. Gnansounou, E., and A., Dauriat, 2010. Techno-economic analysis of li ocellulosic ethanol: A review. Bioresource Technology, 13(101): 4980-4991.gn
15. Dogbe, E.S., M.A., Mandegari, and J.F., Görgens, 2018. Exergetic diagnosis and performance analysis of a typical sugar mill based on Aspen Plus® simulation of the process. Energy, 145: pp. 614-625.
16. Ren, H.Y., F., Kong, J., Ma, L., Zhao, G.J., Xie, D., Xing, W.Q., Guo, B.F., Liu, and N.Q., Ren, 2018. Continuous energy recovery and nutrients removal from molasses wastewater by synergistic system of dark fermentation and algal culture under various fermentation types. Bioresource technology, 252: pp. 110-117.
17. Duque, S.H., C.A., Cardona, and J., Moncada, 2015. Techno-economic and environmental analysis of ethanol production from 10 agroindustrial residues in Colombia. Energy & Fuels, 29(2): pp. 775-783.
18. The Gazette of India: Extraordinary [Part I- Sec. I], Ministry Of Petroleum and Natural Gas Resolution, New Delhi, 3rd September, 2002 No. P-45018/28/2000-C. C.

Persian Abstract

DOI: 10.5829/ijee.2018.09.04.02

چکیده

گسترش جوامع، خصوصی‌سازی و افزایش پیشرفت، صنعت قند را با رقابت داخلی و نیز بین‌المللی مواجه نموده است. بنابراین، برای بقای صنعت، محصولات جانبی مقرون به صرفه و اقتصادی، بسیار حیاتی می‌باشد. هدف از پژوهش حاضر، ارزیابی ظرفیت تولید سوخت اتانول با استفاده از ملاس حاصل از یک کارخانه قند در مرکز هند، در کوتاه مدت است. کارخانه محصولات جانبی، می‌تواند با حمایت از کارخانه اصلی، وضعیت مالی و اقتصادی تولیدکنندگان نیشکر و کارگران را از طریق پرداخت قیمت‌های بالاتر برای محصولات نیشکر بهبود بخشد. همچنین راه‌اندازی صنایع مبتنی بر محصولات جانبی نیشکر می‌تواند فرصت‌های شغلی بیشتری در مناطق روستایی ایجاد کند. برای ارزیابی میزان تولید اتانول، یک مطالعه تجربی انجام شده است که میزان تولید اتانول را طی مرحله تخمیر ملاس نمونه‌گیری شده از گیاه، نشان می‌دهد. از آنجا که کیفیت نیشکر از مکانی به مکان دیگر قابل تغییر است، نتایج بهتری می‌تواند حاصل شود.