International Journal on Emerging Technologies 11(2): 845-848(2020)

ISSN No. (Print): 0975-8364
ISSN No. (Online): 2249-3255

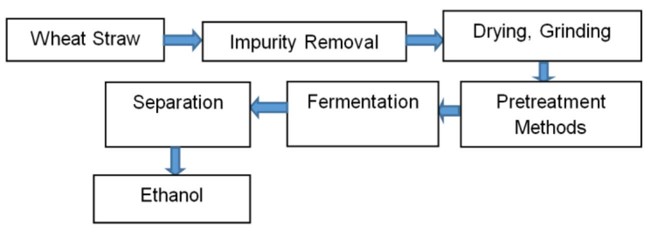
Ethanol Production from Modified Wheat Straw using *Saccharomyces cerevisiae*

Muataz H. Ismael[1], Salah N. Farhan[2], Yaser I. Jasem[3] and Walaa Abid Mahmood[4]
[1]Assistant Lecturer, Department of Chemical Engineering, Diyala, Baqubah, Iraq.
[2]Senior Lecturer, Department of Chemical Engineering, Diyala, Baqubah, Iraq.
[3]Lecturer, Department of Chemical Engineering, Diyala, Baqubah, Iraq.
[4]Lecturer, Department of Chemical Engineering, Diyala, Baqubah, Iraq.

(Corresponding author: Salah N. Farhan)
(Received 04 January 2020, Revised 03 March 2020, Accepted 05 March 2020)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: The aim of this study is to produce ethanol from agricultural residues (wheat straw) by fermentation in a laboratory scale using Baker yeast (*Saccharomyces cerevisiae*). Reduction of the disposal of stable natural wastes through Cellulosic ethanol Conversion would reduce solid waste disposal charges through Nearby and nation governments. Solubilization and separation of one or more of the four main components of biomass cellulose, hemicellulose, lignin, and extractives a good way to make the remaining stable biomass greater on hand to further chemical or biological treatment. The conversion of hemicellulose into sugars varies depending on the chemical modification process, four methods are used as a modification technique to break down the glycoside bond, the first one uses (100 grams) of wheat straw and is poured in a solution which contains of 2% H_2O_2, NaOH for 2 h before fermentation. Second, 250 g of wheat straw is mixed with 0.1 g of benzyl penicillin and 0.7 g of urea. The third is used (250 g) with a sample of cow stomach rumen. The fourth sample was fermentation without additions of any substances for comparison purposes. The results showed that the treated samples were better than non-treated ones and were ordered in a manner as H_2O_2> Rumen > B. Penicillin > without.

Graphical Abstract:



Keywords: Ethanol, Yeast, Fermentation, Treatment.

I. INTRODUCTION

Ethanol is used as a pure fuel or mixed with gasoline at certain rates to improve octane number. It is characterized by being completely biodegradable because it does not contain sulfur. Acetic acid can be produced in less toxic than other alcohols [1].

Ethanol is one of the most important types of alcohol, which can be produced by a fermentation process of compounds containing sugars (starchy material) with the production of carbon dioxide as a byproduct [2]. The production of bio-ethanol from sugars and starches, such as sugar cane and maize, is well established in this period, but it has been concluded as competing with food [3-5].

Ethanol production is done by anaerobic fermentation through Embden-Meyerhoff (EMP) pathway stimulated by enzymes produced from yeast. Heat is used to break down complex sugars into simple sugars and fermentation occurs to produce ethanol [6]. Starch needs to be fermented have to pretreat in order to lose its crystal shape and turns into a soluble gel with high viscosity, this process known as liquefaction. The viscosity then reduced and process of scarification occurs, where dextrin converted to glucose via adding a glucoamylase [7, 8].

Starch → Dextrin → Fermentable Sugar → Ethanol + CO_2

During the fermentation process, a portion of the glucose is consumed for yeast growth purpose. The process is of high efficiency with glucose, in the reactions below, one mole of glucose is converted to tow moles of ethanol and two of carbon dioxide gas [9, 10].

$$C_{12}H_{22}O_{11} + H_2O + \text{invertase} \rightarrow 2\, C_6H_{12}O_6 \quad (1)$$

$C_6H_{12}O_6$ + Zymase → $2C_2H_5OH + 2CO_2$ (2)

The main components of wheat straw are 35-45% cellulose, 20-30% hemicellulose, liginin 8-15%, protein 3%, and ash 10 % which therefore needs to breaking of the glycosidic bonds before fermentation [11].

Baking Yeast (*Saccharomyces cerevisiae*), which has a major role in fermentation processes, does not have the ability to ferment pentose, breaking of the glycosidic bonds before fermentation is needed [12, 13]. Weak acids and furan derivatives so as phenolic compounds produced during chemical hydrolysis of lignocellulosic materials, inhibit cell growth [14]. Temperatures play an important role in the fermentation process and are about 20-35℃ where heat within this range allows good yeast growth and gives good returns from ethanol. Fermentation is an internal energy process [15, 16].

This paper reviews the different chemical methods that have received great attention globally, focusing on process innovations and interesting results from researchers' work in this field. The main objectives are to convert high-hemicellulose compounds into fermented sugars by treating wheat straw residues using chemical methods and biological method with monitoring on pH and total sugar of final ethanol product, inoculums size and nitrogen sources. After the amount of sugar in the fermentation broth vanished, solids are separated from the liquid by centrifugation, ethanol is separated by distillation.

II. MATERIALS AND METHODS

A. Wheat Straw and Yeast

Wheat straw used in the experiments were brought from one of the nearby farms and then washed with water to remove the dust and other suspended materials and then dried under a sun light for a one day then dried in an oven at 30ºC for 24 h and then grind into powdered by using a stainless steel grinder and sieved to 500 µm. *Saccharomyces cerevisiae* yeast used in the present study were obtained from a local market in Diyala Governorate, which was kept in stock solution composed of 20% glycerol and 80% of culture medium which contain in g/L, yeast extract 5, malt extract 5, peptones 3, and glucose 5. The yeast extract was produced by placing a quantity of yeast in a large flask with the addition of glucose in order to make yeast multiply, then heating between 45-55℃ to stop growing. Enzymes were broke down the molecules of proteins found in the yeast into small components and made cell walls permeable by a process known as self-degradability. The components in the cell were then separated from the solution [17].

B. Yeast cultivating

Dry yeast was taken from a sample and was aerobically cultivation at 30℃ and mixing on a rotary shaker ((DUBNOOT BSD/DCE) 180 rpm for 4 hours with a medium consist of yeast extract 10 g/L and glucose 20 g/L and at pH 5.0. Using the centrifuge, the cells were collected at 3000 rpm for 10 minutes. Then by sterilized distilled water, the pellets formed were then washed and suspended directly in the medium to be used as an inoculate (10% (v/v)) [18].

Pretreatment: Four methods of treatment were done to wheat straw, the first one was used 250 g of wheat straw and adding solution containing (2% H_2O_2 (v/v)) and NaOH (2% (v/v)) for 2 h, and the sample was removed and washed with a distilled water prior to fermentation.

The second treatment was done by mixed 0.1 g of benzyl penicillin and 0.7 g of urea with 250 g of wheat straw prior to fermentation. The third is used (250 g) with a sample of cow stomach about 2gm without purification or sequestering. The fourth sample was fermentation without additions of any substances for comparison purposes.

Fermentations: All samples from pretreatment were placed in a batch fermentor (3 L lab flask) an aerobically by adding inoculum 10% (v/v) at 25ºC, the sample were taken at 20, 40 , 60, 80, 100, and 120 h to check all of pH value, specific gravity, sugar content, and ethanol yield.

III. RESULTS AND DISCUSSION

A. Effect of pH and Brix Value

Fig. 1 and 2 shows a decrease in the value of the pH and the amount of sugar over time(Brix Value) to reach the maximum production rate of ethanol at time 72 hr then begins gradual decline over time due to consumption of sugar present as a result of yeast growth. These results are in agreement with Gulten Izmirlioglu and Ali Demirci were they stated that higher growth rate for biomass at this value of pH resulting in lowering brix value [19, 20, 21].

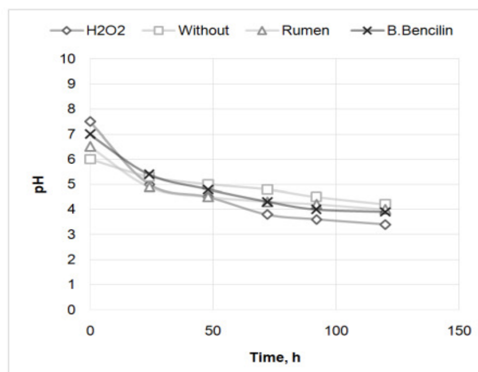


Fig. 1. pH during fermentation time.

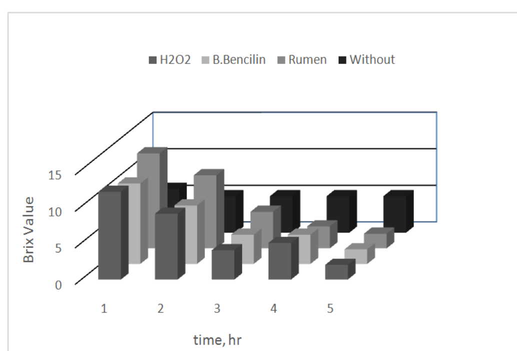


Fig. 2. Brix level during fermentation.

B. Specific Gravity and Ethanol Yield

It is obvious from Fig. 3 that the specific gravity start to decrease. This could be attributed to the lowering in the solid compounds in the fermentation broth, consuming of whet straw. On the other hand, in Fig. 4, there is an increase in ethanol production, these findings are in agreement with Verbelen *et.al.* [22] and Ali *et.al* [23].

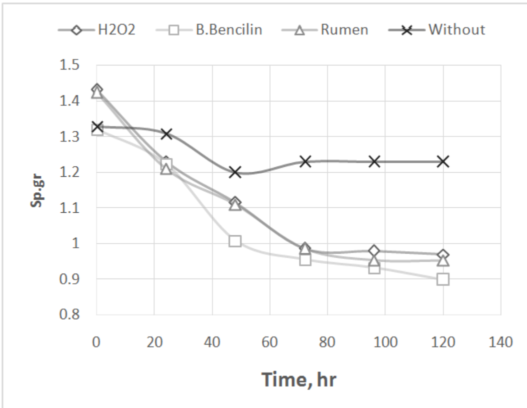


Fig. 3. Specific gravity during fermentation.

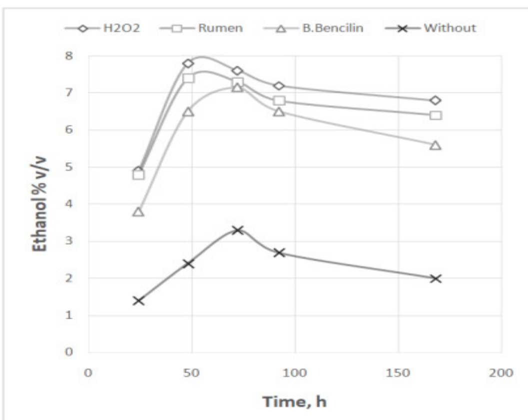


Fig. 4. Ethanol yield during fermentation.

C. Effect of Temperature

As shown in Fig. 5, with constant pH value of 6. The five-day fermentation time was between 20℃ and 40℃ with an increase of 5℃. The percentage of ethanol production increases with the increase in temperature because the optimum temperature for yeast growth is 30-35℃ and at 40℃, there is a decrease in the production of ethanol. There is no growth process for the yeast at this level and at degrees below 30 the growth is slow for the yeast. Amicobic groups use water and the wheat straw to produce fatty acids and gases through the process of rapid digestion within the stomach and when the fermentation in the fermentor, the existing bacteria will increase the fatty acid and lactic acid which gives ethanol [24].

The rate should increase from 20℃ to 40℃. At 50℃ and above, the rates will decrease. The fermentation rate at high temperatures will be low because high temperatures are lethal to yeast. Enzymes move too fast and denature at high temperatures [25].

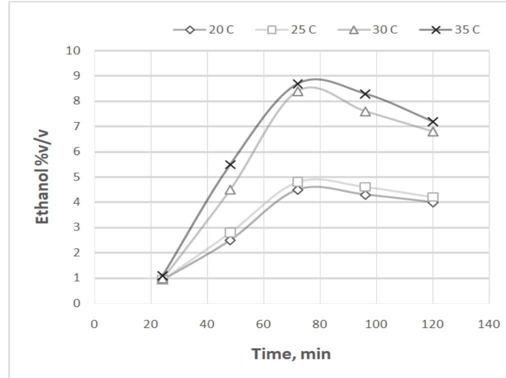


Fig. 5. Ethanol yield during fermentation of sample rumen at different temperature.

IV. CONCLUSION

It is clear that the use of agricultural waste to produce ethanol through fermentation processes is useful because it contains the sugar needed by the yeast to transfer the waste to ethanol. The process of production depends on the availability of good treatment methods to get rid of the classic links, as well as the need to select enzymes to control the production of ethanol and the use of the best organisms to deal with agricultural waste. Results shows that the best treatment method was with rumen and give better ethanol production at 72 hr.

V. FUTURE SCOPE

Trying to isolate and diagnose some enzymes in the intestine of ruminants and study their effect on the production process.

ACKNOWLEDGEMENTS

Authors are thankful to the Department of Chemical Engineering labs, College of Engineering, University of Diyala, Diyala, Iraq, for financial support.

Conflict of Interest. The above-mentioned authors certify that they do not participate in any entity or organization with financial interests such as educational grants, participation in employment offices, consulting offices, ownership of shares and other intellectual property rights and that there is no personal or professional interest in the material discussed in This manuscript.

REFERENCES

[1]. Minteer, S. (2016). Alcoholic fuels, CRC Press.

[2]. Sun, Y., & Cheng, J. (2002). Hydrolysis of lignocellulosic materials for ethanol production: a review. *Bioresource technology*, *83*(1), 1-11.

[3]. Rosillo-Calle, F. (2012). Food versus fuel: toward a new paradigm—the need for a holistic approach. *ISRN Renewable Energy*, *2012*.

[4]. Sims, R. E., Mabee, W., Saddler, J. N., & Taylor, M. (2010). An overview of second generation biofuel technologies. *Bioresource technology*, *101*(6), 1570-1580.

[5]. Fromanger, R., Guillouet, S. E., Uribelarrea, J. L., Molina-Jouve, C., & Cameleyre, X. (2010). Effect of controlled oxygen limitation on Candida shehatae physiology for ethanol production from xylose and glucose. *Journal of industrial microbiology & biotechnology*, *37*(5), 437-445.
[6]. Martín, C., Galbe, M., Wahlbom, C. F., Hahn-Hägerdal, B., & Jönsson, L. J. (2002). Ethanol production from enzymatic hydrolysates of sugarcane bagasse using recombinant xylose-utilising *Saccharomyces cerevisiae*. *Enzyme and Microbial Technology*, *31*(3), 274-282.
[7]. Xu, Z., & Huang, F. (2014). Pretreatment methods for bioethanol production. *Applied biochemistry and biotechnology*, *174*(1), 43-62.
[8]. Verardi, A., Blasi, A., Molino, A., Albo, L., & Calabrò, V. (2016). Improving the enzymatic hydrolysis of *Saccharum officinarum* L. bagasse by optimizing mixing in a stirred tank reactor: Quantitative analysis of biomass conversion. *Fuel Processing Technology*, *149*, 15-22.
[9]. Ward, O. P. (1989). Fermentation biotechnology: principles, processes and products.
[10]. Zhang, M., Wang, F., Su, R., Qi, W., & He, Z. (2010). Ethanol production from high dry matter corncob using fed-batch simultaneous saccharification and fermentation after combined pretreatment. *Bioresource Technology*, *101*(13), 4959-4964.
[11]. Saha, B. C., & Cotta, M. A. (2006). Ethanol production from alkaline peroxide pretreated enzymatically saccharified wheat straw. *Biotechnology Progress*, *22*(2), 449-453.
[12]. DEMİRBAŞ, A. (2005). Bioethanol from cellulosic materials: a renewable motor fuel from biomass. *Energy sources*, *27*(4), 327-337.
[13]. Hahn-Hägerdal, B., Wahlbom, C. F., Gárdonyi, M., van Zyl, W. H., Otero, R. R. C., & Jönsson, L. J. (2001). Metabolic engineering of *Saccharomyces cerevisiae* for xylose utilization. In *Metabolic engineering* (pp. 53-84). Springer, Berlin, Heidelberg.
[14]. Klinke, H. B., Thomsen, A. B., & Ahring, B. K. (2004). Inhibition of ethanol-producing yeast and bacteria by degradation products produced during pre-treatment of biomass. *Applied microbiology and biotechnology*, *66*(1), 10-26.
[15]. Zabed, H., Faruq, G., Sahu, J. N., Azirun, M. S., Hashim, R., & Nasrulhaq Boyce, A. (2014). Bioethanol production from fermentable sugar juice. *The Scientific World Journal*, *2014*.
[16]. Kumar, S., Singh, N., & Prasad, R. (2010). Anhydrous ethanol: A renewable source of energy. *Renewable and Sustainable Energy Reviews*, *14*(7), 1830-1844.
[17]. http://www.yeastextract.info/yeast-extract/how-it-s-made
[18]. Zhang, Y., Wang, C., Wang, L., Yang, R., Hou, P., & Liu, J. (2017). Direct bioethanol production from wheat straw using xylose/glucose co-fermentation by co-culture of two recombinant yeasts. *Journal of industrial microbiology & biotechnology*, *44*(3), 453-464.
[19]. Izmirlioglu, G., & Demirci, A. (2012). Ethanol production from waste potato mash by using *Saccharomyces cerevisiae*. *Applied Sciences*, *2*(4), 738-753.
[20]. Ratnakaram, V. N., Rao, C. P., & Sree, S. (2020). Simultaneous Saccharification and Fermentation of Watermelon Waste for Ethanol Production. In *Emerging Technologies for Agriculture and Environment* (pp. 185-197). Springer, Singapore.
[21]. Darwin, R. O., Alexandra, A., Elena, M., Manjunatha, B., Bryan, R. B., Subbareddy, G. V., ... & Rajeswari, B. (2017). Comparative study of native microorganisms isolated from watermelon (*Citrullus lanatus*) waste and commercial microorganism (*Clostridium thermocellum*) used for bioethanol production. *Afr. J. Biotechnol*, *16*(9), 380-387.
[22]. Verbelen, P. J., Saerens, S. M. G., Van Mulders, S. E., Delvaux, F., & Delvaux, F. R. (2009). The role of oxygen in yeast metabolism during high cell density brewery fermentations. *Applied microbiology and biotechnology*, *82*(6), 1143-1156.
[23]. Ali, A. A. H., Alrahman, Z. M. A., Alfeetori, O. H., & Jebril, W. A. (2019). Biomass energy: Bio-ethanol production from date molasses using alcoholic fermentation. In *AIP Conference Proceedings* (Vol. 2146, No. 1, p. 020010). AIP Publishing LLC.
[24]. Zebeli, Q., & Metzler-Zebeli, B. U. (2012). Interplay between rumen digestive disorders and diet-induced inflammation in dairy cattle. *Research in veterinary science*, *93*(3), 1099-1108.
[25]. Remize, F., Cambon, B., Barnavon, L., & Dequin, S. (2003). Glycerol formation during wine fermentation is mainly linked to Gpd1p and is only partially controlled by the HOG pathway. *Yeast*, *20*(15), 1243-1253.

How to cite this article: Ismael, M. H., Farhan, S. N., Jasem, Y. I. and Mahmood, W. A. (2020). Ethanol Production from Modified Wheat Straw using *Saccharomyces cerevisiae*. *International Journal on Emerging Technologies*, *11*(2): 845–848.