Egypt. J. Chem. **Vol. 65,** No. SI:13, pp. 127 – 131 (2022)

Egyptian Journal of Chemistry
http://ejchem.journals.ekb.eg/

Improving Biogas Production from Rice Husk Waste by Mixing with Pomegranate peels Waste by using Anaerobic Digestion

Ruaa Omar Taha [*], Sameera Majid Minti, Farah Ali Mohammad

Department of Chemical Engineering, University of Technology, Baghdad, Iraq.

Abstract

Biogas is one of the most important sources of renewable energy and is considered as an environment friendly energy source. The major goal of this research is to see if rice husk (Rh) waste and pomegranate peels (PP) waste are suitable for anaerobic digestion and what effect NaOH pre-treatment has on biogas generation. Rice husk and pomegranate peels were tested in anaerobic digestion under patch anaerobic conditions as separate wastes as well as blended together in equal proportions. The cumulative biogas output for the blank test (no pretreatment) was 1923 and 2526 ml, respectively using a single rice husk (Rh) and pomegranate peel (PP) substrates. The 50% rice husk digestion and 50% of pomegranate peels for blank test gave the result 2246 ml of accumulative biogas during 15 days of digestion. These findings show that Rh degradation is less appropriate for the digestion of a single substrate. Because of Rh's high lignin material. The digestion of the rice-husk-peel blend enhanced the digestibility of the rice husk and thus increased the yield of biogas. 3% NaOH chemical pretreatment are investigated in addition to blank test in order to find the effect of pretreatment on rice husk and pomegranate peels for biogas production. The pretreatment increases the accumulative biogas for Rh, PP and mixture of 50% Rh with 50% PP from 1923, 2526 and 2246 ml to 2007, 2560 and 2309 ml respectively.

Keywords : Biogas; Rice husk ; Pomegranate peels; Anaerobic digestion

1. Introduction

The world is developing toward a new era, the era of transition from almost dependence on fossil fuels to the wider use of alternative energy. Sources and renewable energy as a solution for the problem of energy supply which accompanies with population growth and development of technologies [1]. Different sources of biomass, as a fordable and a renewable known – fossil sources, include different animals organic waste, agricultural, municipal, and industrial waste [2,3]. In this regard, aerobic digester of agricultural residues and other biodegradable wastes. Is being widely used as the best treatment option with a potential to extract about 70-50% methane (CH4) and 40-30% carbon dioxide (CO2), and both are suited for the generation of renewable energy, such as biogas, recycling organic materials and pollution control [4]. Therefore, biogas productions using anaerobic digestion can be intended one of the best technologies for reducing the size and mass of 50% of incoming wastes, reduction of pathogens controlling the greenhouse gas emissions, and stabilizing crop biomass before its use in agricultural activities [5]. Pretreatment is effective and may play an important role in improving the degradation of biological reactors and many increase biogas productions [6,7]. Waste rice husk is one of the biomasses that might be fed to the sock for biogas production (Rh). Since the nature is rich and there is plenty of carbon accessible in the form of rice celluloses on the composer of rice husk (Rh), it is excellent for biogas generation as a feed stock [8]. Rice straw's high lignin level makes it difficult for microorganisms to decompose the substrate, necessitating pretreatment with NaOH, which is predicted to reduce the lignin content of rice straws [9]. The simultaneous choice of two or more biomass mixtures is a strategy for increasing both the bioconversion rate and the methane output [10]. In the study pomegranate peel (PP) waste was used, the use of these wastes could facilitate anaerobic decision

*Corresponding author e-mail: ruaa.taha.100@gmail.com : Tel (+9647902762882)
Receive Date: 03 October 2021, **Revise Date:** 17 February 2022, **Accept Date:** 31 March 2022, **First Publish Date:** 31 March 2022
DOI: 10.21608/EJCHEM.2022.99280.4618

(AD) so that we can prevent environmental issues by collecting and supply them as raw materials for the production of bio methane fuel gas from one side and reduce the issues of wastes managements, on the other side [11]. Pomegranate peel (PP) waste as a source of lignocelluloses to generate high volume biogas has lesser digestibility and low protein content compared with other fruit wastes and therefore, is not suitable as animals feed. So, their storage a superfluous material in factories is causing air pollution and public health problems. However, many studies have revealed the organic waste digest many contribute to improve the balance of nutrients, reducing the rate of acidification, reducing toxic compounds, lowering costs for preprocessing, and thus increasing the biogas production [12]. The digestate may be utilized as an excellent organic fertilizer, and the biogas may be utilized to create heat and/or power [13]. Anaerobic decision (AD) for combinations of rice husk (Rh) and other agriculture residual material has been proven in some studies [14, 15].

In this study, the biogas production from rice husk (Rh), pomegranate peels (PP) and a mixture consist of rice husk (Rh) and pomegranate peels (PP) with NaOH pretreatment and without pretreatment was evaluated in digester patch reactor.

The overall objectives of this study are the following:

1. To investigate how the pomegranate peels (PP) when we mix it with rice husk (Rh) can affect on biogas production.
2. Studying NaOH pretreatment of biogas production on rice husk (Rh) and pomegranate peels (PP).

2. Materials and Methods

2.1. Sample collection

The organic wastes used in the anaerobic patch reactors whereas follow

a-Rice husk (Rh) obtained from an agricultural land in the south of Iraq, called AL-Meshkhab.

b-Pomegranate peels (PP) were collected from the pomegranate extraction manufactures in Baghdad that has stock piled it as waste.

c-The rumen fluid was used as inoculums, that was in fresh condition was obtained from slaughterhouse in Alyarmouk, Baghdad, Iraq. We use inoculums rather than without inoculums to shorten decision time before preprocess activities on rice husk (Rh) and pomegranate peels (PP) wastes so to provide appropriate feed for the digestion, first step, dried and then smash and homogenous particle size of 2-6 mm according to Forester Carneiro *et al*. [16].

2.2 Data collection

Before starting the experiment, the carbon and nitrogen content of rice husk (Rh) and pomegranate peels (PP) were tested using established techniques [17], and the parameters measured are listed in table 1. The C/N ratio was determined.

Table 1. Characteristics of rice husk and pomegranate peels

Parameters	Rice husk waste (Rh)	Pomegranate peels waste (PP)
PH	--	3.9
C/N	62.43	22.59
Total organic Carbon (%)	36.21	30.5
Total KJedhal Nitrogen (%)	0.58	1.35
Moisture content (%)	0	0

2.3 Blank test (control)

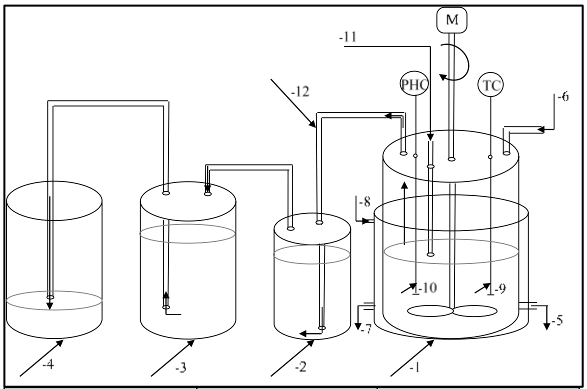
One of the goals of our research is to see how efficient pre-treatment is in improving traditional digestive efficiency. The blank test was used to investigate the improvement of digestion. It's anaerobic digestion at 35°C and pH 7 for 15 days with a retention period of 15 days.

2.4 Pretreatment process

The pre-treatment was performed by soaking rice husk (Rh) and pomegranate peels (PP) each one in a % NaOH solution flowing by 500 ml distilled water, stirred until normal pH, filtered and rinsed with running water until normal pH, then dried for one night. This rice husk (Rh) and pomegranate peels (PP) know was ready to digest in bio reactor for 15 days.

2.5 Experiment Procedures

Figure 1 depicts the experimental setup conceptually. We utilized one batch enclosed anaerobic bio reactor with a capacity of two liters. The jacketed reactors were all started up at the same time, and the digestion took place at the ideal temperature of 36°C and pH of 6.5. (7). The temperature is monitored online using a calibrated sheeted type T thermocouple inserted from the top of the reactor. The thermocouple was calibrated with a mercury thermometer before use in the experiments. The temperature change in the biomass medium was displayed on a 95 cm digital display board. The temperature in the reactor was maintained at 36oC (+1) in all tests by using a water bath. The pH was set at the optimal value of 7 using a sensor Direct pH probe [18]. To begin with, N2 was supplied to the reactor in order to remove air (oxygen) [19]. The raw material (a combination of 500 ml inoculums and 500 gm dry sample passed through the reactor with the addition of 500 ml distilled water) was then added. In a jacketed bio reactor, the mixture was digested for 15 days. Organic matter was constantly mixed at a rate of 10 rpm with a Heidolph stirrer motor of type 5011 RZO to produce temperature distribution and maintain a consistent pH [20]. The resulting gas combination was then washed with a concentrated basic solution of NaOH (10 N), with the acid gases (H2S, CO2) trapped by NaOH and the residual gas (methane) flowing up to the gas collector. Three times a week, the NaOH solution was changed. The pressure created by digestion displaces an equivalent volume of water into a calibrated cylinder, and the volume of water collected reflects the volume of methane gas generated.



1- Anaerobic Jacketed Reactor	5- Sampling Hole	9- Temperature Sensor
2- Acid Gas Scrubber	6- Inlet Hole	10- pH Probe
3- Gas Collector	7- Water Outlet Hole	11- Acid/Base Inlet Hole
4- Calibrated Cylinder	8- Water Inlet Hole	12- Plastic Tube Connection

Figure 1: Schematically representation of experimental apparatus.

3. Results and Discussion

3.1 The effect of NaOH pretreatment on biogas generation

One of the aims of this study is to show the effect of NaOH pre-treatment on the anaerobic digestion of rice husk (Rh), pomegranate peels (PP) and on a mixture of both them. By observing figure 2 (a, b, c) it can be found that biogas production from pre-treated samples with 3% NaOH has the highest value thorough 15 days of digestion. Chemical pre-treatment for rice husk, pomegranate peels and the mixture of them produced (2007, 2560, 2309 ml) respectively of cumulative biogas after 15 days of anaerobic digestion. Table 2 listed the amount of biogas ascending from the first days to final day of digestion. While the samples without treatment produced lowest value through 15 days of digestion (1923, 2526, 2246 ml) respectively cumulative biogas production.

The results were obtained in agreement with Chandra et al[20] .'s research, which says that the addition of NaOH enhances the hydrolysis process, which increases the quantity of biogas produced. Furthermore, NaOH pre-treatment might expedite the process of lignocellulose content degradation because lignin molecules can occupy the fermentation process carried out by microorganisms, necessitating the pre-treatment [19, 20, 9]. According to the findings of the study, the addition of NaOH had a greater influence on biogas output than the absence of pre-treatment. Table 2 shows the results of the digestion studies after 15 days.

Table 2. Results of laboratory experiments

days	**(Biogas production ml)**		**(Biogas production ml)**		**(Biogas production ml)**	
	Rh Without NaOH	**Rh With NaOH**	**PP Without NaOH**	**PP With NaOH**	**Rh + PP Without NaOH**	**Rh + PP With NaOH**
1	200	172	255	250	250	220
3	210	215	260	261	259	250
5	222	214	273	280	269	273
7	223	251	285	292	275	288
9	239	255	340	343	290	299
11	255	285	355	360	293	310
13	280	289	363	372	300	325
15	294	326	395	402	310	350
Accumulated biogas (ml)	1923	2007	2526	2560	2246	2309

4.2 Effect of pomegranate peels addition when mixed with rice husk on biogas production

The results, as we can see in table 2. The sample of rice husk alone with pre-treatment and without showed the lowest cumulative biogas production (2007, 1923 ml respectively) during 15 days of anaerobic digestion. Because of the high lignin concentration and the presence of indigestible polymers non the substrate, rice husk digestion is difficult. Materials containing a high concentration of lignin, such as rice husk, must be prepared before digestion using a variety of techniques (mechanical, physicochemical, and biological) or multi-stage digestion [21]. A high C/N ration might potentially contribute to rice husk's poor digestion. Rice husk had a C/N ratio of (62.43), which is considerably below the optimum range for anaerobic fermentation (20-30) [22]. The best results of all experiment were achieved with pomegranate peels alone for both samples which pre-treated and not pre-treated with NaOH. (2309, 2246 ml respectively) of cumulative biogas production which is higher that rice husk alone, this phenomenon could be related to many factors such a good C/N ratio for pomegranate peels in addition the pomegranate peels with a loose and soft structure, exposed more interaction area with the inoculum and was easily digestible [23] when we mix pomegranate peels with rice husk in equal ration 1:1, the results showed that the accumulated biogas production increase to (2560, 2526 ml) during 15 days for both samples (pre-treated with NaOH and not pre-treated) respectively which is also higher than rice husk alone. This was almost due to optimal C/N ration in these mixture in comparison with rice husk alone. Therefore, the digester was expected to be at an optimal condition for biogas production when we mix pomegranate peels with rice husk [24].

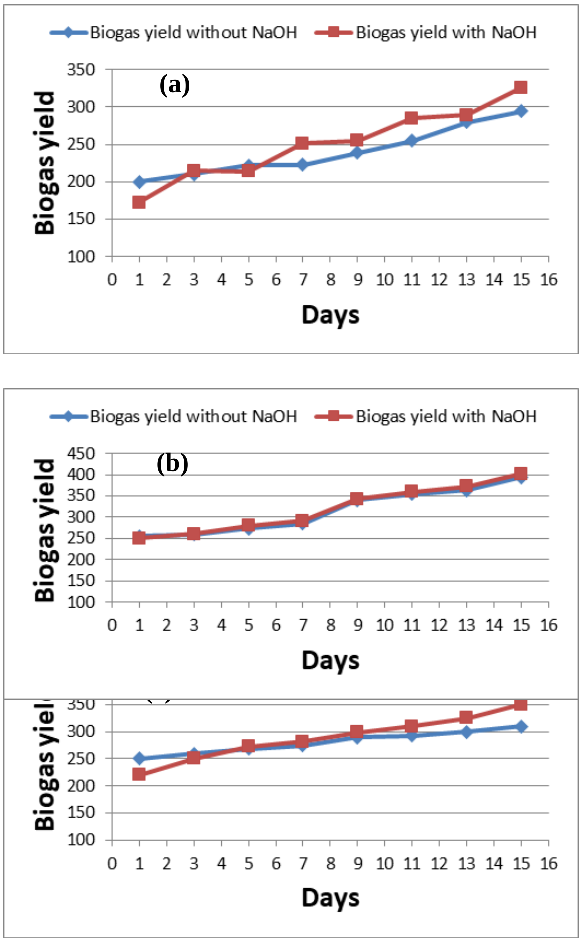


Figure 2. biogas yield during 15 days for :(a) Rice husk sample. (b) pomegranate peels sample. (c) mixture of rice husk & pomegranate peels sample.

Conclusions

This investigation revealed that anaerobic digestion of Rh is difficult. Rh, with its high lignin concentration and high C/N ratio, is a less appropriate material for single substrate anaerobic digestion due to its poor biogas and methane output. The anaerobic digestion of Rh with PP increased the energy potential of Rh, but the methane output of all mixtures was lower than the methane yield of 100% PP substrate. The (NaOH) chemical pretreatment technique can improve methane production. In regions where rice cultivation is prevalent, the digestion of Rh with PP might be an excellent chance to combine energy generation with trash management.

References

[1] I. M. Alfa, S.O. Dahunsiso, O.T. Iorhemen, C.C. Okafor, S.A. Ajayi. Comparative evaluation of biogas production from poultry droppings, cow dung and lemon grass. Bioresource Technol.157 (2014) 270. https://doi.org/10.1016/j.biortech.2014.01.108

[2] E.H. Sims. Biomass and resources bioenergy options for a cleaner environment in developed and developing countries, Elsevier Science, London, UK, (2004). https://doi.org/10.1016/B978-0-080-44351-5.X5000-4

[3] R.O. Taha, A.H.Saban. Effect of yltrasonic pretreatment on pyrolysis of microalgae. AIP conference proceedings 2190 (2019) 020027. https://doi.org/10.1063/1.5138513

[4] M. Taherdanak, H. Zilpuei. Improving biogas production from wheat plant using alkaline pretreatment. Fuel 115 (2014) 714. https://doi.org/10.1016/j.fuel.2013.07.094

[5] M.A. Dareioti, S.N. Dokinakis, K. Stametelstou, C. Zafiri, M. Kornaros, Exploitation of olive mill waste water and liquid cow manure for biogas production, Waste manage. 30 (2010) 1841. https://doi.org/10.1016/j.wasman.2010.02.035

[6] S. Cahaiprapat, T. Laklam. Enhancing digestion efficiency of POME in sequencing batch reactor with ozonation pretreatment and cycle time production. Bioresour Technol. 102 (2011) 4061. https://doi.org/10.1016/j.biortech.2010.12.033

[7] B. Yang, C.E. Wyman. Effect of xylan and lignin removal by batch and flow through pretreatment on enzymatic digestibility of corn stover cellulose : Biotechnol. Bioeng. 86(1) (2004) 88. https://doi.org/10.1002/bit.20043

[8] A.Teghammar. Biogas production from lignocelluloses : PhD Thesis : chalmers University of Tchnology. https://publications.lib.chalmers.se/records/fulltext/176194/176194.pdf

[9] Y. He, Y. Pang, X. Li, Y. Liu, R. Li, M. Zheng. Investigation of the change of main composition and extractives of rice straw pretreatment with NaOH for biogas production energy fuels, 23 (2009) 2220. https://doi.org/10.1021/ef8007486

[10] R. Alvarez, G. Lidèn. Low temperature anaerobic digestion of mixtures of lama, cow and sheep manure for improved methane production. Biomass and Bioenergy 33(13) (2009) 572. https://doi.org/10.1016/j.biombioe.2008.08.012

[12] M.A. Dareoti, S.N. Dokianakis, J. Stamatelatou, C. Zafiri, M. Kornavos. Exploitation of olive mill waste water and liquid cow manure for biogas

production, Waste manage 30 (2010) 1841. https://doi.org/10.1016/j.wasman.2010.02.035

[13] R. Chandra, H. Takeuchi, T. Hasegawa. Methane production from lignocellulosic agricultural crop wastes : a review in context to second generation of bio fuel production. Renewable and sustainable energy reviews 16(3) (2012) 1462. https://doi.org/10.1016/j.rser.2011.11.035

[14] V.A. Ezekoye, B.A. Ezekoye. Characterization and storage of biogas produced from the anaerobic digestion of cow dung, spent grains, cow dung, and cassava peels, rice husk. Pacific journal o science and technology 10(2) (2009) 898. http://repository.unn.edu.ng:8080/xmlui/handle/123456789/6251

[15] V.A. Ezekoye, C.E. Okeke. Design construction, and performance evaluation of plastic biodigester and the storage of biogas. Pacific journal o science and technology 7(2) (2006) 176. https://doi.org/10.1155/2020/1848714

[16] T. Forstez–Carreivo, M. Pèrez, L.I. Romero. Influence of total solid and Inoculum contents on performance of anaerobic reactors treating food waste. Bioresour Technol 99 (2008) 6994. https://doi.org/10.1016/j.biortech.2008.01.018

[17] L.S Clescerl., A.E. Green brg, A.D. Eaton. Standard Methods for Examination of water & waste water (20th ed.), Washington, D.C. (1999).

[18] M.R. Salsabil, A. Prorot, M. Casellas, and C. Dagot. Pretreatment of activated sludge : Effect of sonication on aerobic and anaerobic digestibility. Chemical engineering Journal 148(2-3) (2009) 327. https://dx.doi.org/10.1016/j.cej.2008.09.003

[19] J. Kim, Ch. Park, T. Kim, N. Lee, S. Kum, S. W. Kim, and J. Lee. Effect of various pretreatments for enhanced anaerobic digestion with waste activated sludge. Journal of bioscience and bioengineering 95(3) (2003) 271. https://dx.doi.org/10.1016/j.cej.2008.09.003

[20] R.Chandra, H. Takeach, T. Hasegawa. Hydrothermal pretreatment of rice straw biomass : A potential and promising method for enhanced methane production. APPl Energy, 94 (2021) 129. https://dx.doi.org/10.1016/j.apenergy.2012.01.027

[21] M.A. Millet, A.J. Baker, L.D. Satter. Physical and chemical pretreatment for enhancing cellulose sacchaification. Biotech Bioeng. Symp 6 (1976) 125.

[22] A. J.Ward, P.J. Hobbs, P.J. Holliman, D.L. Jones. Optimization of the anaerobic digestion of agricultural resources. Bioresource Technology 99 (17) (2000) 7928. https://doi.org/10.1016/j.biortech.2008.02.044

[23] X.Jiang, J. Hayashi, Z. Y. Sun. L. Yang , Y. Q. Tang, H. Oshibe, N. Osaka, H. Kida. Improving biogas production from protein – rich distillery waste water by decreasing ammonia inhibition. Process bio chem. 48 (2013) 1778. https://doi.org/10.1016/j.procbio.2013.08.014

[24] W. Qu, Z. Pan, R. Zhang, H. Mam., X. Cahr, B. Zhu, Z. Wang, G. G. Atungulu. Integrated extraction and anaerobic digestion process for recovery of nutracenticals and biogas from pomegranate marc. Transactions of the ASABE (American Society of Agricultural and Biological Engineers) 52(6) (2009) 1997. https://doi.org/10.13031/2013.29196