Effect of various thermochemical pretreatment methods on the biomethanisation of hemp (*Cannabis sativa*) hurd and kinetic analysis

Alpcan Arıç [1] , Sadık Can Karagöz [1] , Tuba Ceren Öğüt [1] , S. Tuğçe Dağlıoğlu [2] , Gözde Duman [3] , Jale Yanık [3] , Nuri Azbar *[1]

[1] Faculty of Engineering, Bioengineering Department, Ege University, Izmir, Turkey

[2] Center for Environmental Studies, Ege University, Izmir, Turkey

[3] Faculty of Science, Department of Chemistry, Ege University, Izmir, Turkey

*Corresponding author. E-mail address: nuri.azbar@ege.edu.tr (N. Azbar), Faculty of Engineering, Bioengineering Department, Ege University, Izmir, Turkey, Phone:00902323115816, 00902323115385

Statement of Novelty

The effect of pretreatments on biogas production potential based on changes in chemical structure was investigated for hemp hurd for the first time. Lignocellulosic wastes with similar cellulose, hemicellulose and lignin contents of two plant species which were grown in the same location by the same cultivation methods were used to investigate the effect of the genotype factor on BMP of lignocellulosics.

Introduction

Hemp is a plant which almost all components have a specific economic value including its roots, flowers, leave, seed and stalk (fiber and hurd). The hurd is the residual part after fiber processing. The hurds consist of 40–48% cellulose, 18–24% hemicellulose and 2124% lignin. Today, hurd is mostly used as construction materials [30]. However, given the increasing demand for biofuels, hurd can also be used as a source for bioenergy. Biogas production from hurd as a feedstock is one of these alternatives. Yet, the high lignin content of hurd induce low accessability to organics for biodegradation. For this reason, pretreatment is necessary. Therefore, an evaluation of the pretreatment conditions for hurd a new feedstock is required since the optimization of those depends on the biomass nature and composition.To the best of our knowledge, there are only two studies including biogas production from hurd. In one of them, co-digestion of hurd with cheese whey was studied without pretreatment.In this study, the effect of pretreatment methods (acid, alkali and thermal) on the biomethane production performance of two different hemp hurds was investigated. For this purpose the changes in chemical structure of pretreated hurds were evaluated. In addition, influential kinetic models predict CH_4 production from hurd were applied.

2. Materials and methods

2.1. Raw materials

In this study, the hurds subject to work were obtained from two varietis of hemp, namely Narlısaray (NS) and Futura 75 (F), from Samsun area located in the north part of Turkey. The harvest yields of hemp hurds are 69,6 kg/ha and 43,3 kg/ha for NS and F, respectively. Hemp stalks, which were collected separately from leaves and inflorescences during harvest, were separated into fiber and hurd by mechanical processing. Then, the hurd was ground the particul size of < 6 mm.

2.2. Pretreatment of Hurds

In this study, chemical pretreatment, thermal pretreatment and their combinations were performed. In chemical pretreatment, two types of alkaline (NaOH and KOH) and acids (H_3PO_4 and H_2SO_4) were used. H_2SO_4 and H_3PO_4 were selected for acidic pretreatment because sulfuric acid widely available and is relatively inexpensive, and phosporic acid is a source of phosphorus which would be beneficiary for anaerobic digestion. . Varying concentrations of acid and alkaine soluıtions(0.1, 0.5, and 1 M of acid/alkaline solutions) were tested to determine the optimum pretreatment technique and achieve the best economic balance.

2.3. Batch digester start-up and experimental design

Biochemical methane production potential of the pretreated hurd was performed by the BMP procedure in 100 mL amber bottles, as described by Owen et al.

2.5. Kinetic analysis

Widely used. first-order kinetic model and modified Gompertz model and modified Gompertz model were applied and tested to understand the impact of the pretreatment techniques as a function of hemp varieties tested

3. Results and discussion

In this study, the effects of different pretreatment methods on the biochemical methane potential (BMP) of hurds from two hemp species, namely, Narlısaray (NS) and Futura 75 (F), were investigated. The effect of pretreatment on BMP was discussed on the basis of the change in the chemical constituents of the raw material. The highest BMP yields of 272 mL CH_4/g VS (F) and 218 mL CH_4/g VS (NS) were obtained when the combined alkaline and thermal pretreatment was applied which resulted in the highest amount of hemicellulose degradation. (143% for alkaline and 74% for thermal, respectively, higher than those from raw hurds). It was found that BMP yields and the efficiency of pretreatment for two hemp species depended on genotypes, not on the content of chemical constituents of raw material. Additionally, the first-order kinetic model and the modified Gompertz model were simultaneously used to estimate the CH_4 yield results of hurd and the model parameters. The first-order kinetic model resulted in the best fit [$R^2 \geq 0.96$; root mean square error (RMSE) ≤ 0.225] with predicted yield for untreated control , in, while for pretreated hurds, the modified Gompertz model was the best fitting ($R^2 \geq 0.98$; RMSE $\leq$ 0.503).

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Declarations

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