Effect of heat treatment on hydrogen production by combined fermentation of wild carp and excess sludge

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Abstract. A lignocellulose-rich biomass, the wild carp can be efficiently hydrolyzed into reducing sugar after a certain degree of pretreatment, and it is used as a high-quality raw material for the development and utilization of biomass energy such as fuel ethanol and hydrogen. In this study, the wild carp was pretreated at 50 °C, 60 °C, 70 °C, 80 °C, and 90 °C to investigate the effects of different heat treatment temperatures on the hydrogen production of wild mash and excess sludge mixed fermentation, and analyzed by gas chromatography. The experimental results show that when the pretreatment temperature is 70 °C, the gas production is the highest, 216mL, the highest hydrogen production is 43.01mL, and the hydrogen concentration is up to 20.73%.

1. Introduction

With the intensification of the energy crisis, countries around the world have accelerated the development of biomass energy [1-2], including bio-hydrogen, biogas, fuel ethanol and so on. As a renewable energy source, lignocellulose is hydrolyzed to produce reducing sugars such as glucose and xylose, and anaerobic fermentation of reducing sugars can produce biohydrogen. However, the binding of lignin components to cellulose causes a decrease in reducing sugar production, which affects fermentative hydrogen production. Therefore, the substrate needs to be pretreated before fermentation to remove the lignin from the surface of cellulose and hemicellulose to achieve the effect of removing lignin [3-8]. The wild carp is rich in sugar and fiber materials, which can be used for fermentative hydrogen production. The anaerobic fermentation gas production technology can realize the recycling of resources and energy in the wild carp. The excess sludge contains a large amount of microorganisms and is rich in organic matter such as protein and polysaccharide[9]. Therefore, in this experiment, the excess sludge and wild carp are used as substrates to study the hydrogen production test after pretreatment of wild carp at different temperatures, in order to obtain wild carp. The best heat treatment method provides certain technical support for the utilization of...
biomass energy in the wild donkey.

2. Experimental materials and methods

2.1 Experimental materials
The experimental wild donkey was collected from a village in Xiamen. The remaining sludge was taken from a sewage treatment plant in Xiamen. The sludge was stored at 4 °C, and the residual sludge solids ratio (TS) was about 3%.

2.2 Wild carp pretreatment method
The dried wild cockroaches were dissolved in 30 mL of distilled water and placed in a constant temperature water bath at 50 °C, 60 °C, 70 °C, 80 °C, and 90 °C, water bath for 30 min, and then cooled to room temperature under natural conditions.

2.3 Hydrogen production test of combined sludge and wild carp
The pre-treated residual sludge and wild carp fermentation hydrogen production test was carried out in a 250 mL Erlenmeyer flask, and the pH of the substrate was adjusted to neutral before the sludge fermentation. Take 250 mL of excess sludge and an appropriate amount of wild scorpion in an Erlenmeyer flask, and purge the Erlenmeyer flask with nitrogen for 5 min to remove excess oxygen and quickly seal the device. The sealed conical flask was placed in a constant temperature water bath and anaerobic fermentation was carried out at 37 °C. The fermentation gas was collected and analyzed by the drainage method. The experimental setup is shown in Figure 1.

![Figure 1] Experimental device schematic
1-fermented bottle; 2-linked glass elbow; 3-drainage bottle and gas collection device; 4-measuring cylinder; 5-sampling port; 6-constant water bath

2.4 Gas Chromatograph Composition Analysis of Fermentation Gas
The composition of the fermentation gas was analyzed by Agilent Technologies 7890B GC System gas chromatograph. The column type was 5A and the diameter was 3mm × height 2mm. The parameter setting was: column temperature 50 °C, injector temperature 50 °C, thermal conductivity detector. The temperature was 120 °C, the carrier gas was helium, and the flow rate was 30 mL/min. The concentration of hydrogen gas was measured.

3. Experimental results and analysis

3.1 Effect of heat treatment method on hydrogen production from wild carp fermentation
Pretreatment of wild carp was carried out at different temperatures of 50 °C, 60 °C, 70 °C, 80 °C, and 90 °C to investigate the effect of temperature on gas production. The experimental results are shown in Table 1.
Table 1. Effect of different temperature on hydrogen production by combined fermentation of wild carp and excess sludge [not a three-line table]

| temperature(℃) | gas production (mL) |
|----------------|---------------------|
| 50             | 156.5               |
| 60             | 175.5               |
| 70             | 216                 |
| 80             | 175.5               |
| 90             | 171                 |

It can be seen from Table 1 that when the temperature is 50 °C, the gas production is 156.5 mL, the gas production is 175.5 mL when the temperature is 60 °C, the gas production is 216 mL when the temperature is 70 °C, and the gas production is 80 °C. 175.5 mL; when the temperature is 90 °C, the gas production is 171 mL. The gas production increases with the increase of temperature. When the temperature is 70 °C, the gas production reaches the highest. As the temperature continues to rise, the gas production begins to decrease.

3.2 Gas chromatograph analysis of the composition of the fermentation gas

The composition of the fermentation gas was analyzed by gas chromatography to study the effect of different temperatures on the hydrogen production after pretreatment. The experimental results are shown in Figures 2, 3, 4, 5 and 6.

Figure 2. Gas composition analysis at 50 °C

Figure 3. Gas composition analysis at 60 °C

Figure 4. Gas composition analysis at 70 °C

Figure 5. Gas composition analysis at 80 °C
Figure 6. Gas composition analysis at 90 °C

The experimental results show that when the temperature is 50 °C, the hydrogen concentration is 13.867%, the hydrogen production is 21.7mL; when the temperature is 60 °C, the hydrogen concentration is 16.857%, the hydrogen production is 29.58mL; the temperature is 70 °C, the hydrogen concentration was 20.73%, the hydrogen production was 43.01mL, the hydrogen concentration was 15.441%, the hydrogen production was 27.10mL, the hydrogen concentration was 13.992%, and the hydrogen production was 23.93mL. With the increase of temperature, the activity of hydrogen-producing bacteria gradually increases. When the temperature is 70 °C, the activity of hydrogen-producing bacteria is the best. As the temperature continues to rise, the high temperature destroys the structure of hydrogen-producing bacteria and denatures the hydrogen-producing bacteria. Thereby affecting the amount of hydrogen produced.

4. Conclusion [The conclusion is best to have two points, write an introduction in front]

(1) The experimental results show that different temperatures have a certain effect on the hydrogen production by co-pretreatment with residual sludge fermentation. With the increase of temperature, the gas production gradually increases. When the temperature reaches 70 °C, the gas production reaches the highest. At 216 mL, as the temperature continues to rise, the gas production begins to decrease.

(2) Analysis of the fermentation gas by gas chromatograph shows that the hydrogen concentration increases with the increase of temperature. When the temperature reaches 70 °C, the hydrogen concentration reaches 21.73%.

5. References

[1] Mehdí Mehrpooya, Maryam Khalili, Mohammad Mehdí Moftakhari Sharifzadeh. Model development and energy and exergy analysis of the biomass gasification process (Based on the various biomass sources)[J]. Renewable and Sustainable Energy Reviews, 2018, 91.

[2] Carlos Rodríguez-Monroy, Gloria Mármol-Actores, Gabriel Nilsson-Cifuentes. Electricity generation in Chile using non-conventional renewable energy sources-A focus on biomass[J]. Renewable and Sustainable Energy Reviews, 2018, 81.

[3] Parameswaran B, Karri S, Raveendran S, et al. Short duration microwave assisted pretreatment enhances the enzymatic saccharification and fermentable sugar yield from sugarcane bagasse[J]. Renewable Energy, 2012, 37: 109-116.
[4] Raveendran S, Mathiyazhakan K, Parameswaran B, et al. Dilute acid pretreatment and enzymatic saccharification of sugarcane tops for bioethanol production[J]. Bioresource Technology, 2011, 102:10915-10921.

[5] Yadhu N G, Joelle D C, Florence H, et al. Comparison of some new pretreatment methods for second generation bioethanol production from wheat straw and water hyacinth [J]. Bioresource Technology, 2011, 102:4416-4424.

[6] Anita S, Narsi R B. Enzymatic hydrolysis optimization of microwave alkali pretreated wheat straw and ethanol production by yeast[J]. Bioresource Technology, 2012, 108:94-101.

[7] Xia Ao, Cheng Jun, Song Wenlu, et al. Enhancing enzymatic saccharification of water hyacinth through microwave heating with dilute acid pretreatment for biomass energy utilization [J]. Energy, 2013, 61:158-166.

[8] Paula A P, Albino A D, Irene F, et al. Influence of ligninolytic enzymes on straw saccharification during fungal pretreatment [J]. Bioresource Technology, 2012, 111:261-267.

[9] Guo L, Liu H, Li X, et al. Bioproduction of volatile fatty acids from excess municipal sludge by multistage countercurrent fermentation[J]. Chinese Journal of Biotechnology, 2008, 24(7):1233-1239.

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