EFFECT OF THERMO-CHEMICAL PRETREATMENT ON VEGETABLE WASTES (CABBAGE AND POTATO) FOR BIOGAS PRODUCTION

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ABSTRACT

The paper reported thermochemical pretreatment effect (5 min) on vegetable wastes like cabbage and potato for production of biogas. The vegetables were hydrolyzed by dilute sulphuric acid in an autoclave at pH 4 for 5 min at 121°C temperature and 15 psi pressure followed by acetogenesis and methanogenesis with 8 days of retention time resulted high biogas production with higher conversion efficiency. The results showed that the cumulative methane yield for cabbage and potato were 510 mL and 330 mL, respectively per 100 g of each total solid.

Keywords: Biogas, Cabbage, Methane, Pretreatment, Potato, Thermo-chemical

I.INTRODUCTION

Energy crisis has augmented research in newer thrust areas [1]. It is observed that globally around one third amount of supplied food for human consumption gets wasted due to several reasons[2]. India stands second in the production of fruits and vegetable in the world. It produces ~50 MT of vegetable waste which is ~ 30% of its total production as they decay easily [3]. Indian farmers cultivate vegetables like cabbage, potato etc. but they get minimum profit due to several problems like lack of preservative systems, food processing industries and maximum cost of production. This vegetables waste create environmental problem. Natural decomposition of vegetables produces marsh gas (methane) [4,5]. Methane is responsible for global warming [6]. But vegetables are enriched with carbohydrate which can be used for biogas production. Potato and cabbage wastes are difficult to degrade for bioenergy production. Very few works has been done using potato and cabbage [7-9]. Methane is an alternative source of energy. Different thermochemical pretreatment on several wastes were studied by few authors [10-16]. But, in acidic pretreatment very low amount of chemicals are utilized. Production of glucose by acidic hydrolysis facilitatesmethane production by batch digestion. It has been reported that the biogas production can be increased by addition of human urine as a biocatalyst [17-20].

So, objective of the present study was effective utilization of vegetable waste (cabbage and potato) using thermochemical pretreatment method with minimum cost to produce optimum methane.

II.MATERIALS AND METHODS

2.1 COLLECTION AND PREPARATION OF RAW MATERIALS

Cabbage and potatoes were collected from local market. These vegetables were washed with water, dried and cut into pieces.

2.2 PRETREATMENT METHOD (HYDROLYSIS)

Hundred gramcabbage was weighed by digital weighing balance and took into a conical flask. In the conical flask 300 mL of water was added. Required amount ofdilute sulphuric acid (N/10) was added into it by stirring with a glass rod till the pH of the mixture reached to 4. Then the conical flask was transferredinto anautoclave. By heating the mixture was digested in the autoclave. Five minute duration of digestion period was continued after attainment of 121°C temperature and 15 psi constant pressure. Similarly potato was pretreated for biogas production.

2.3 ACETOGENESIS

Each set was cooled to room temperature. Each digested mixture was treated with dilute sodium hydroxide (N/10) to increase the pH value 6.0. Each set was allowed to treat 5 days facultative condition to get volatile fatty acid.

2.4 METHANOGENESIS

Each digested waste was introduced into the digester fitted with gas burette and aspirator bottle (Fig. 1). Anaerobic digestion was done by adding 150 mL of human urine in each set of cabbage and potato wastes. The gas was collected by downward displacement of water [21]. Methane and carbon di oxide was measured by syringe method [22]. For that a syringe was fitted with a flexible tube and dilute sodium hydroxide solution was used for estimation of carbondioxide as sodium hydroxide absorbs carbon dioxide but does not absorb methane.

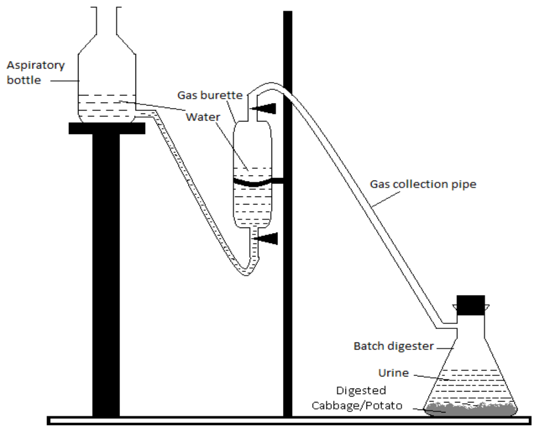


Fig. 1: Schematic diagram of digester set-up

2.5 STATISTICAL ANALYSIS

The significance in the change in methane productionin subsequent days was determined by one way analysis of variance (ANOVA) using IBM SPSS Statistics 20 software package. The data are presented as Means±StandardError. When significant (5% level) differences were observed, individual means were compared using Tukey's Post Hoc multiple comparison test.

III. RESULTS AND DISCUSSION

3.1 EFFECT OF PRETREATMENT

Initially the cabbage and potato were predigested for effective biogas production. Starch is most widely discussed in vegetable kingdom. It is often found in potato and seeds. It is made by two kinds of polymers of glucose. The simpler bond is called amylase which is a linear polysaccharide withα-1,4-glycosidic linkage (20% of starch). While 80% of starch is water insoluble fraction called as amylopectin which is a branch chain of polysaccharide with again α-1,4-glycosidic linkage (Fig 2.a &b). Raffinose is a tri-saccharide which is widely found in legumes and cruciferous vegetables like beans, peas, cabbage etc. It consists of galactose connected to sucrose via α-1,6-glycosidic linkage (Fig 2 c).

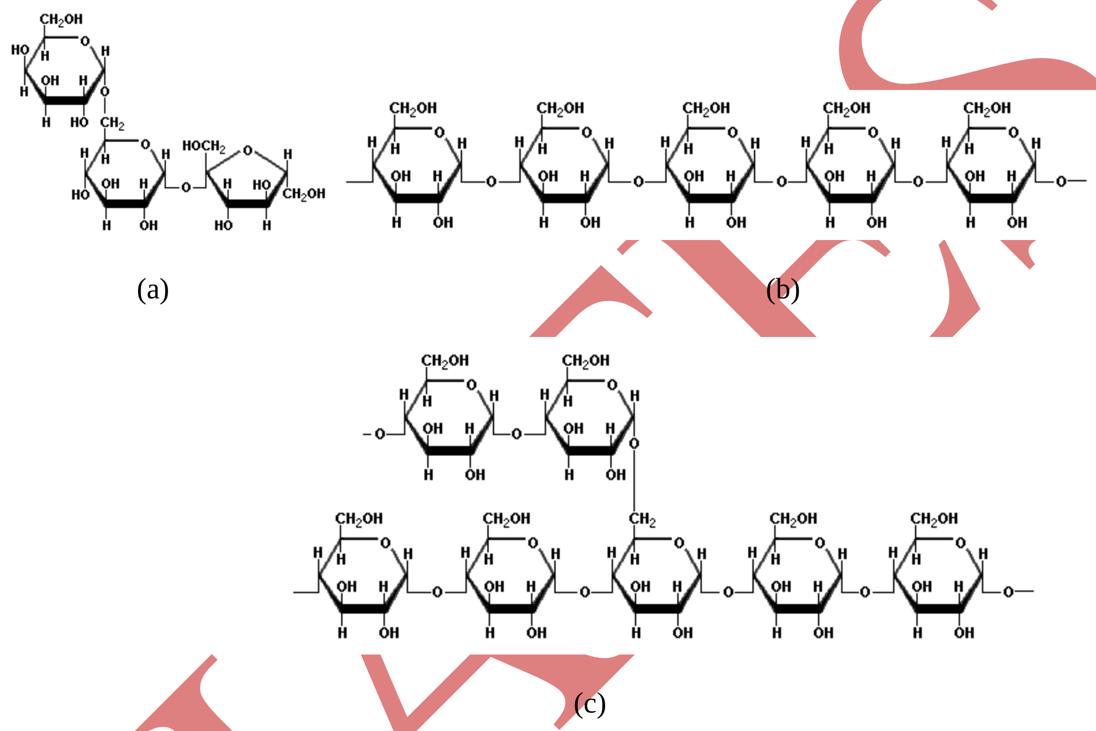


Fig. 2: (a) Raffinose (b) Amylose (c) Amylopectin

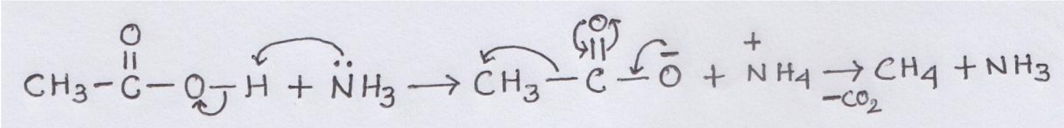
(Source: http://www.scientificpsychic.com/fitness/carbohydrates1.html)

Kinetic model of acid hydrolysis of potato starch at pH 3.0 produce glucose [23]. During digestion at high pressure and temperature with dilute sulphuric acid, the oxygen bridges are hydrolysed easily and glucose units are broken up. Thus the enhancement of hydrolysis process oncabbage and potato helps the acetogenesis as well as methanogenesisin the batch digestion.

3.2 DECARBOXILATION OF ACETIC ACID

Mechanism of decarboxylation of acetic acid using human urine in the methanogenesis step has been reported bySau et al. [18-20] as under.

$$\text{Urine} \xrightarrow{\text{deamination}} NH_4 \quad (1)$$



(2)

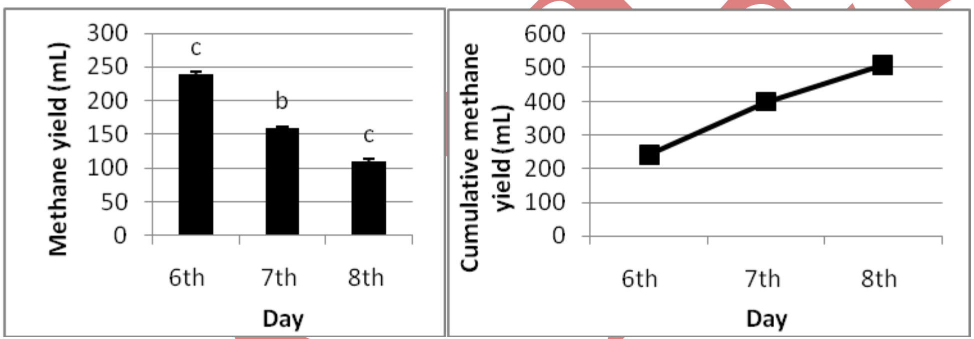
Similar observation was reported by Haque and Haque (2006) who increased 30% production of biogas by addition of human urine.

3.3 EFFECT OF PRETREATMENT ON DAILY AND CUMULATIVE METHANE PRODUCTION

The daily methane production of pretreated cabbage is shown in Fig. 3(a). It shows that the methane gas production started on 6th day and finished on 8th day. The maximum amount of methane was 240 mL on 6th day and minimum amount was 110 mL on 8th day.

The result of this study implies that the thermochemical pretreatment improved the biodegradability of cabbage, facilitating its use by anaerobic microorganisms, resulting the less time required for complete digestion. The gradual decrease of methane production is due to decrease of substrate concentration.

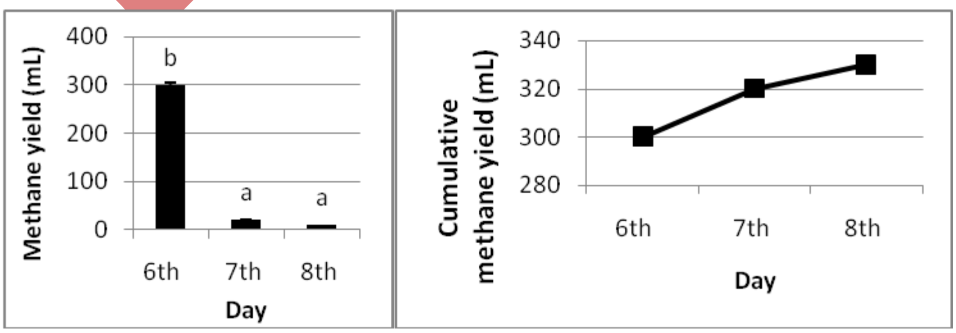
The cumulative methane yield for cabbage was 510 mL/100 g total solid (TS) which is shown in Fig. 3(b).



(a) (b)

Fig 3. (a) Daily methane production and (b) cumulative methane production from pretreated cabbage; *n*=3;Vertical bars indicate errors of means

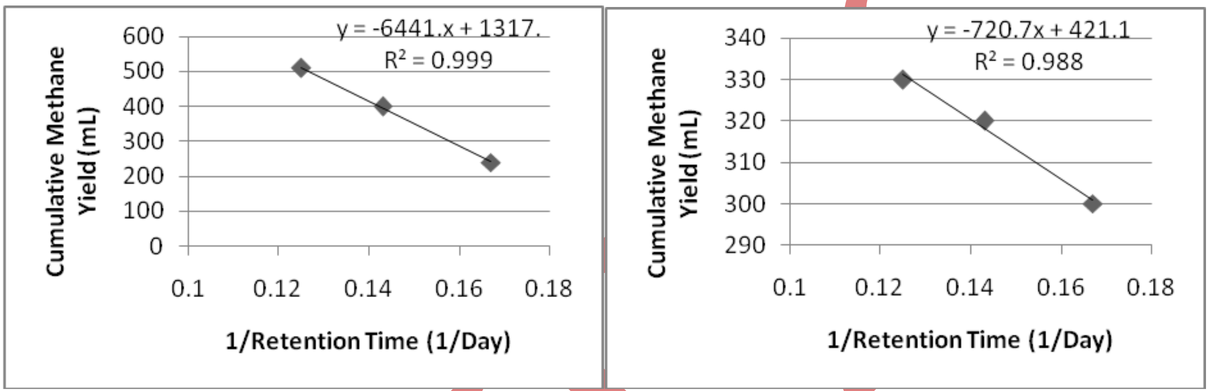
The daily methane production and cumulative methane production from potato are shown in Fig. 4 (a) and 4(b), respectively.The maximum and minimum methane production from potato were 300 mL and 10 mL, while the cumulative methane production from potato was 330 mL/100 g TS. The possible explanation is same as stated in cabbage. But there was low production of methane in potato as comparison to cabbage. Because it is difficult to cleave more number of glycosidic linkage in potato where as it is easy to break less number of glycosidic linkage in cabbage in the hydrolytic stage.



(a) (b)

Fig 4: (a) Daily methane production and (b) cumulative methane production from pretreated potato; *n*=3;Vertical bars indicate errors of means

Cumulative methane yield of cabbage and potato have been plotted against 1/retention time, keeping all other parameters constant which are shown in Fig. 5 (a) and 5 (b), respectively. The figures show linear relationship of methane yield with 1/retention time. Ultimate values of methane yield (B_0) of the samples represent the retention time approaches infinity. B/B_0 termed as biodegradability constant, the same constant as stated by Chen and Hashimoto [24]. Ultimate methane yield could be calculated by extra plotting the graph where 1/retention time approached zero and their values for cabbage and potato were nearly 1317 mL / 100 g TS and 421 mL / 100 g TS, respectively. It indicated that ultimate methane yield was dependent on composition of the wastes digested on infinite retention time.



(a) (b)

Fig. 5: Plot of methane yield of (a) cabbage and (b) potato with inverse retention time (1/Day)

IV.CONCLUSION

In the present study biogas production from cabbage and potato was tried by using efficient pretreatment method. The finding of the study ensured that the production of methane gas from cabbage and potato wastes were enhanced by pretreatment method and the biogas was obtained within a short period. The method was cost effective. Due to more glycosidic linkage in potato, the biogas production from potato was less as compared to cabbage.

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