

IMPROVEMENT OF ANAEROBIC DIGESTION OF RICE STRAW USING WET – MILLING PRETREATMENT APPROACH

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ABSTRACT

As rice production continues to rise in order to provide a stable food source for over half of the world's population, so rice straw will continue to be an abundant and accessible agricultural waste. Rice straw is a widely available lignocellulosic waste with potential for energy recovery through anaerobic digestion. Lignin slows the hydrolysis phase, resulting in low methane recovery and long digestion periods. Pretreatment with wet milling was tested in contrast with grinding rice straw and control one without rice straw, as a technique for enhancing the anaerobic digestion. Two mixtures were used, M1 containing grinded rice straw and M2 containing wet milled rice straw and the both were inoculated with seed sludge and kept under thermophilic conditions (55°C) with dry fermentation (total solids, TS%) over 20. Control vials were used with only seed sludge. Two batch cultures lasted for 35 days for each. The results showed that wet milling seems to enhance methane production from rice straw with maximum production of 1493.98 ml/g-vs compared with 387.7 ml/g-vs from grinded one. Methane percentage was ranged from 48 to 55%. Acetate production was low ranged from 0.74 to 0.93mM/kg mixture which meant success of methane production. Thermophilic condition was used at 55°C which in contrast to previous study enhance the degradation. Methane potential from grinded rice straw, wet milled rice straw, and glucose as reference was 234, 230, and 338 l/kg vs respectively.

Keywords: Dry anaerobic-digestion, Methane production, Rice straw, Wet-Milling, Pretreatment, Thermophilic.

INTRODUCTION

Rice is the most important staple food consumed daily by at least half of the world's population, including all Asian countries, most of West and North Africa, some countries in East and Central Africa (Sreepada and Vijayalaxmi, 2013). The Food and Agriculture Organization of the United Nations (FAO) estimated that a total of 679 million tons of rice were produced in 2009 (FAOSTAT, 2011), which equates to approximately 916 million tons of rice straw available for energy production (Kadam *et al.*, 2000).

Egypt has a large rural population whose major energy source was biofuel (crop residue and fuel wood). However, rapid economic development has increased rural access to commercial energy, and the use of biofuel is decreasing. As a result, crop residue is not in such high demand as fuel, so it is increasingly burned in the crop fields (El Saidy, 2011).

The issue that contributed to formation of smoke cloud over Egypt that always in parallel to the period of rice straw burning by farmers in the delta Governorates especially Dakahlya, Sharkia, and Kalyobia (Moussa and Abdelkhalek 2007) in a phenomenon called (Black cloud). Akmal *et al.* (2011) estimated the amount of rice straw produced annually in Egypt by 3.5 million tons.

A major problem with burning of rice straw in the fields is the incomplete combustion of the burning nature which result in emission of large amounts of smoke and other pollutants into the atmosphere, including toxic gases (CO₂, carbon monoxide (CO), volatile organic compound (VOC), fine/inhalable particles and carcinogenic polycyclic aromatic hydrocarbons as recorded by (Kim Oanh *et al.*, 2005), which accelerates increase in atmospheric temperature and can cause global warming. In addition to their effects on ambient air hygiene it poses a public health hazard as the smoke from biomass burning has been shown to be potentially toxic (Kim Oanh *et al.*, 2002). Due to health and environmental concerns, many countries have imposed new regulations restricting field burning activities (Mansaray *et al.*, 1999). Therefore, there

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were a lot of trials suggested several alternatives methods of rice straw uses instead of its burning. Van Nguu (2000) mentioned that the most traditional uses of rice byproducts includes straw and hull were used for energy, animal feed, building materials and paper production. Mansour *et al.* (2007) suggested recycling of rice straw with a mixture of cement not only forms a sustainable low cost building material, but could also reduce air pollution. In addition to these benefits, the straw could act as a thermal insulation material for the unpleasant Egyptian weather. Another potential use of rice biomass for energy production can be utilized worldwide; even in the developing countries is the conversion of rice residues into the clean-burning fuel through anaerobic digestion. The issue which represents an important trend for Egypt, in the present time where Egypt is facing a high population growth rate, rising fuel costs and much need for clean fuel sources for generation of heat and /or electricity. During the anaerobic digestion process, microorganisms convert biomass into biogas, a mixture of methane and carbon dioxide with trace amount of other gases like carbon monoxide and hydrogen, in the absence of oxygen (Ondrej and Dagmar, 2013). The produced biogas can be used as fuel to generate heat and/or electricity. Furthermore, the digestate can be used as a good organic fertilizer (Chandra *et al.*, 2012). The most important challenges and limitations in the process of converting rice straw to biogas are mainly related with high Carbon/Nitrogen (C/N) ratio or low hydrolysis performance and digestibility because of high lignin content and its complex, stable and recalcitrant lignocellulosic structure (Chen and Lei, 2008). Therefore, it needs a further balance of nutrients and destructive pretreatments. Pretreatment is a key process for accomplishing efficient enzymatic hydrolysis of lignocellulosic biomass, and it has been subject of many studies (Sun and Cheng, 2002; Mosier *et al.*, 2005; Alvira *et al.*, 2010). Among the pretreatment methods used wet milling method is described as an energy saving pretreatment method (Endo *et al.*, 2008 and Hiden *et al.*, 2009). The advantages of this pretreatment method were include its environmental-friendly nature given only water that used as a carrier; it is effective for enzymatic hydrolysis, and has a low energy consumption compared with conventional ball milling (Hiden *et al.*, 2009; Yanagida *et al.*, 2009). As little research has been conducted to examine the effect of direct biogasification of rice straw under anaerobic condition which is still important and promising, especially in rural areas of developing countries. So the objective of this study was to assess the availability of direct anaerobic digestion of rice straw with anaerobic sludge, and to examine the effect of wet milling pretreatment on methane yield and biogasification characteristics of rice straw during semi-continuous batch culture under thermophilic condition.

MATERIALS AND METHODS

1. Seed sludge

The seed thermophilic methanogenic sludge used in the study was collected from a wastewater treatment center in Hiroshima, Japan. The digested excess sludge referred to as sludge in this article is a digested sludge obtained after the fermentation of methane by thermophilic anaerobic digestion of excess activated sludge (Nishio and Nakashimada, 2007). This sludge was anaerobically incubated at 55°C for 60 days in the laboratory to achieve complete consumption of the substrate, in order to be used as inoculum or seed sludge. The sludge was stored at the refrigerator with -4°C before use and its Characteristics were summarized in Table 1.

2. Biomass used in the study

2.1 Rice straw

Rice straw used in this study was collected from field at Fukushima prefecture; in Japan in 2013. The air dried rice straw was cut into small pieces and further milled to powder, by grinding with a hammer mill and fraction passed 250µm mesh. Its Characteristics were summarized in Table 1.

2.2 Treated Rice straw

Rice straw was treated with a wet-milling method, using a bead mill with 4L of volume (LME4, Tsukuba, Japan), to accelerate methane production that was developed by Ohtuka and Nakamura in Forestry and Forest Products Research Institute, Japan (Hiden *et al.*, 2009). Its character was summarized in Table 1.

3 Batch Experimental design

3.1 First batch

3.1.a Mixture 1 (M1) using Grinded rice straw

Mixture 1 (M1) was used to measure methane production from grinded rice straw, 80g of the seed sludge was mixed with 4g rice straw, 1g NaHCO₃ and 16g Milli Q water. The mixture was filled into 700 ml anaerobic vials. The headspace of the bottle was filled with nitrogen gas to achieve anaerobic condition and the anaerobic vials were statically set at the incubator with 55°C. Simultaneously, the control culture without rice straw was also carried out. The triplicate culture was performed for each experiment. The character, conditions, ratios and experimental setup of M1 are illustrated in table 2. TS and VS of M1 content were illustrated in table 3. (Abouelenien *et al.*, 2010).

3.1.b Mixture 2 (M2) using treated rice straw

Mixture 2 (M2) was used to measure methane production from rice straw treated with wet-milling method, 80g of the seed sludge was mixed with 20g treated rice straw and 1g NaHCO₃. The mixture was filled into 700 ml anaerobic vials. The headspace of the bottle was filled with nitrogen gas to achieve anaerobic condition and the bottle was statically set at

the incubator with 55°C. Simultaneously, the control culture without rice straw was also carried out. The triplicate cultures were performed for each experiment. The characters, conditions, ratios and experimental setup of M2 were illustrated in table 2. TS % and VS% of M2 content were illustrated in table 3. (Abouelenien *et al.*, 2010).

3.2 2nd batch

3.2.a Mixture 1 (M1) using Grinded rice straw

At the end of first batch which was reached when gas production stopped, the anaerobic vials were opened and 20g of the first batch M1 was mixed with 1g grinded rice straw and 4 ml Milli-Q water. The mixture was filled into 500 ml anaerobic vials of total volume. The headspace of the bottle was filled with nitrogen gas to achieve anaerobic condition and the bottle was statically set at the incubator with 55°C. Simultaneously, the control culture without rice straw was also carried out. The triplicate cultures were performed for each experiment (Abouelenien *et al.*, 2009).

3.2.b Mixture 2 (M2) using treated rice straw

At the end of the first batch which reached when gas production stopped, the anaerobic vials were opened and 20g of the first batch M2 was mixed with, 5 g pretreated rice straw.

The mixture was filled into the bottle with 500ml of total volume. The headspace of the bottle was filled with nitrogen gas to achieve anaerobic condition and the bottle was statically set at the incubator with 55°C. Simultaneously, the control culture without rice straw was also carried out. The triplicate culture was performed for each experiment. (Abouelenien *et al.*, 2009).

4. Analytical methods

Fermentation samples (ca. 0.3 g wet weight) were withdrawn into 2-ml plastic tubes and suspended with 1.2 ml deionized water. The suspension was centrifuged at 3,000 rpm for 10 min at 4 °C, and the clear supernatant was used for measurement of VFAs. VFAs were measured using High Performance Liquid Chromatograph (Shimadzu, Kyoto, Japan) that was equipped with Aminex HPX-87H Column, 300mm x 7.8mm (Bio-Rad, Tokyo, Japan). The column temperature was 65 °C. The flow rate was 0.8 ml min⁻¹ for 0.005 M H₂SO₄ solution, used as a mobile phase. Total solids (TS) and Volatile solid (VS), were measured in accordance with the standard methods (APHA, 1998). To measure total solids in the organic matter, the sample was put on the glass filter (GS-25, ADVANTEC, 47mm) and dried more than 24 h at 80°C and weighted. Then, the dried sample was treated at 600°C for 3h, and then weighted to measure volatile solids (APHA, 1998).

Gas production was measured periodically by displacement of saturated aqueous NaCl in a

graduated cylinder. The compositions of CH₄, H₂, and CO₂ were determined by a gas chromatograph (GC-8A, Shimadzu) with a thermal conductivity detector equipped with a glass column (2m x 3 mm) packed with unibeads C 60/80 (Shimadzu) at 140°C. Argon was used as the carrier gas at a pressure of 100kPa. (APHA, 1998).

Calculation of methane potential

Methane production was calculated as the volume of methane produced per unit weight of straw TS or VS loaded. The cumulative methane production by the stems and leaves of each variety was fitted with the modified Gompertz equation using the solver function in Microsoft Excel:

$$M = P \times \exp \left\{ -\exp \left[\frac{R_m \times e}{p} (\lambda - t) + 1 \right] \right\} \quad (\text{Feng } et al., 2013)$$

Where M is the cumulative methane production (ml), t is the incubation time (days), λ is the lag phase (days), P is the methane production potential (ml), R_m is the methane production rate (ml/d) and e is the exponential index.

RESULTS

The substrate characterization, composition, and concentrations in grinded rice straw, wet-milled rice straw and seed sludge, were shown in Tables 1 and 3. On a dry matter (TS) basis, wet milled rice straw contained higher VS than Grinded rice straw and seed sludge; the VS % content of wet milled rice straw was 87%, compared to that of grinded rice straw that was 85%.

The course of daily biogas production was illustrated in Fig.1 with peak of production observed in the 3rd day of first batch for all treatments. With highest amount obtained from Wet-milled pretreated rice straw (M2), 240 ml/g-VS/d followed by grinded (M1), 132.2 ml/g-VS/d, and finally control (59.9 ml/g-VS/d). While in the 2nd batch there were two peaks of biogas production from both M1 and M2, the first peak observed in 1st day, (the 36th day of the total course), with 161,5 and 899.47 ml/g-vs/day from M1 and M2 respectively. The 2nd peak was reached at 12th d (48th day of the total course) with 228 and 806 ml/g-vs/d from M1 and M2 respectively. Additionally it was observed that in the 2 batches gas production was higher in the beginning of each batch and then decreased toward the end of the batch with higher biogas yield in the 2nd batch than the first.

The results of cumulative biogas yield were illustrated in Fig. 2a for Grinded, pretreated and control, the highest amount was obtained from M2 in both 1st and 2nd batches, with values of 860 and 3267 ml/g-vs respectively.

The methane content was measured every day, and the average methane content in each group was 55.4, 48 % and 24% for M2, M1 and control respectively. The other components of biogas were Carbon dioxide, Hydrogen and Nitrogen. Fig2.b illustrated the cumulative methane production from all mixtures during 1st and 2nd batches under thermophilic (55C°) conditions. Highest cumulative methane was obtained at the end of the 2nd batch from M2 (1493.98 ml/g-vs), with about 4 times as that obtained from M1 (387.7 ml/g-vs).

The changes in water content, total solid percentage (TS %) and Volatile solid percentage (VS%) during Anaerobic Digestion of rice Straw from M1 and M2

in initial and final of 1st and 2nd batch were illustrated in table 5. TS% was decreased from 20.9 to 20% and from 18.9 to 16.3% in initial and final of 1st and 2nd batches of M1, and from 20.4 to 19.7% and from 19.5 to 19.2% in initial and final of 1st and 2nd batch of M2 respectively. On the other hand VS% was decreased from 65 to 57.73% and from 77.8 to 67.17 % of M1 1st and 2nd batch respectively, and from 66.9 to 64.3% of M2 1st and 2nd batch respectively.

Table. 6 illustrated the potential methane production from grinded, wet milled, and glucose as reference was 234, 230, and 338 l/kg vs respectively.

Figures caption

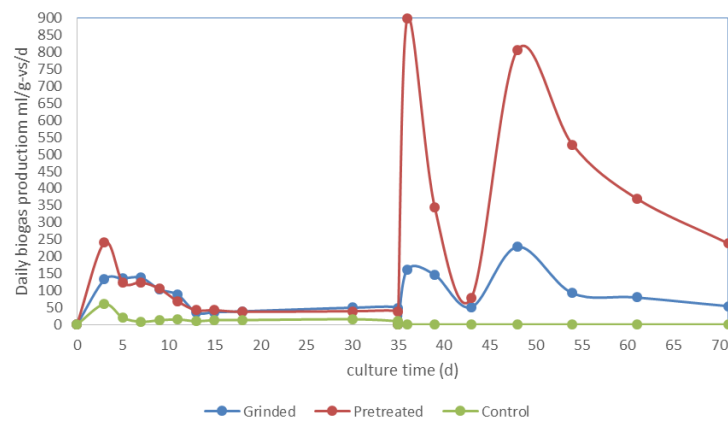


Fig. 1: Daily biogas production from dry anaerobic digestion by repeated batch culture of M1 Containing Grinded rice straw or M2 containing pretreated rice straw (by wet milling). Seed sludge was used as inoculum. Fermentation temperatures were 55 °C (thermophilic). Duration of batch I was 35 days; batch II was 35 days (fixed culture time).

Fig. 2a

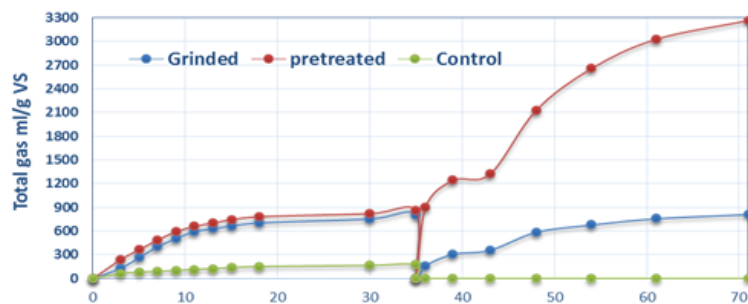


Fig. 2b

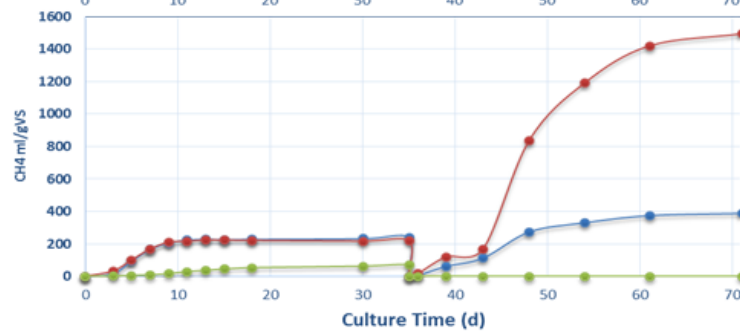


Fig. 2 (a,b): Cumulative biogas and Methane production from dry anaerobic digestion by repeated batch culture of M1 Containing Grinded rice straw or M2 containing pretreated rice straw (by wet milling). Seed sludge was used as inoculum. Fermentation temperature was 55 °C (thermophilic). Duration of batch I was 35 days; batch II was 35 days (fixed culture time).

Table 1: Characteristic of rice straw and seed sludge used in the present study.

Parameter	Rice straw	Rice straw treated with a wet-mill	Seed sludge
Total Solids, % (w/w)	98.3	82.7	78.5
Volatile Solids, (g/g-TS)	0.85	0.87	0.857

Table 2: Rice straw pretreatment conditions and Experimental setup that used in the present study.

Mixture	Pretreatment condition	seed sludge: Rice straw (volume basis)	Temperature (C)
M1	Grinded alone	4 : 1	55
M2	Wet milling	4 : 1	55
Control	-	1: 0	55

M1: Mixture was used to measure methane production from grinded rice straw.

M2: Mixture was used to measure methane production from rice straw treated with wet-milling method.

Table 3: Feed substrate characteristics in the present study.

Mixture	Pretreatment condition	TS%	VS% of TS
M1	Grinded alone	20.9	65.01
M2	Wet milling	20.4	64%
Control	-	17.45	60.6

M1: Mixture was used to measure methane production from grinded rice straw.

M2: Mixture was used to measure methane production from rice straw treated with wet-milling method.

TS %: Total solids %

VS%: Volatile solids %

Table 4: Methane Yields (in terms of VS) from Anaerobic Digestion of Rice Straw

Methane Yield (L/Kg VS added)	Type of pretreatment	Digestion Temp (°C)	Time period (d)	References
46	Cut (1cm)	35	92	Mussoline <i>et al.</i> (2013)
231	Codigestion with pig waste water	35	189	Mussoline <i>et al.</i> (2012)
302-340	Cut (1cm), Codigestion with pig waste water & paper Mill Sludge	35	92	Mussoline <i>et al.</i> (2013)
195	Cut (50-100 mm)	40	40	Dinuccia <i>et al.</i> 2010
280	Cut (3-5)	22	120	Lei <i>et al.</i> 2010
215	Pulverized	35	120	El-shinnawi <i>et al.</i> 1989
190	2% NH ₃	35	24	Zhang and zhang 1999
198	Cut (25mm) + 2% NH ₃	35	24	Zhang and zhang 1999
245	Ground (25mm), 2% NH ₃ , preheated to 110C	35	24	Zhang and zhang 1999
273	Cut/ pre-digested with biogas sludge for 46 hrs	26-28	146	Sun <i>et al.</i> 1987
224 [#]	Cut/ delignified	30	63	Ghosh (1999)
328 [#]	Cut/ delignified/white rot fungi	30	63	Ghosh (1999)
296 [#]	Cut/ delignified/brown rot fungi	30	63	Ghosh (1999)
240	Cut/ white rot fungi	18-28 (Ambient)	89	Lianhua <i>et al.</i> (2010)
93	Milled/white rot fungi	25	59	Lianhua <i>et al.</i> (2010)
124	Milled/white rot fungi	35	59	Lianhua <i>et al.</i> (2010)
388	Grinded Rice straw	55	71	Current study
1494	Wet milling Rice straw	55	71	Current study

VS%: Volatile solids %

Table 5: Changes in water content, TS% and VS% and during anaerobic digestion of rice straw with different experimental conditions.

	Grinded rice straw				Wet milling			
	1 st batch		2 nd batch		1 st batch		2 nd batch	
	Initial	final	Initial	final	Initial	final	Initial	final
Water content	79.1	79.97	81.07	83.7	79.6	80.3	80.5	80.8
TS%	20.9	20.03	18.93	16.3	20.4	19.7	19.2	19.5
VS%	65.01	57.73	67.17	77.8	64	59	66.9	64.27

TS %: Total solids %

VS%: Volatile solids %

Table 6: Properties of methane production of tested biomass.

Biomass	Methane potential (ml/g-VS)	Max. methane production rate (ml/g-VS/d)	Delay time (d)
Grinded rice straw	234	44	2.8
Grinded rice straw with wet-milling	230	38	2.2
Glucose (as a reference)	338	40.4	3.6

VS%: Volatile solids %

DISCUSSION

Two semi continuous batch cultures were conducted to evaluate the process of anaerobic digestion of rice straw. The whole duration of biogas production lasted 35 days for each batch. The biogas production increased rapidly in the initial time and then decreased by the end of each batch in all mixtures. The methane percentages (55.4, 48 % and 24% for M2, M1 and control respectively) were lower than that obtained by Abouelenien *et al.* (2010) and Magbanua *et al.* (2001). As protein rich substrates such as Poultry manure, hog wastes and sewage sludge produced higher methane percentage than that obtained from carbohydrate as the main component of rice straw is complex carbohydrate in the form of cellulose, hemicellulose and lignin (Angelidaki and Sanders 2004).

The rice straw as a substrate with high lignin content, inappropriate C/N ratio, and high total solids content can be easily anaerobically digested only when it is pretreated (Cundr and Haladová; 2014). Wet milled pretreated rice straw (M2) showed highest biogas and methane yield if compared with control and grinded rice straw (M1), this could be explained as follow; rice straw is a lignocellulose containing primary cellulose and hemi-cellulose which is difficult to degrade using conventional anaerobic digestion processes. The degradation of lignocelluloses into biogas is a complicated process, since lignocelluloses have a recalcitrant structure which is naturally designed to prevent enzymatic degradation (Demirel

and Scherer; 2011 and Niu *et al.*, 2013). Lignocellulose formed in a compact and crystalline structure and often contain a high amount of lignin. In order to permit degradation of these materials in an anaerobic digester, the structure has to open up and/or the lignin has to be degraded or removed. Pretreatment of rice straw by mechanical size reduction and/or wet milling improves its digestion (Zhang and Zhang, 1999; Sun and Cheng, 2002; Mosier *et al.*, 2005 and Alvira *et al.*, 2010). In the current study the produced methane was much higher than that produced from previous work as illustrated in table 4.

Anaerobic digestion was performed under dry condition with TS % of 20.9 and 20.4 for M1 and M2 respectively (table 3). Using thermophilic (55°C) condition of incubation as a new technique. Dry anaerobic digestion (water content 75%) has some benefits of using smaller reactor size and smaller wastewater treatment facility than those of conventional processes (Abouelenien *et al.*, 2009). Rice straw as a carbon rich substrate In contrast to organic nitrogen rich substrates, with which anaerobic digestion in dry condition proceeded at a lower efficiency due to the accumulation of ammonia (Koster and Lettinga 1984; Heinrichs *et al.*, 1990; Krylova *et al.*, 1997; Sung and Liu 2003), and will not show this problem. Temperature played an important role in determining both biogas yield and kinetics (Contreras *et al.*, 2012). Thermophilic temperature will enhance the degradation of rice straw and improve the anaerobic digestion by

methanogenic bacteria in the sludge (Buhr and Andrews 1977).

The C/N ratio of rice straw is very high which is not appropriate for anaerobic bacteria, (Forster-Carneiro *et al.*, 2007). To adjust the C/N to the preferred range 15–30 (Li *et al.*, 2013), sludge was added to rice straw. In the current study TS% of both mixtures were decreased by anaerobic digestion as illustrated in table 5. Also reduction in VS was observed in both mixtures after first and second batch.

VFA was measured at the initial and final of first and second batch, only acetate and propionate were detected in trace amounts. Acetate was detected in trace amounts not exceed the range of 0.74–0.93mM/kg-mixture. And this meant that all amounts of acetate produced were rapidly converted to methane and no acetate accumulation was observed. In all mixtures better performance of anaerobic digestion was observed in 2nd batch than the first one (table 5 and fig 2 a,b). This could be explained through the process of acclimatization which occurred to methanogens in seed sludge for the degradation of rice straw (Demirci and Demirer, 2004).

The decreased TS % and consequently VS % of M1 and M2 in 1st and 2nd batch (Table 5) indicated the degradation of rice straw organic matter to methane during the anaerobic digestion under different experimental conditions in the current study. This results were in compatible with that obtained by Contreras *et al.* (2012) and Cunderand Haladova (2014).

The Methane potential (MP) has been widely used to determine the methane yield of organic substrates in specific conditions (Owen *et al.*, 1979; Nallathambi, 1997; 2004; Luna-delRisco *et al.*, 2011). The methane potential, however, of untreated rice straw is on the lower end when compared to other agricultural biomasses and agro-industrial by-products. Several studies have been conducted to determine the ultimate methane yield of rice straw with various inocula, and the results range from 92 to 404 L/kg of VS added at ambient and mesophilic temperatures, (Dinuccio *et al.*, 2010; Lei *et al.*, 2010 and Lianhua *et al.*, 2010). There is considerable variation in methane yield of straw depending on the type of pretreatment, if any, and the digestion conditions (Moller *et al.*, 2004). The values of potential methane production from grinded, wet milled, and glucose as reference was 234, 230, and 338 l/kg vs respectively which located in the range that mentioned in the previous studies (Table. 6).

CONCLUSION

One of the major challenges with the digestion of rice

straw is the lignocellulosic structure that makes bacterial decomposition difficult. Wet milling was seemed to enhance methane production from rice straw with maximum production of 1493.98 ml/g-vs compared with 387.7 ml/g-vs from grinded one. Methane percentage was ranged from 48 to 55%. Acetate production was low and ranged from 0.74 to 0.93mM/kg mixture which was meant success of methane production. Thermophilic condition was used at 55°C which in contrast to previous study enhance the degradation. Methane potential from grinded, wet milled, and glucose as reference was 234, 230, and 338 l/kg vs respectively.

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تحسين الهضم اللاهوائي لقش الأرز باستخدام تقنية الطحن الرطب كمعالجة قبلية لزيادة معدل انتاج غاز الميثان كمصدر للوقود الحيوي

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يستمر انتاج الارز بالارتفاع من اجل توفير مصدر غذاء مستقر لاكثر من نصف سكان العالم. وما زال قش الارز من اكثر المخلفات الزراعية وفرة وسهولة في الحصول عليها وهو من اكثر المواد اللجنوسيلوزية انتشارا ووفرة من حيث امكانية الحصول علي الطاقة منها من خلال الهضم اللاهوائي. ولكن وجود اللجنين يساهم بشكل كبير في ابطاء عملية التحلل مما يؤدي الي انخفاض معدل انتاج الميثان ويطيل من فترات عملية الهضم لقش الارز. وفي هذا البحث تم اختبار معالجة قش الارز بالطحن الرطب كاسلوب لتعزيز عملية الهضم اللاهوائي ومقارنة بأسلوب الطحن الجاف فقط لقش الارز مع وجود التجربة الحاكمة بدون قش ارز واستخدام الحماة فقط. وتم استخدام اثنين من الخلائط 1M حيث تحتوي علي قش الارز الجاف المطحون فقط و2M تحتوي علي قش الارز المعامل بالطحن الرطب وكلا منهم تم اضافة الحماة لة كمصدر للبيكتريا المصنعة لغاز الميثان وتم ابقائهما تحت الظروف الحرارية العالية عند ٥٠ درجة مئوية تحت ظروف التخمر الجاف حيث يحتوي علي مجموع المواد الصلبة اكثر من ٢٠% وقد استمرت التجربة ٣٥ يوم واجريت علي مرحلتين من التخمر. اظهرت النتائج ان الطحن الرطب لقش الارز ساهم بشكل كبير في عملية انتاج غاز الميثان من قش الارز حيث وصل الي ٤٩٣ مل/جم من المواد الصلبة المتطايرة مقارنة بأسلوب الطحن الجاف فقط لقش الارز الذي اعطي غاز الميثان بمعدل ٣٨٧,٧ مل/جم مواد صلبة متطايرة وقد تراوحت نسبة الميثان الناتجة خلال هذا البحث من ٤٨-٥٥% وكما تراوحت نسبة الاسيتات من ٠,٧٤-٠,٩٣ مليمولار/كجم من الخليط مما يعني نجاح انتاج غاز الميثان ولقد اظهرت الظروف الحرارية عند ٥٥ درجة مئوية علي خلاف الدراسات السابقة انها عززت من انتاج غاز الميثان حيث ان الكمية القياسية المتوقعة لانتاج الميثان من قش الارز الجاف المطحون وقش الارز المعامل بالطحن الرطب والجلوكوز كمرجع هو ٢٣٤، ٢٣٠ و ٣٣٨ لتر/كجم من المواد الصلبة المتطايرة علي التوالي.