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Ensiling of Wet Rice Straw using Biogas Slurry and Molasses in Monsoon of Bangladesh

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Abstract

This paper presents an experiment of the preparation of ensilage with wet rice straw (WRS) treated with biogas slurry (BGS) and ensiled with molasses to increase the nutritional and preservation quality of straw in monsoon season of Bangladesh in the Department of Animal Science, Bangladesh Agricultural University (BAU), Mymensingh. Chopped wet straw was preserved in plastic containers under airtight condition at room temperature based on the treatments as T_0 (100% WRS only), T_1 (0% BGS), T_2(5% BGS), T_3 (10% BGS) and T_4 (15% BGS) with 5% molasses as DM basis in each treatment except T_0 to investigate physical quality, chemical composition, *in vitro* organic matter digestibility (IVOMD) and metabolizable energy (ME) content at 0, 30, 45, 60 and 90 days. The highest CP content was found to be 7.70% in T_4 and highest DM and EE content were found to be 31.42 and 4.86% in T_0 respectively. The lowest CP and DM content were found to be 4.02 and 21.94% in $T_{0,}$ respectively and lowest EE content was found to be 3.13% in T_4. The CP and DM were increased (P<0.05) and EE were decreased (P<0.05) with the increasing of ensiling time from 0 to 90 days. The highest OMD and ME content were found to be 48.46% and 6.98 MJ/Kg DM in $T_4$and the lowest OMD and ME content were found to be 34.31 and 4.84% in $T_{0,}$ respectively. The pH value was also decreased (P<0.05) with the increasing of BGS and ensiling time. Considering all the physical and chemical properties, among all the treatments, T_2 and T_3 are acceptable for preparing ensilage. Ensilage of WRS with biogas slurry will not only reduce waste disposal and pollution problem, but also provide inexpensive feed components for ruminants.

Keywords: Wet rice straw; Ensiling; Digestibility; Nutritive value; Metabolizable energy

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Introduction

Livestock is a very important component of the economy of Bangladesh which contributes about 1.66% to GDP and 14.21% to agricultural sector [1]. But a large numbers of animals are suffering from shortage of feeds both in quality and quantity. The available roughage and concentrate for feeding livestock can meet only 50 and 10%, respectively of the requirement [2]. The livestock is beset with innumerable problems such as inadequate feed supply, under nourishment, high incidence of diseases, improper management in one side and poor genetic makeup on the other side. As in many countries in the world, pressure on the available land in Bangladesh is increasing rapidly, due to a high rate of population growth, industrialization and rapid urbanization. Because of scarcity of land for human food production it is not possible to spare land exclusively for the production of livestock feed. Available feeds are sometimes fed without consideration of their quality or the requirements of the animals.

Straw based feed is the main feed in the aspects of Bangladesh which constitutes about 87% of the total dry roughage and 72% of total roughage [3]. Rice straw is the vegetative part of the rice plant (Oryza sativa L.), cut at grain harvest or after. Rice straw is a versatile by-product of rice cultivation as it is used in many ways including fodder for livestock and even as a building material. Rice straw consists predominantly of cell walls, comprised of cellulose, hemicellulose, and lignin. Cellulase, hemicellulase and ligninase are required to break down these components [4]. Straw is highly fibrous residue having low protein (CP <3%) content which mostly indigestible. The poor digestibility of straw is further caused by the presence of high amount of inhibitory mineral element called silica. Silica, one element of the rice cell walls, can be present in high concentrations ranging from 5% to 15%, depending on the rice variety [5] and the availability of this mineral in the soil [6]. The digestibility of straw can be improved with the treatment of chemical or biological agents to loosen its lignocellulose bond. Several studies have reported the physical, chemical characterization and utilization of rice straw as ruminant feed [7,8].

Cattle population in Bangladesh is 23.44 million [9]. Cow dung production in the country is about 85.41 million ton per year [10,11]. Huge amount of cow dung are not properly used and these are the cause of environment pollution. Biogas production from cattle manure is an efficient way of utilizing cow dung that produces not only fuel but also slurry, an effective soil amendment. But, the byproduct from a biogas plant, bio-slurry is not using properly and most of the cases causing environmental and social hazard by discharging it in public places though it rich in nutrients especially protein (16-20% CP) and produced through beneficiary anaerobic microorganisms.

Biogas slurry can be used in animal feed with other feed ingredients having high palatability. During the fermentation process in the biogas digester there may be the production of microbial proteins, and several simple molecules in the usable form [12].

In Bangladesh, farmers usually store rice straw in heaps after sun drying. However, due to heavy rainfall (337 mm), and high humidity (86%), they cannot dry their straw during monsoon (July to August). As a result, about 8 million tons of straw dry matters (DM) are usually rotten [13]. About 20-30% of Boro paddy straw is spoiled during monsoon due to heavy rainfall, insufficient sunshine and scarcity of labor which causes feed scarcity of cattle and also environmental hazard.

Ensiling wet rice straw with biogas slurry and molasses will increase crude protein and other nutritive value of the diet lowering the pH value and produce lactic acid producing bacteria which will facilitate the natural preservation [14].

The aims of this study are to know the nutritive value of biogas slurry and wet rice straw and find out a convenient option of utilization of biogas slurry and wet rice straw. In addition, the optimum proportion of biogas slurry and wet rice straw for preparation of ensilage are determined and also minimize the environmental pollution.

Materials and Methods

Collection of experimental materials

Biogas slurry and wet rice straw was collected from Sheep and Goat farm, Bangladesh Agricultural University (BAU), Mymensingh. Fresh biogas slurry was collected from biogas plant of Sheep and Goat farm. Enough care was taken during collection of the samples. Molasses and air tight plastic containers (30L size) were purchased from local market.

Preparation of ensilage

Ensilage was prepared in the Goat and Sheep farm, Department of Animal Science, Bangladesh Agricultural University, Mymensingh during the period from 20th December to 25th March, 2017. Rice straw was collected just after harvesting. After collecting wet rice straw were chopped about 3-4 cm long by chopper. Then ensilage was prepared by mixing previously chopped fodder with fresh biogas slurry in varying ratios; 95: 0, 90: 5, 85: 10, 80: 15 and 5% molasses in each treatment. For proper mixing, biogas slurry and molasses were mixed first and then finally mixed with straw. When straw were properly mixed with biogas slurry and molasses, these were placed into air-tight plastic containers which were previously marked according to the treatment. Finally, plastic containers were kept in a room for 90 days for successful ensiling.

Chemical analysis

pH of ensilage was determined by digital pH meter after putting 2g sample in 50 ml distilled water. Dry matter was determined by drying the ensilage at 65°C for 48 h. Crude Protein (CP) was measured using Kjeldahl method while other proximate constituents, ether extract (EE), ash, crude fiber (CF) and nitrogen free extract (NFE) according to procedures described by AOAC (2004). In vitro organic matter digestibility (IVOMD) and metabolizable energy (ME) content of ensilage were done following the method described by Menke *et al.* [15].

Statistical analysis

All data were statistically analyzed using SAS Statistical Discovery Software, NC, USA and differences among the treatment means were determined by Duncan's Multiple Range Test (DMRT).

Results and Discussion

Physical properties and pH of ensilage

The physical properties of the ensilage are shown in **Table 1**. All ensilages had pleasant aroma, desirable light brown color, soft texture and no mould growth was observed any of the ensilage, indicating optimum fermentation. A pleasing aroma and good color was obtained when poultry droppings were ensiled with maize forage [16], citrus pulp or weeds [17].

The pH is shown in **Figure 1** Significant differences (p<0.05) were observed among the treatments. After ensiling, the highest pH value was observed by treatment T_0 followed by T_1, T_2, T_3 and

Table 1 Chemical composition of biogas slurry and wet rice straw.

Chemical composition(g/100g DM)	Ingredients	
	Biogas slurry	Wet rice straw
Dry matter DM% (Fresh basis)	9.54	26.56
Organic matter (OM)	71.9	78.37
Crude Protein (CP)	14.4	3.01
Crude Fiber (CF)	21.27	31.56
Ether extract (EE)	1.23	4.43
Nitrogen free extract (NFE)	31.53	31.74
Ash	22.23	14.32

T_4. It was observed that pH value decreased with the increase level of biogas slurry. The lower pH of ensilage indicates good fermentation quality which was due to presence of higher water soluble carbohydrates in fodder that enhanced lactic acid production [18]. Ensiled materials should reach a pH of less than 5 in order to destroy Salmonella and other pathogens [19]. In the present studies, pH values lower than 5 were attained in all ensilage.

Chemical composition of ensilage

DM contents of different ensilages are presented in **Table 2**. It was observed that Dry Matter (DM) content (g/100g) of ensilage differ significantly (p<0.05). The highest DM was obtained in T_0 followed by T_1, T_2, T_3 and T_4. The DM at different treatments T_0, T_1, T_2, T_3 and T_4 were found 31.42, 30.72, 29.37, 28.65 and 27.69% respectively. The reason of decreasing the DM content in the study may be due to decomposition and fermentation. Losses of DM may come from run off, oxidation and loss of volatile organic compounds [20].

Crude protein composition of the silage was increased with increased proportion of BGS **(Table 2)**. The highest (7.70%) CP content was found in T_4 and the lowest (4.02%) CP content was found in T_0. The CP content differ with the addition of biogas slurry (p<0.05). Maize stover ensiled broiler litter for 6 weeks and found that CP was increased with increased proportion of poultry litter [21]. The crude protein of sorghum forages ensiled with broiler litter increased with increased proportion of poultry litter [22,23]. Ensiled rice straw with poultry litter at different ratios and recorded the highest crude protein in ratio 50:50 [24].

Crude fiber composition of the silage was decreased with increased proportion of BGS **(Table 2)**. The CF content of different treatments (T_0, T_1, T_2, T_3 and T_4) of ensilage was 22.53, 21.13, 20.16, 20.17 and 20.09%, respectively. In the present experiment the value of CF was higher (22.53%) in controlled T_0 than treated (T_1, T_2, T_3 and T_4) wet rice straw but the differences between T_2, T_3 and T_4 were not statistically significant (p>0.05). The CF content

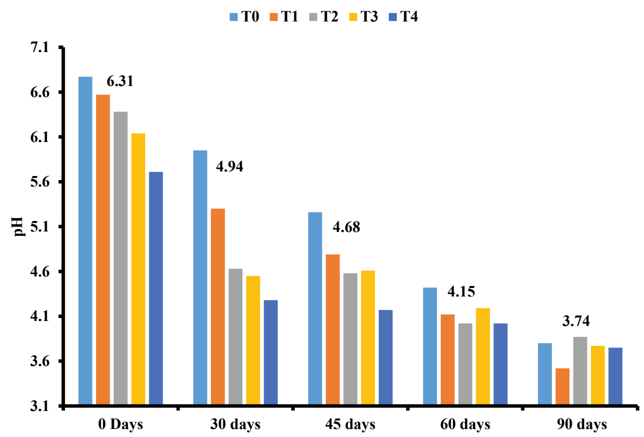


Figure 1 Changing pattern of pH values of different ensilage.

Table 2 Physical properties of ensilage at different levels of biogas slurry.

Parameters	Ensilage with different percentage of biogas slurry				
	0% (control 1)	0% (control 2)	5%	10%	15%
Color	Light Brown	Light Brown	Brown	Brown	Brown
Aroma	Good	Good	Acceptable	Molasses smell	Pungent smell
Texture	Hard	Soft	Soft	Soft	Very soft
Mould	Absent	Absent	Absent	Absent	Absent

0% (control 1) = Only WRS, 0% (control 2) = WRS and 5% molasses, 5% = WRS+ 5% BGS+ 5% molasses, 10% = WRS+ 10% BGS+ 5% molasses, 15% = WRS+ 15% BGS+ 5% molasses

was decreased from 22.53 to 20.09% with the addition of BGS (0 to 15%). When Kyasuwa hay (*Pennisetum pedicellatum*) ensiled with poultry litter, CF was decreased from 20.46% in treatment 80:20 to 15.95% in 50:50[25]. The reason of CF decrease may be due to addition of biogas slurry which contain lower CF than rice straw and also indicated the higher decomposition of wet rice straw ensiling with the addition of bio-slurry [26].

Ether extract components of ensilages were not significantly (p<0.05) different among the treatment groups **(Table 2)**. The EE content of different treatments (T_0, T_1, T_2, T_3 and T_4) of ensilage was 4.86, 4.55, 3.39, 3.35 and 3.13%, respectively. It was observed that EE was decreased with the addition of biogas slurry but the differences between T_2, T_3 and T_4 were not statistically significant (p>0.05). The highest EE was obtained by treatment T_0 followed by T_1, T_2, T_3 and T_4. It might be due to the lower EE content of biogas slurry and higher decomposition of wet rice straw. The result of this study is similar to [25] indicated that, when Kyasuwa hay (*Pennisetum pedicellatum*) ensiled with Poultry litter, EE declined with increased proportion of poultry litter.

The Ash content composition of the silage was decreased with increased proportion of BGS **(Table 3)**. The Ash content of different treatments (T_0, T_1, T_2, T_3 and T_4) of ensilage was 7.21, 6.37, 4.57, 4.36 and 3.96%, respectively. The Ash content was decreased significantly (p<0.05) with the increase of BGS. It might be due to utilization of ash for the microbial growth during the ensiling period. A linear increase in ash with increased proportion of broiler litter was observed [22,23]. The ash content of silage increases up to 28 days of ensiling [27].

In vitro organic matter digestibility of ensilage

The in vitro organic matter digestibility (OMD) differed significantly (p<0.05) due to different levels of BGS **(Figure 2)**. The OMD content of different treatments (T_0, T_1, T_2, T_3 and T_4) of ensilage was 34.31, 39.49, 40.29, 45.03 and 48.46%, respectively. It showed that the highest *in vitro* OMD was observed in T_4 and the lowest was in T_0. The increase in *in vitro* organic matter digestibility of rice straw ensiled with animal excreta and rumen digesta was observed [28].

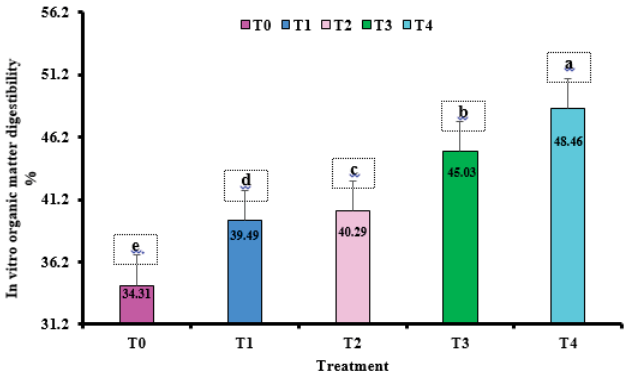
Metabolizable energy content of ensilage

Metabolizable energy content of ensilage is shown in **Figure 3**

Table 3 Chemical composition of wastage at different level of Biogas Slurry, Parameters (%) Wastelage with different percentage of Biogas Slurry.

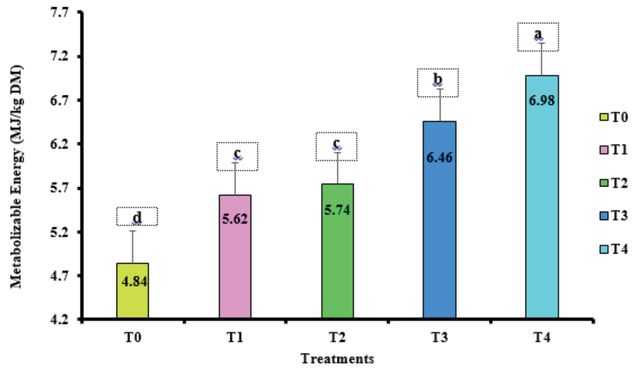
DM basis	T_0	T_1	T_2	T_3	T_4	TTT_4	60%
Dry matter (Fresh basis)	31.42^{a} ± 0.51	30.72^{b} ± 0.04	29.37^{c} ± 0.04	28.65^{d} ± 0.05	27.69^{e} ± 0.04		37.34^{a} ± .03
Crude protein	4.02^{e} ± .043	4.30^{d} ± .032	6.47^{c} ± .030	6.75^{b} ± .039	7.70^{a} ± .033		18.95^{a} ± .12
Crude fibre	22.53^{a} ± .04	21.13^{b} ± .048	20.16^{c} ± .047	20.17^{c} ± 0.049	20.09^{c} ±.037		17.81^{d} ± .02
Ether extract	4.86^{a} ± .042	4.55^{b} ± .034	3.39^{c} ± .017	3.35^{c} ± .048	3.13^{c} ± .023		3.05 ± .01
Ash	7.21^{a} ± .037	6.37^{b} ± .045	4.57^{c} ± .040	4.36^{d} ± .038	3.96^{e} ± .048		14.45^{a} ± .03

*Means with different superscripts within row and column are significantly different (P<0.05)
T_0=100% wet rice straw, $T_{1=}$5% molasses + 95% wet rice straw, T_2 =5% BGS + 5% molasses + 90% wet rice straw, T_3 = 10% BGS + 5% molasses + 85% wet rice straw, T_4 =15% BGS + 5% molasses + 80% wet rice straw



To=100% WRS, $T_{1=}$5% molasses + 95% WRS, T_2 =5% molasses + 5% BGS +90% WRS, T_3 =5% molasses $_+$ 10% BGS + 85%WRS, T_4 = 5% molasses + 15% BGS + 80% WRS. Bar represents mean ± SD. a, b, c, d, e values with different superscripts differ significantly (p<0.05) among treatments.

Figure 2 *In vitro* organic matter digestibility (%) of ensilage at different level of Biogas Slurry.



T_0=100% WRS, $T_{1=}$5% molasses + 95% WRS, T_2 =5% molasses + 5% BGS +90% WRS, T_3 =5% molasses $_+$ 10% BGS + 85%WRS, T_4 = 5% molasses + 15% BGS + 80% WRS. Bar represents mean ± SD. a, b, c, d, e values with different superscripts differ significantly (p<0.05) among treatments.

Figure 3 Metabolizable Energy (MJ/kg DM) of ensilage at different level of biogas slurry.

The values for metabolizable energy (ME) content (MJ/Kg DM) of ensilage differed significantly (p<0.05) among the treatments. The ME content of different treatments ($T_{0,}$ $T_{1,}$ T_2, T_3 and T_4) of ensilage was 4.84, 5.62, 5.74, 6.46 and 6.98%, respectively. The highest ME (6.98) was observed in T_4 which was higher than that of $T_{0,}$ $T_{1,}$ T_2, and T_3 treatment. The lowest ME (4.84) was observed in control treatment (T_0). Bostami *et al.* (2009) also reported that ME content was increased in treated ensiled maize stover than untreated ensiled maize stover [29]. Ensiling period has no significant (p>0.05) effect on ME content of silage [30,31].

Conclusion

The results suggest that ensiling wet rice straw with up to 10% biogas slurry and 5% molasses significantly improves the nutritional values of ensilage and may be a feasible means of preserving and converting slurry, in to a palatable and nutritious feed for cattle. In addition, ensilage of wet rice straw with biogas slurry as a feed ingredient will not only reduce waste disposal and pollution problem, but also provide inexpensive feed components for ruminants.

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