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Preservation of wet rice straw using urea and molasses in monsoon of Bangladesh

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ABSTRACT

An experiment of treated and ensiled wet rice straw with urea and molasses was performed to explore the chemical composition, physical quality, in vitro digestibility and its potentiality as a quality feed for ruminants. In this experiment, plastic containers were used to preserve chopped wet rice straw under airtight condition based on the treatment as T_1 (wet rice straw only), T_2 (straw with 5% molasses), T_3 (straw with 5% urea), T_4 (straw with 5% urea and 5% molasses) and T_5 (straw with 10% urea and 5% molasses) to analyze chemical composition, physical quality, metabolizable energy (ME) content, in vitro organic matter digestibility (OMD) and in vitro gas production (IVGP) at five different ensiling times of 0, 30, 45, 60 and 90 days. The physical quality (color, smell, softness characteristics) of wet rice straw was improved with urea and molasses treatment. Treatments T_5 was found better as there was no fungal growth till 90 days of ensiling. The addition of urea and molasses improved the physical quality, nutritive value and preservation quality of wet rice straw. Urea and molasses treated and ensiled (T_5) straw showed better color, nutritional quality, softness and longer preservation capacity compared with all treatments followed by T_4, T_2 and T_3. The crude protein (CP) content was increased ($P<0.05$) but the crude fibre (CF), dry matter (DM), ash contents and ether extract (EE) were decreased ($P<0.05$) in all of the treatments (T_2, T_3, T_4 and T_5) compared to control (T_1). The OMD, IVGP and ME contents were increased in all of the treatments (T_2, T_3, T_4 and T_5) compared to control (T_1). The highest OMD, IVGP and ME values were observed in treatment T_5 and the lowest values were in control (T_1) Through the Consideration of all the chemical and physical properties, among all of the treatments, 10% urea and 5% molasses are found acceptable for the preservation of rice straw. Thus, environment friendly and cost effective feed can be formulated.

Key Words: *Wet rice straw, Ensiling, Chemical composition, Physical quality and In vitro digestibility.*

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I. Introduction

Livestock is an essential part of Bangladesh that not only contributes to meat and milk production but also provides a huge opportunity in employment (Begum et al., 2011). The gross domestic production of agricultural products in Bangladesh is 19.95% (BBS, 2011) causes green revolution in the country through a transformation of traditional products to supported inputs that changes agro-ecology, socioeconomics and climate. The total livestock population in Bangladesh is estimated at 242.38, 14.86, 35.37, 262.67 lakh cattle, buffaloes, sheep, goats respectively (Bangladesh Economic Survey, 2018-2019). Statistics showed that contribution of livestock to GDP is 1.47% and to the agricultural sector is 13.46% and about 20% of the population directly and 50% is partly dependent on livestock (Bangladesh Economic Survey, 2018-2019). Bangladesh has higher cattle production but the quality of feed and fodder is a major concern. The shortage of quality feeds is the main obstacle to the development of livestock. Crop residue and pasture are the sources of animal feeding that are deteriorating the production performance of animals. Though the availability of concentrate (DM basis) and total roughage (DM basis) in Bangladesh are 1.27 and 13.4 million metric tons (MMT) respectively, the deficit is 50 and 90%, against the requirement of 12.6 and 27 MMT (BBS, 2004). Rice straw is being utilized by the cattle and buffaloes as sole feed, in the rural area of Bangladesh along with some roadside grass or weeds of cropland in different seasons of the year (Akbar et al., 1995). However, heavy rainfall (230cm) and high humidity (86%) causes serious loss of the quantitative and qualitative availability of rice straw. During monsoon (July to August), about 7.7 million tons of rice straw dry matter rotten has been estimated (Chowdhury and Huque, 1996). Addition of molasses to ensile crop residues has shown a potentiality of improving the nutritive value. As it is wholesome, effective, easy to use, dust-free and palatable, so it is preferable and suitable to feed ruminants. It facilitates natural preservation by producing lactic acid bacteria that lower the pH (Premier Molasses, 2006). The adverse effects of feeding moldy straw on animal health during monsoon create a need to develop a method that will reduce nutrient loss and provide a positive effect on animal health. Therefore, urea and molasses may be used for improving the preservation and nutritive quality of wet rice straw.

II. Materials and Methods

Experimental location and duration

The experiment was operated in two phases: Firstly, it was the treatment of straw and secondly, laboratory analysis of treated straw was performed. Straw treatment and other activities were carried out in the Goat and Sheep farm, Department of Animal Science, Bangladesh Agricultural University, Mymensingh, during the period from June to August, 2016. The laboratory analysis was conducted in Animal Science and Animal Nutrition Laboratory, Faculty of Animal Husbandry, Bangladesh Agricultural University, Mymensingh.

Collection of materials

Wet rice straw was collected from Sheep and Goat farm, Bangladesh Agricultural University (BAU), Mymensingh. Commercial fertilizer grade, commercial cane molasses, granulated urea (NH_2-CO-H_2N, 46%N) and plastic containers were purchased from the local shop.

Processing and treatments of the sample

Wet rice straw was chopped into about 3-4 cm length. Then, it was placed on the floor, mixed well and treated with 5% urea, 10% urea and 5% molasses. The amounts of ingredients were measured on DM basis. The treatments under the study were as follows:

Treatments	Sample
T_1	0% urea + 0% molasses + 100% wet rice straw
T_2	0% urea + 5% molasses + 95% wet rice straw
T_3	5% urea + 0% molasses + 95% wet rice straw
T_4	5% urea + 5% molasses + 90% wet rice straw
T_5	10% urea + 5% molasses + 85% wet rice straw

Preservation of the treated sample

The properly treated and mixed samples were poured into the separate plastic containers and pressed and squeezed by hand pressure, to make it airtight sufficiently and to close the cover tightly. Each container was labeled according to treatment number. The treated samples were incubated at room temperature under laboratory conditions for 0, 30, 45, 60 and 90 days from June to August. The wet rice straw was ensiled for 3 months to preserve the wet rice straw from spoilage and to supply quality feed for animals.

Observation and collection of samples for chemical analysis

The preserved samples were opened at intervals of 30, 45, 60 and 90 days. The observation of physical changes of all preserved samples was documented. 100g of sample was taken out from each treatment to perform the chemical analysis. Wet rice straw sample was also taken for chemical analysis. Before chemical analysis, all of the samples were air dried and ground properly by grinding machine of about 1mm in diameter for in vitro digestibility and chemical analysis.

Chemical analysis

Chemical composition of the air-dried samples of treated wet rice straw was determined. The samples were analyzed for dry matter (DM), crude fiber (CF), crude protein (CP), ash and ether extract (EE), following the methods of AOAC (2004) at the laboratory of Animal Science, Bangladesh Agricultural University, Mymensingh.

In vitro digestibility

This experiment was carried out to predict the organic matter (OM), metabolizable energy (ME) and digestibility of feed of wet rice straw sample using hay as standard. Blank was used to correcting the gas measurement. The method of Menke et al. (1979) was followed to measure in-vitro organic matter digestibility of samples.

Calculation of in-vitro gas production (IVGP)

The organic matter digestibility was calculated from the gas production rate (Gb) and the content of crude protein (XP, g/100g DM) with the following formula:

$$do = 0.76\ Gb + 0.637\%\ XP + 22.5$$

In which, Gb was calculated by,

$$\text{Gb (ml 200 mg DM. 24h)} = \frac{(V24 - V0 - Gbo) \times 200 \times (FH + FHS)/2}{W}$$

Where, Vo = Position of the piston at the beginning of the incubation,
V_{24} = Position of the piston after 24 hours of incubation,
Gbo = Mean gas production in 24 hours of rumen liquor without sample,
F_H = 44.16/ (Gb_H-Gbo), roughage correction factor,
F_{HS} = 59.8/ (Gb_Hs-Gbo), concentrate correction factor,
W = Weight of the test sample in mg dry matter.

Calculation of metabolizable energy (ME) content and organic matter digestibility

The metabolizable energy (ME) (MJ/Kg DM) and digestibility of organic matter (OMD) (%) were calculated from the value of crude protein (%CP) and the volume of gas (Gv) using Menke and Steingass (1988).

Statistical Analysis

A 5×5 factorial design with 3 replicates was followed in this experiment. Data were analyzed statistically by using SAS Statistical Discovery Software, NC, USA. The differences among the treatment means were determined by Duncan's Multiple Range Test (DMRT).

III. Results and Discussion

Effect of treatment and physical properties of ensiled wet rice straw

The physical properties of ensiled straw with different treatments (T_1, T_2, T_3, T_4 and T_5) at different ensiling periods (0, 30, 45, 60 and 90 days) were presented in Table 01. All of the treatments showed good color till 90 days but undesirable chocolate color had found in T_1 after 60 days of ensiling indicating the spoilage of wet rice straw. Among the treatments, T_2 and T_4 smelled good till 90 days but T_3 and T_5 obtained ammonia smell from 0 to 90 days of ensiling that smell was reduced by exposing to air. Addition of molasses during fermentation indicated good ensilage quality, color, smell and no fungal growth (Snijders and Wouters, 2004). In poultry droppings treated napier ensilage, propagation of fungus was not noticed but in controlled treatments, some were observed (Panna et al., 2019). The color of ensilage was changed in maize stover with the excreta of caged layer (Jamee et al., 2020).

Table 01. Effect of different treatment and physical properties of ensiled wet rice straw

Characteristics	Observation	Treatment				
		T_1	T_2	T_3	T_4	T_5
Color	0 Day	Straw color	Light Brown	Light Brown	Light Brown	Brown
	30 Days	Light Brown	Brown	Brown	Brown	Brown
	45 Days	Brown	Brown	Brown	Brown	Brown
	60 Days	Dark Brown	Brown	Brown	Brown	Brown
	90 Days	Chocolate	Dark Brown	Brownish yellow	Dark Brown	Brownish yellow
Smell	0 Day	Straw	Molasses smell	Pungent smell of ammonia	Straw	Pungent smell of ammonia
	30 Days	Straw	Molasses smell	Ammonia smell	Molasses smell	Smell of ammonia
	45 Days	Bad	Moderate Good	Ammonia smell	Good	Ammonia smell
	60 Days	Bad smell	Moderate Good	Ammonia smell	Good	Ammonia smell
	90 Days	Bad smell	Very Good	Ammonia smell	Very good	Ammonia smell
Softness	0 Day	Hard	Hard	Hard	Hard	Hard
	30 Days	Hard	Hard	Hard	Hard	Moderate soft
	45 Days	Hard	Moderate soft	Moderate Soft	Soft	Soft
	60 Days	Hard	Soft	Soft	Soft	Soft
	90 Days	Moderate soft	Soft	Soft	Soft	Soft
Fungus	0 Day	Absent	Absent	Absent	Absent	Absent
	30 Days	Absent	Absent	Absent	Absent	Absent
	45 Days	Absent	Absent	Absent	Absent	Absent
	60 Days	Present	Absent	Absent	Absent	Absent
	90 Days	Present	Present	Slightly present	Slightly present	Absent

T_1= wet rice straw, T_2 = 5% molasses + wet rice straw, T_3=5% urea + wet rice straw, T_4 =5% urea+ 5% molasses + wet rice straw, T_5= 10% urea + 5% molasses + wet rice straw. Hard indicates not acceptable by ruminants (cattle, goat, and sheep). Soft indicates acceptable by ruminants (cattle, goat, and sheep).

Dry Matter

The ensilage dry matter of different treatments at different ensiling period is presented in Table 02. T_1 showed the highest DM followed by T_2, T_4, T_3 and T_5 but the differences between the values T_2 and T_4, T_3 and T_5 were no significant. The DM contents were found 28.21, 27.72, 26.61, 27.15, 26.83%, respectively at 0, 30, 45, 60 and 90 days of ensiling period. The DM content was decreased with ensiling period from 28.21 to 26.83% with the increase of ensiling period from 0 to 90 days. Same findings were obtained in some experiments. During ensiling, the reduction of DM content with the addition of molasses was reported in Nour (1990). Due to increasing the ensiling period of 2 to 4 months, DM content was reduced from 28.0 to 26.4% (Man and Wiktorsson, 2003). The increase of duration from 0 to 90 days caused the decrease of DM content from 31.76 to 27.37% (Sarker et al. 2018). The improvement of DM content was observed with the increase of poultry droppings from 0 to 45% of dry matter in Napier grass ensilage (Panna et al., 2019). DM content was declined for the fermentation with a higher amount of caged layer excreta while maize stover was used (Jamee et al., 2020).

Table 02. Effect of treatments and ensiling period on dry matter of ensilage

Ensiling (Days)	Treatments					Mean	SEM
	T_1	T_2	T_3	T_4	T_5		
0	26.11	27.10	26.41	34.27	27.07	28.21^a	0.296
30	27.87	27.99	25.49	30.60	26.44	27.72^a	0.260
45	29.74	30.42	22.86	26.70	24.26	26.61^b	0.411
60	31.91	29.51	23.24	26.50	22.51	27.15^b	0.466
90	33.48	32.78	22.48	26.44	18.99	26.83^b	0.433
Mean	30.60^a	29.08^b	24.09^c	28.90^b	23.85^c		
SEM	0.396	0.257	0.381	0.307	0.507		

*Means with different superscripts within row and column are significantly different ($P<0.05$), T_1= wet rice straw, T_2 = 5% molasses + wet rice straw, T_3= 5% urea + wet rice straw, T_4 =5% urea+ 5% molasses + wet rice straw, T_5= 10% urea + 5% molasses+ wet rice straw.

Crude Protein

The crude protein of ensilage with different treatments at different ensiling period is represented in Table 03. The CP percentage of different treatments (T_1, T_2, T_3, T_4 and T_5) was 3.85, 5.85, 6.37, 6.50 and 7.20% respectively. T_5 (7.20%) showed the highest CP content followed by T_4, T_3 T_2 and T_1. The CP amount was improved from 3.85 to 7.20% between T_1 and T_5 treatments. Among the treatments, there were significant differences between T_2 and T_5 but T_3 and T_4 which were significantly identical. It was found that due to the increase of ensiling period from 0 to 75 days, CP amount was improved from 9.24 to 22.77% while Napier grass was treated with poultry droppings (Panna et al., 2019).

Table 03. Effect of treatments and ensiling period on crude protein of ensilage

Ensiling (Days)	Treatments					Mean	SEM
	T_1	T_2	T_3	T_4	T_5		
0	2.29	5.04	4.26	4.49	5.22	4.26^e	0.058
30	3.59	5.58	5.17	5.63	6.97	5.38^d	0.121
45	4.25	5.70	6.22	6.22	7.31	5.94^c	0.161
60	4.41	6.60	7.53	7.28	7.42	6.64^b	0.294
90	4.73	6.35	8.68	8.88	9.10	7.54^a	0.216
Mean	3.85^d	5.85^c	6.37^b	6.50^b	7.20^a		
SEM	0.224	0.216	0.157	0.172	0.080		

*Means with different superscripts within row and column are significantly different ($P<0.05$)

In urea and molasses treated ensilage, the increment of CP amount was observed for the availability of energy from high crude protein content (urea and molasses), which was used by the micro-organisms for producing microbial protein in the ensilage of rice straw. The increase of the ensiling period (0 to 90 days) resulted in the increment of CP amount from 4.26 to 7.54%. The result was supported by the CP content increased with ensiling time (Man and Wiktorsson, 2007). The addition of poultry droppings caused the difference of CP content while Napier grass was used as ensilage (Panna et al., 2019). The increased CP amount was found with the ensiling period while poultry droppings and maize stover were used (Jamee et al., 2020).

Crude Fibre

The crude fibre amount of ensilage with different treatments at different ensiling period is presented in Table 04. In untreated (T_1) rice straw, the CF amount was showed significantly ($P<0.05$) higher than the treated (T_2 to T_5). The CF content of 5% molasses treated (T_2) and 5% molasses with 5% urea treated (T_4) were statistically similar, ($P>0.05$). Sudesh-Rudortra (2004) reported a decrease of CF content of wheat straw from 42.74 to 35.66% when wheat straw was treated with 4% urea. The decrease of CF with ensiling period was observed but again it was improved in 90 days which wasn't significantly different ($P<0.01$) while maize stover with poultry droppings was used (Jamee et al., 2020).

Table 04. Effect of treatments and ensiling period on crude fiber of ensilage

Ensiling (Days)	Treatments					Mean	SEM
	T_1	T_2	T_3	T_4	T_5		
0	23.91	20.09	24.28	22.61	22.06	22.59^c	0.232
30	24.89	21.95	23.11	23.24	22.60	23.15^b	0.275
45	25.91	23.61	25.20	22.54	24.50	24.35^a	0.477
60	22.94	20.58	20.73	21.21	20.25	21.14^d	0.197
90	23.88	21.24	21.70	19.65	18.59	21.01^d	0.543
Mean	24.81^a	22.29^c	22.98^b	22.25^c	21.60^d		
SEM	0.255	0.226	0.602	0.291	0.350		

*Means with different superscripts within row and column are significantly different (P<0.05)

Ether Extract

The ether extract amount of ensilage with different treatments at different ensiling period is presented in Table 05**.** The EE amount at T_1, T_2, T_3, T_4 and T_5 treatments of ensilage was 3.66, 3.35, 2.36, 2.91 and 3.40%, respectively. Significant differences (P<0.05) were found among treatments except for T_2 and T_5 which were statistically identical. In treatment (T_1), the EE amount was the highest and the lowest was in (T_3). There were significant differences (P<0.05) among T_1, T_3 and T_4. 1.72, 2.18, 3.20, 3.89 and 4.69% EE amount of ensilage were observed at different ensiling periods (0, 30, 45, 60 and 90 days) respectively. It was significant (P<0.05) when EE percentage was improved from 1.72 to 4.69% with the increase of the ensiling period of 0 to 90 days. This result is supported by Abd El-Galil (2006) who found that EE content of rice straw silage increased with bacterial inoculants.

Table 05. Effect of treatments and ensiling period on ether extract of ensilage

Ensiling (Days)	Treatments					Mean	SEM
	T_1	T_2	T_3	T_4	T_5		
0	1.75	1.81	1.45	1.80	1.82	1.72^e	0.073
30	2.29	2.36	1.74	2.30	2.26	2.18^d	0.083
45	3.31	4.33	2.43	2.80	3.15	3.20^c	0.064
60	3.20	4.52	2.90	3.38	4.56	3.89^b	0.138
90	5.35	5.20	3.30	4.30	5.23	4.69^a	0.111
Mean	3.66^a	3.35^b	2.36^d	2.91^c	3.40^b		
SEM	0.083	0.102	0.086	0.103	0.093		

*Means with different superscripts within row and column are significantly different (P<0.05)

Ash

The Ash amount of ensiled wet rice straw among different treatments at different ensiling period is presented in Table 06. The percentage of Ash among different treatments (T_1, T_2, T_3, T_4 and T_5) was 5.03, 4.99, 3.79, 4.70 and 4.63%, respectively. Significant differences (P<0.05) among treatments were found. The highest ash amount was found between T_1 & T_2 (untreated treatments) and 5% urea treated (T_3) rice straw had the lowest value. Kim et al. (2014) reported the increment of ash of ensilage with the increase of the ensiling period up to 28 days. During ensiling, bacterial inoculation did not affect the ash amount while grass and corn silages were prepared in Jalc et al. (2009).

Table 06. Effect of treatments and ensiling period on ash of ensilage

Ensiling (Days)	Treatments					Mean	SEM
	T_1	T_2	T_3	T_4	T_5		
0	5.69	5.32	5.29	5.57	3.42	5.08^a	0.038
30	3.35	4.40	4.28	3.85	3.96	4.01^d	0.029
45	3.81	4.57	3.66	4.49	4.87	5.06^a	0.042
60	3.66	4.90	5.18	4.85	4.46	4.61^b	0.064
90	3.43	5.78	4.74	4.73	3.26	4.39^c	0.098
Mean	5.03^a	4.99^a	3.79^c	4.70^b	4.63^b		
SEM	0.080	0.030	0.067	0.059	0.035		

*Means with different superscripts within row and column are significantly different (P<0.05)

Effect of treatment and ensiling on *in vitro* gas production (IVGP)

The production of gas in ensiled wet rice straw among different treatments at different ensiling period is presented in Table 07. The gas production of T_1, T_2, T_3, T_4 and T_5 treatments was 19.22, 24.98, 25.32, 22.59 and 25.25ml respectively. The highest (25.32ml) gas production was found in T_3 and the lowest (19.22) was in T_1. In the present study, results showed a significant increase of gas production by all the treatments ($P<0.05$) but T_2, T_3 and T_5 had no significant differences ($P>0.05$) among them. The gas production at different ensiling period was 21.03, 24.16, 24.15, 23.78 and 24.24 ml. The gas production was increased from 0 to 90 days but the values of 30 and 45 days of ensiling showed no significant differences ($P>0.05$). Dried pomegranate seeds ensiling for ruminants caused a significant increase in gas production with the incubation period (Taher-Maddah et al., 2012).

Table 07. Effect of treatments and ensiling period on *in vitro* gas production of ensilage

Ensiling (Days)	Treatments					Mean	SEM
	T_1	T_2	T_3	T_4	T_5		
0	21.89	19.14	20.33	21.93	21.86	21.03^{c}	0.308
30	21.86	25.14	26.36	21.26	27.15	24.16^{ab}	0.337
45	20.02	28.18	26.45	22.78	24.33	24.15^{ab}	0.331
60	19.10	25.24	26.50	23.13	25.93	23.78^{b}	0.344
90	14.23	27.19	26.98	25.84	26.98	24.24^{a}	0.306
Mean	19.22^{c}	24.98^{a}	25.32^{a}	22.59^{b}	25.25^{a}		
SEM	0.324	0.305	0.368	0.360	0.271		

*Means with different superscripts within row and column are significantly different ($P<0.05$)

Effect of treatment and ensiling on *in vitro* organic matter digestibility (IVOMD)

The organic matter of ensiled wet rice straw of different treatments at different ensiling period is presented in figure 01. The amount of OMD of T_1, T_2, T_3, T_4 and T_5 treatments was 40.80, 45.28, 45.52, 45.59 and 45.92%, respectively. In the present experiment, T_5 showed the highest in vitro OMD and T_1 had the lowest value. The OMD in vitro system at different treatments was increased significantly ($P<0.05$) except T_3 for the addition of different amounts of molasses and urea. Mahr-un-Nesa et al. (2004) observed higher digestibility in 5% urea treated of wheat straw and ensiled with corn steep liquor. The increment of OMD was found due to the increase of time during ensiling while maize stover was treated with poultry droppings (Jamee et al., 2020).

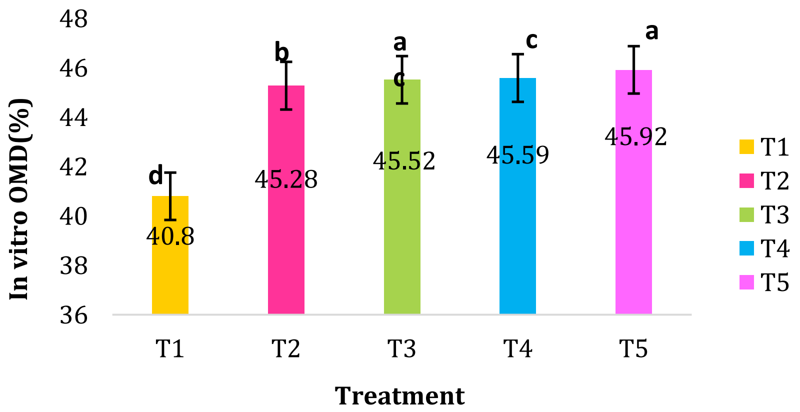

Figure 01. In vitro organic matter digestibility (%) of ensilage at different level urea and molasses

Effect of treatment and ensiling on metabolizable energy (ME)

The ME amount of ensiled wet rice straw of different treatments at different ensiling period is presented in figure 02. 4.93, 5.89, 5.72, 5.41 and 6.00 MJ/Kg DM, ME content were observed at different treatments (T_1, T_2, T_3, T_4 and T_5). T_5 (6.00 MJ/Kg DM) had the highest ME which was higher than T_1, T_2, T_3 and T_4. The lowest ME (4.93 MJ/Kg DM) was observed in T_1. In treated ensiled maize stover, ME content was improved than untreated ensiled maize stover that was reported by Bostami et al. (2009). Moreover, the ME of ensiled wet rice straw at 0, 30, 45, 60 and 90 days of ensiling period was 4.97, 5.52, 5.84, 5.86, 5.75 MJ/Kg DM, respectively. From 0 to 60 days, the ME was improved but in 90 days of ensiling, it was declined which is statistically found identical to 45 and 60 days. ME was reduced with the different treatments of poultry excreta in Napier grass ensilage (Panna et al., 2019). ME content was statistically increased while caged layer excreta were added in maize stover (Jamee et al. 2019).

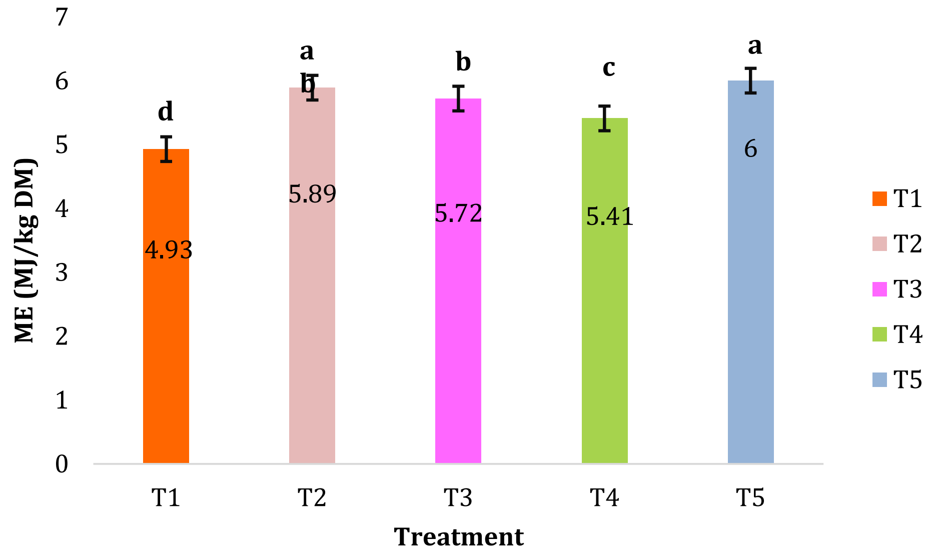

Figure 02. Metabolizable energy (MJ/Kg DM) of rice straw silage at different amount of urea and molasses

Among the treatments, if considered nutrient contents, digestibility and physical quality, the T_5 was considered better than other treatments with ensiling time of 90 days, as there were some improvements in physical changes and chemical content with no fungal growth.

IV. Conclusion

Ensilage is a very versatile product and can be used as a basal diet or as a concentrate type supplement to forage or other roughages. The addition of urea and molasses improves the physical quality, preservation capacity and nutritive value of wet rice straw. Urea and molasses treated and ensiled rice straw showed better color, nutritional quality, softness, and longer preservation quality. So, farmers may use either urea (10%) with molasses (5%) in wet rice straw for preservation.

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