Effect of combined lactic acid bacteria at the ensiling of rice straw with whey or molasses plus urea on degradability, palatability, digestibility, and nutritive values.

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Objective: This study was designed to ensiling rice straw by using some additives and assessing its effect on the fermentation, degradability, feed consumption, and digestibility.

Methods: Ensiling rice straw using either water (50ml/kg v/w), or molasses plus urea (45 ml / 5g /kg), or whey (55ml/kg v/w) was conducted in this study. Each of these treatments inoculated with three levels of lactic acid bacteria. The best treatments from in-vitro results were used to compare with urea treated rice straw in the digestibility trials. Twelve adult Ossimi rams (average weight =61.4±0.16 kg) randomly distributed on four experimental diets in a 4 x 4 Latin square (3 in each block), each period lasted 28 d.

Results: Added whey or molasses plus urea (MU) showed well properties for ensiled rice straw (ERS), especially with the high level of lactic acid bacteria addition. Accumulative gas
production has corresponded with the degradability of OM, NDF, and CP (%). The feed consumption of ERS and palatability increased with the whey or MU as an additive, especially with a high level of lactic acid bacteria. Despite the similarity of the apparent digestibility coefficients of NDF, and ADF for a diet including ERS with lactic bacteria compared that containing 3% urea-treated rice straw (UTRS), the digestibilities of protein, organic matter, and ether extract were significantly higher when emulated to the group fed UTRS. The total digestible nutrients and digestible protein of the groups fed on diets that included any of ERS with whey or MU were superior to a diet contain UTRS.

**Conclusion:** The results concluded that added either whey or molasses plus urea can be successful in improving the quality of the ensiling rice straw.

**Keywords:** Ensiled rice straw; Molasses plus urea; Whey; Lactic acid bacteria; Degradaability; Digestibility and nutritive values.

**INTRODUCTION**

At a time when the population increase and depletion of some important agricultural resources, especially those used in animal feed the demand for animal protein grows, principally in poor countries within the arid area. On the opposite hand, a lot of ingredients accumulate and are not being optimally exploited, especially rice straw (RS), which is produced in large quantities. These lots of RS unused left improperly disposed of by burnt directly, wasting resources and causing environmental pollution [1]. In Egypt, the shortage of feedstuffs and an increase in the price of feed materials over the ability of farmers has become a limiting factor for the sustainable development of the livestock industry. This occurs despite the existence of more than 37 million tons annually of crop residues, where rice straw represents about 10.81 to 16.22%. [2]. Recently, there are many methods attempted to enhance the nutritive value of RS through physical, chemical, and biological treatments. Most of those methods have not been popularized and adopted by farmers, others cause environmental pollution, such as ammonia or
urea treatment [3]. Data on ensiling dry RS silage are lacking, especially with the difficulty of chemical and biological degradation due to complicated structure from highly lignified structural cells. Accordingly, pretreatment of this biomass is critical before its subsequent transformation and comprehensive utilization [1]. Moreover, bad storage of RS under the extreme sun within the tropics causes damage to the biomass. Besides, the seasonality of straw harvesting, and an annual supply of feedstock needed, long-term effective storage of harvested straw is required. Preliminary studies indicated that ensiling could be a promising technology for supplying year-round availability of feedstock moreover as being effective pretreatment. A study by [1] observed that ensiling fermentation was effectively increased degradability in silage. However, the decrease of water-soluble carbohydrates (WSC), and also the count of epiphytic lactic acid bacteria (LAB) are reflecting on the successful ensiling of RS [4]. According to the report of [5] who stated the addition of either molasses plus urea (MU) or whey increases the energy and nitrogen content of the silage. Several studies have focused on inoculation of *Lactobacillus plantarum*, LC279063 by [4] or NLRI401 by [6] to round baled of whole-crop rice led to boost the silage quality with reducing pH value, butyric acid (BA) and ammonia nitrogen (NH$_3$-N) concentrations, while, lactic acid (LA) and acetic acid (AA) concentrations were raised and crude protein (CP) content. Carbohydrate (CHO) or CHO-rich materials are commonly used as effective additives for ensiling crops that have low WSC. Additionally, adding whey might induce favorable activities of microorganisms and thus end in fermentation improved. Therefore, the simultaneous application to use the mixture of LAB with either carbohydrate or whey for ensiling rice straw will be better [4], however, information is absent for this mixture. Molasses or whey are used as supplements to ensile crop residues, but a bit is thought about their potential to ensile with LAB inoculation. The target of this study was to assess the potential of inoculation of LAB with either cane molasses plus urea or whey as silage additives to ensiling RS.
MATERIALS AND METHODS

The experiment was conducted under the control and advice of the Animal Care and Use Committee (ID#01-02-02-37) and recorded within the Department of Researchers Affairs at the Institute under No. (14-6-9); Animal Production Research Institute (APRI), Agricultural Research Center (Giza, Egypt), which complies with European Union standards in this regard.

Bundling and ensiling rice straws

This study hypothesized that made simulation of fermentation which occurs during the silage making by adding some additives that play a task in overcoming the obstacles facing the ensiling of RS. Also, it aimed to review the effect of ensiled rice straw (ERS) inoculated with LAB on its palatability and nutritional value as ruminant feed. Chopped RS into lengths of 2 to 3 cm with a fodder chopper, then manually mixed and ensiled as following: I) ensiled rice straw by water (RW), ii) ensiled rice straw by molasses & urea, 45 ml molasses +5 g urea per kg fresh RS (RMU) and iii) ensiled rice straw by whey, 550 ml fresh whey per kg RS (RWh). Macerated RS with water to adjust the moisture till reaches 60% in both RW and RMU, while the moisture adjusts with whey only in RWh. Three levels of LAB (Lactobacillus plantarum L, Ecosyl MTD/L, Ecosyl Products Ltd., Stokesley, North Yorkshire, UK) 0.1×10^6, 0.2×10^6, and 0.3×10^6 cfu/L were dissolved in deionized water and sprayed to be treatments as following: RW (RWL1, RWL2, and RWL3), RMU (RMUL1, RMUL2, and RMUL3) and RWh (RWhL1, RWhL2, and RWhL3). Four replicates of every treatment packed (Approximately 1000 g per treatment) into a 1L laboratory glass bottle were tightly and stored at the ambient temperature (22°C to 28°C) next being wrapped with rivet tops and plastic tape. Quaternary per treatment was opened on 45d after ensiling. Data of the chemical composition and fermentation quality were 9 (treatments)×4 (replicates)=36 observations corresponding to each variable.

In-vitro gas production kinetics and degradability:
Rumen fluid was collected from three Ossimi rams before the morning feed into a Thermo flask. The procedure for the in-vitro gas production was as established by [7]. The rumen liquor collected was properly mixed and filtered through 4 layers of cheesecloth and mixed with the buffered mineral solution [8] at ratio 1:4 (rumen fluid to buffer, v/v). Briefly, a 0.6 g silage sample was transferred into a 100ml glass bottle incubated in 60 ml of diluted rumen fluid. The gas production (GPt) measured intermittently throughout the incubation using the Reading Pressure Technique (RPT) (Hangzhou Runchen Electron Com., Hangzhou, China). Headspace gas pressure measured at 3, 6, 12, 24, 48, 60, and 72h. Results of kinetic parameters of GPt (ml/g DM) were fitted using the NLIN option consistent with [9] as GPt = b × (1 − e−c(t−L)), where GPt is that the volume of GPt at time t; b is that the asymptotic GPt (ml/0.6 g DM); c is that the rate of GPt (ml/h) and L (h) is that the discrete lag time prior GPt.

Metabolisable energy value of the ERS at 24h (ME, MJ/kg DM) was calculated according to [10] as: ME (MJ/kg DM) = 2.20 + 0.136 GPt + 0.057CP (R2= 0.94), where GPt is 24h net gas production and CP could be a crude protein (%). Another run was applied to estimate IVOMD, IVNDFD, and IVCPD (%) at 48h of incubation for tested ERS (4 replicates/treatment), where the residual solutions were filtered by gravity, using Whatman No 4 filter paper. Four bottles with no substrate added were included as blanks in each run. Microbial crude protein (MCP) productions were then calculated using the subsequent equations: MCP (g/kg DM) =DOM x 0.03217 [11]. Where OMD is organic matter digestibility.

The relative feed value (RFV) accounted as RFV= (DDM (%DM) x DMI (%BW))/1.29.

Where, DDM (digestible dry matter) and DMI (dry matter intake potential like of body weight) were calculated from ADF and NDF, respectively as DDM (% DM) =88.9-0.78 x ADF (% DM) and DMI (%BW) =120/ NDF (% DM).

Feed intake and Digestibility trial
Digestibility trials were applied to investigate the attractability and palatability of ERS and assess the nutritional value of the tested diet. Ensiling RS (RWL3, RMUL3, and RWhL3) were packed out in blue drums (55-gallon) as a prior-experimental step description for 45d. On the other hand, 3% urea-treated rice straw (UTRS) were packed in sealed blue drums for 3 weeks (as control) according to a recommendation of [4] to be comparable to one another ERS. Four composite samples of UTRS were randomly chosen from several different positions for analysis. Twelve adult Ossimi rams (average body weight = 61.4±0.16 kg) selected from the sheep flock kept at Sakha Research Station were allotted randomly to 12 cages in a 4 x 4 Latin square (3 in each block) for 17d as adaption period, subsequently 5d for samples collection for every stage to determine digestibility. All animals had unrestricted access to water throughout the experiments. Diets and animals were randomised to ensure that no animal received the same diet twice. The concentrate feed mixture (The livestock insurance fund, Giza, Egypt; 14% CP and 65% total digestible nutrients on a fresh matter basis) fed at the level of 0.5% BW/d with roughage was fed ad libitum. Feed offered and refused, and fecal excretions were weighed, individually homogenized, and from each, a 10% sample was collected daily in the morning during each 5d collection period. All samples were oven-dried at 55°C for at least 72 h, ground to pass through a 1mm screen, and stored until analyses. Apparent digestibility was measured as the portion of nutrient intake not retrieval in feces. The organic matter (OM) true digestibility was estimated according to [12], considering that only the NDF fraction of the feces is originated from the feed [13]. The feed residues of tested ERS were collected and analysed to determine the actual feed intake. Relative palatability indices were calculated as FI = (a component in FO × mass FO) – (a component in RF × mass RF) for tested ERS. Where, FI= quantity of feed intake, FO= quantity of feed offered, and quantity of feed residues (RF). Eating chewing and ruminating behaviors in the different groups were visually tracked over 24h for the experimental rams. The number of times of eating and rumination was
recorded every 5 min, assuming that each behavior continued for 5 min. Given that the total time spent chewing is the total time spent eating and ruminating. Therefore, the total time spent in inactivity was determined as being 24h, and then the total time spent on chewing was subtracted.

Chemo-physical and microbial assessment of rice straw ensiled:

After 45 d, the fermentation was terminated, the packed opened and characterized ERS. The color was determined using color charts. The taste of the silage, which was defined as existence nice, pleasant, or fruity, was measured as defined by [14]. A subsample10 g forage (fresh basis) was blended with distilled water (90 mL) filtered through 4 layers of cheesecloth. The supernatant was used to determine pH used (Hanna, model HI 8424), ammonia-N (NH3-N) was estimated as described by [15]. Samples for organic acids (Acetic, Propionic, and Butyric) concentrations prepared according to [16] then analyzed by gas-liquid chromatography (GC 2010, PerkinElmer), capillary column (HPINNOWAX, 30m_0.250 mm_0.25 mm). The LA concentration was determined by methods of Analytical Chemistry of Foods methods [17]. The aerobic stability test was determined by monitoring the temperature increase of silage samples due to microbial activity during exposure to air as a method [18]. The total of LAB in fresh samples was counted by pour plating on MRS agar, while an account of yeasts and molds applied by pouring on malt extract agar (Oxoid CM0059). Plates were incubated at 37°C for 48 h and numbers of colony-forming units (cfu) were enumerated. Yeasts and moulds were enumerated according to [18] methods 28.1.1 and 28.1.4.

Composite feed, silages, and feces samples were dried at 45°C for 72 h until a constant weight was achieved. Dried samples were ground to pass a 1mm screen to analyzed DM according to [19]. Crude protein (CP) and ash were determined in both fresh samples of silage and feces. Total nitrogen (TN) was determined by Kjeldahl nitrogen analyser (Kjeltec 8200; FOSS, Höganäs, Sweden), and the CP was calculated as TN×6.25. Ash was measured
by incinerating in a muffle furnace at 550°C for 4h. All of the chemical examines were executed in triplicate and expressed on a dry matter basis. Neutral detergent fiber (NDF) was assayed with the addition of a heat-stable amylase but without sodium sulfate and acid detergent fiber, procedures were performed as a description of [20]. Water-soluble carbohydrate (WSC) consistency was determined by the colorimetric method [21]. Nonfibrous carbohydrates (NFC) was calculated by difference, where: 

\[ \text{NFC} = 100 - (\% \text{NDF} + \% \text{CP} + \% \text{Fat} + \% \text{Ash}) \]

The chemical composition of ERS and the experimental rations are presented in Table (2&5). The buffering capacity (BC) was determined according to the method described by [22]. The ensilability of RS was assessed by calculating the fermentation coefficient (FC) according to the formula described in [23].

**Statistical analysis:**

The digestibility trials subjected to ANOVA for a 4x4 Latin square design using the General Linear Models (GLM) procedures of the Statistical Analysis System Institute (SAS version 9.4, SAS Institute, Inc. 2002) according to the following model: 

\[ Y = \mu + \alpha + \beta + \gamma(\beta) + p + \varepsilon \]

where \( \mu \) is the general mean, \( \alpha \) is the fixed effect of treatment, \( \beta \) is the random effect of the square, \( \gamma(\beta) \) is the random effect of the animal within a square, \( p \) is the random effect of the period and \( \varepsilon \) is the random error. The data of silage fermentation quality, chemical composition, and gas production kinetics were analyzed separately for variance using a general linear model (GLM). Differences between treatment means were determined by Duncan's multiple range test. Differences among means with \( P<0.05 \) were accepted as representing statistically significant differences.

**RESULTS**

**Physical characteristics evaluation**

The results of the physical quality evaluation of ERS in terms of colour, odor, texture, and molds are shown in Table 1. The ERS was loose and had no clumps and indicated that the
fermentation occurred as in the good quality silage, which gives a good impression. Regarding the temperature, there were no differences among all types of tested ERS. While the pH values were decreased (P<0.05) by adding the LAB, the decline of pH significantly (P<0.05) better with a high level of LAB addition. Acetic acid was significantly (P<0.05) increased in the ERS with the increased level of added LAB. Ammonia concentration in ERS and buffering capacity were significantly (P<0.05) increased with the presence of MU or whey and was significantly (P<0.05) more at the higher level of addition of LAB. The values of buffering capacity and Flieg Score significantly (P<0.05) improved with the presence of MU or whey. The higher level of addition of the LAB was significantly (P<0.05) higher than the low levels.

Regarding the number of microorganisms in ERS, no differences were found with mold counts among different ensiled types of RS and the numbers were in the normal range. Lactic acid bacteria, aerobic bacteria, and yeasts significantly (P<0.05) augmented with MU or whey, while were significantly (P<0.05) raised when added a higher level of LAB. The probability for the effect of silage type had a significant (P<0.05) effect on the concentration of LA, ammonia, buffering capacity, and fermentation coefficient, while it did not affect the pH, acetic acid, butyric acid, and Flieg Score. The probability for the effect of LAB had a significant (P<0.05) effect on pH, acetic acid, butyric acid, and Flieg Score, while it did not show an effect on LA, buffering capacity, and fermentation coefficient. Concerning the microbial count, the probability for the effect of silage type had a significant (P<0.05) effect on the total number, LAB, anaerobic bacteria, and yeast, whereas the probability for LAB showed an effect on a total count, except on the number of LAB and yeast.

**Chemical composition of ERS**

The chemical composition of the tested ERS in Table 2 shows that the ERS was of good quality, having a relatively appropriate DM content and high NDF and ADF contents. The DM content of ERS was higher (P<0.05) for silages included LAB with either MU or whey vs
RWL1 and RWL2 except for RWL3. Added of either MU or whey led to a significantly (P<0.05) increased of the ash content in ERS with significant (P<0.05) lower of OM compared with their absence. Moreover, ash content was significantly(P<0.05) evident with the increased addition of LAB, which reflected significantly(P<0.05) on lower OM. On the contrary, there was a significant (P<0.05) rise in the content of CP for ERS, especially when that contained MU or whey. The increase in protein content of ERS was significantly (P<0.05) greater with the addition of LAB bacteria. The content of ERS from EE and ash significantly (P<0.05) increased in the presence of MU or whey, and their content significantly (P<0.05) increased content further with the addition of the higher level of LAB bacteria.

As anticipated, the NDF and ADF content of the different ERS types, there was a significant (P<0.05) declined in its content in particular with those containing MU or whey. The content of NDF and ADF of ERS significantly (P<0.05) lowered with a higher level of addition of LAB bacteria. As for the content of different ERS types of NFC or WSC, it was significantly (P<0.05) higher when added either of MU or whey, while significant (P<0.05) furthers more with the addition of LAB. As for the effect of the ensiling method for RS on the chemical composition of the tested ERS, the ensiling process had a significant (P<0.05) moral effect on all components of the ERS, except for DM and EE content. While, LAB bacteria had a significant (P<0.05) effect on all ERS components except for OM, CP, and Ash content.

No significant difference was found in potential gas production (b) among all tested silage except RWL1 was decreasing (p<0.05). The gas production rate constant for the insoluble fraction b (h⁻¹) was not different among all experimental ERS incubated.

**In-vitro incubation of ERS**

The Basic pattern fermentation, GPt, and degradability of different types of ERS are shown in Table 3. The values of pH were significantly (P<0.05) observed lower when the ERS contained MU or whey compared to their absence when *in-vitro* incubation. A significant
(P<0.05) decline was also noted with the increase in the level of addition of the LAB. An opposite trend was observed with NH$_3$-N (g kg$^{-1}$ TN). Although the total of SCFA’s increased with ERS which included MU or whey at *in-vitro* incubation, the content of acetate, propionate, and butyrate (mmol/l) was not different. These results indicate that the fermentation efficiency in the rumen will increase with feeding on ERS which includes either MU or whey, especially when the addition of a high level of LAB.

The number of bacteria and protozoa significantly (P<0.05) increased with *in-vitro* incubation of ERS that included either MU or whey. On the other hand, found that adding LAB to the ERS significantly (P<0.05) increased the numbers of bacteria and protozoa. While significantly (P<0.05) increasing in volume of GPt with added MU or whey in ERS, the gas rate released was comparable among the different forms of ERS.

The gas released corresponds to the degradability of OM, NDF, and CP (%). The gas released corresponds to the degradability of OM, NDF, and CP (%). The degradability rates of IVOMD, IVNDFD, and IVCPD (%) increased (P<0.05) significantly of RMU and RWh compared to RW, especially with a high LAB level. The same trend was observed with ME (MJ/kg DM), MCP (g/kg DM), and RFV. The higher DM consumption with the ERS reflects the higher IVOMD, IVNDFD, and IVCPD.

**Chemical composition, intake, and palatability**

The content of DM and OM in the control diet were significantly (P<0.05) higher compared to those diets containing the experimental ERS. At the same time, the content of DM and OM decreased (P<0.05) in diets containing ERS especially with that employing MU or whey. The same trend was seen with the content of NDF and ADF in the ERS. In opposite, the control diet contents of CP, EE, and ash decreased (P<0.05) compared to feeds containing tested ERS. In the same context, the content of these components was significantly (P<0.05)
high in diets containing ERS, which included both MU or included whey. The same trend was seen with the contents of NFC, and WSC.

Although there were no differences in offered of all EAR types, the consuming and palatability for RWL3, RMUL3, and RWhL3 were significantly (P<0.05) higher compared to the control group fed UTRS. The consumption of RWhL3 was significantly (P<0.05) higher compared to RWL3 and RMUL3. The residues of feed (kg) were significantly (P<0.05) reduced when sheep fed ERS compared to fed on UTRS. While the feed residue of RWhL3 was lower (P<0.05) compared to RMUL3, which was significant (P<0.05) higher than the residual when fed RWL3. This result was reflecting on the eating time (min/d) of feed which decreased (P<0.05) at fed UTRS compared to the time spent on eating for fed ERS, except for RWL3. Reversing the trend was observed for actual feed consumption (AFC) and palatability compared to the time animals spent chewing feed (min/d). While the same trend of chewing time was observed with feed residue.

**Apparent Nutrient Digestibility**

The results obtained in Table 5 indicate that there were no differences (P>0.05) in the digestibility coefficient of NDF and ADF among all different tested groups. Feeds RMUL3 and RWhL3, which contained ERS, whether treated by MU or whey, showed a significant (P<0.05) increase in the digestibility coefficients of OM, CP, and EE compared to control. No differences are shown for CP and EE content of RWL3 compared to RMUL3, RWhL3, and control. The results appear that diet RWhL3, which contained ERS with whey, was significantly (P<0.05) superior for total digestible nutrients (TDN) and digestible crude protein (DCP) over the other tested groups, while there was no difference between RMUL3 and the control group.

**DISCUSSION**

**Physical quality evaluation**
Several studies have demonstrated that increasing dietary concentrate contents would increase the feed intake of ruminant animals, although they are typically fed high-fiber diets due to physiological and economic considerations [24]. The extent of fermentation and quality of ensiled crops hinges on pH value and well-preserved silage usually has a low pH but the LA concentration may be high [25, 26]. In our current study, the ERS preservation was good, as evidenced by the relative confidente pH, butyric acid, and NH₃–N values, and the relatively suitable ratio of LA to acetic acid, these data are in agreement with the results found by [27].

Whey is considered to be of high quality if the quality of the protein is taken into account, as it contains all the essential amino acids, vitamin D, and lactose [28] as the effects of lactose increase on the final products of fermentation with L. plantarum strain. From this, it can be speculated that the improvement of the fermentation which occurred with added whey at ERS, due to the type of sugars present in the whey compared to those in molasses. Generally, the acceleration of homofermentative attributable to adequate WSC during the initial stage of ensiling with L. plantarum addition, thus producing more LA, as was reported by [1]. The factors affecting the quality of fermentation include not only the physiological properties of epiphytic bacteria but also the chemical composition of ensiled material [26]. Microorganisms can be assorted according to their efficiency to grow at low, reasonable, or altitude temperatures (psychrophilic, mesophilic, and thermophilic microorganisms, respectively). In general, the proper temperature for good silage fermentation is <25°C [25]. Silage pH is a substantial factor in the long-range stability of the ensiled plant substance. A report by [28] stated that improvements in the aerobic stability of wheat silage were as a resulted of added LAB where leads to a decline in pH slowly.

The concentration of LA increased by the addition of whey or MU, compared to the non-addition and further was shown with an increased level of LAB. Rapid production of LA is important to obtain high-quality silage, as it is responsible for inactivating plant enzymes and
unwanted microorganisms that may inhibit fermentation or lead to deterioration of silage even
after the end of fusion, i.e. silage with low stability [25]. The pH values of ERS reported in our
study at 45d are within the range reported for well-ensiled materials [5] who reported that the
potential of sugarcane molasses and whey as additives to ensile lemongrass leaves was
investigated. The presence of acetic acid in silage indicates that fermentative bacteria were
active during ensiling, where acetic acid resulting from WSC fermentation [26]. The acetic
acid concentration in any subsequent period was lower than the LA concentration. The
concentration of acetic acid at any given ensiling period was lower than that of LA.

Increased NH$_3$-N in the silages containing urea could be a result of increased degrading
activities of bacteria. The simultaneous addition of MU resulted in higher NH$_3$-N values [26]
and with whey [5]. Soluble proteins could not be utilised optimally in the absence of adequate
WSC, therefore molasses, a source of WSC, is often used along with urea to help to prevent
silage instability [29]. A study by [26] states that the buffering capacity of silages increases
with the addition of urea. In the same context [30] found that the addition of 0.5% urea or 0.5%
urea plus 5% molasses to the silage significant effect on buffering capacity.

In the current study, the ERS was well preserved as indicated by good fermentation
characteristics especially with MU or whey, such as pH value and NH$_3$-N/TN ratio, as well as
Flieg points after 45 d of ensiling. In work by [1] reported lower yeasts and molds, and greater
aerobic stability in corn silage treated with MU and added LAB. Lower WSC content of RS in
the harvest stage restricts LAB growth during silage fermentation [29]. Therefore, adding MU
or adding whey resulted in the necessary nutrients for the LAB, which improved the
fermentation efficiency in silage. High numbers of yeasts in ensiled materials tend to spoilage
more quickly than that with lower numbers of yeasts when exposed to air [6], because many of
these yeasts are lactate assimilators. A report by [28] observed an increase in the LA
concentration in silage 15% with added molasse while increased 25% with whey and was
higher than in silage supplemented with commercial additive. Added whey or MU [5] improved the action of LAB, which is capable of amino acid. In the present study inoculation with LAB reduced P<0.05) pH, as well as the acetic acid, butyric acid, and NH₃-N contents, but increased the LA content. Current results imply that LAB inoculation promoted rapid acidification, which inhibited the proteolytic activities of plant enzymes [25]. The difference in the fermentation quality of silage among rice varieties was mainly because of the WSC concentration in the straw; LAB application and selection of rice varieties whose straw contains high levels of WSC are a good strategy for ERS. Therefore, the strain of bacteria used in the preparation of ERS can promote the propagation of LAB, decrease pH, inhibit the growth of clostridia and aerobic bacteria, and improve the quality [7]. The improvement in the quality of the wheat silages attributed to decrease major spoilage microorganisms such as aerobic, yeasts, which can utilize both WSC and LA, followed by molds [6].

**Chemical composition of ERS**

The ERS at appropriate forage ratios is a good option for making well-preserved RS as indicated by better ensiling profiles, ERS quality, and feeding values during ensiling. The effect of N level supported in this study caused favorable ensiling fermentation and lower fiber fractions [18]. The results obtained were very beneficial for the preservation and utilization of ERS without causing environmental concerns. A study [6] informed that the growth of LAB inoculant in silage might decrease DM loss. It is well documented that the silage content of DM records good values at appropriate storage periods of not less than 45d where usually recommended to ensiled materials at DM content not less than 30% [25]. This increase in ash content may be due to the molasses and whey added, as led to provide nutrient requirements of microorganisms in silage, which reflected on the fermentation and consumption of OM [28].

These levels of CP and NH₃-N in ERS indicated that possible responses in microbial growth from supplemental MU or whey. Similar to the findings of some previous studies [5,
the CP content increased at the end of the 45th d in ERS which including LAB with either MU or whey. Researchers showed an increase in the protein content of silage as a result of the high recovery of nitrogen applied and may reach up to 77% recovery [26]. Nitrogen recovery is a positive feature of urea from both the nutritional and economical aspects [25], also urea acts beneficially in the fibrous portion of the ensiled forage. Two main processes occurring in ammoniated forage mass with urea: ureolysis and ammoniolysis [3]. The increase of total fat in silo could be explained by a decrease of DM due to a loss of carbohydrates while increasing fat and fatty acids which is improbable to be aerobically degraded [7]. Regarding EE content, [1] documented that the content of EE increasing when ensiled alfalfa, it is possible that the increased number of organisms that are active in silage causes an increase in the fat content.

As a result of fermentation that occurs with the added either of MU or whey during the ensiled occur breakage of some cell walls, which leads to a decrease in the proportion of NDF and ADF as the suggestion of [5]. Furthermore, [1] stressed that the RS had high contents of structural carbohydrates, where NDF and ADF contents are approx. 71 and 41% of DM, respectively. Consequently, RS is difficult for long-term preservation through natural fermentation. The addition of molasses led to increasing NFC and WSC in the silage, as well as the addition of whey [28]. Higher contents of NFC or WSC could be anticipated from saccharolytic activity during silage fermentation [5]. Many factors affect the chemical composition of silage, such as the type and amount of feed additives and fermentation conditions [6]. The ensiling process, as one of the methods of preserving and treating green materials, has a significant effect on components of produced silage [1]. Many studies stated that [5, 18, 25, 26, 28] some components increase in ERS, while other studies reported that the opposite happens in other some ingredients [4].

In the current study perhaps the higher content of degradable nutrients in ERS provides an appropriate substrate for microorganisms which resulted in relatively high gas production. This
indicates that a combination of MU or whey may enhance the quality of the silage. In work of [3] indicated that the gas potential extent of gas production (b) and cumulative gas production at 120 h was increased by MU supplementation regardless of used dose (P<0.001). The molasses supplementation increased (b) value (P<0.001) regardless of added urea or no.

**In-vitro rumen fermentation**

In the current study, incubation of ERS including either MU or whey, with LAB inoculation to improve the basic pattern of in-vitro fermentation. One explanation for this observation might be underlying changes in the chemical composition of tested silage which results in enough energy and nitrogen source for enhanced and activities of microorganisms [6]. According to the suggestion of [26] might be increasing consumption of ERS leading to an increase in the final pH in the cultured fluid, possibly indicating the rapid release of NH$_3$-N from ERS and lower NH$_3$-N uptake by ruminal bacteria. The NH$_3$-N, SCFA's, acetic, and butyric acid was typical dominant fermentation because of the action of proteases during silage fermentation [5]. This indicating that the availability of microorganisms' requirements of a source of energy and nitrogen is a good thing in the ensiling process. A considerable increase in bacteria and protozoans indicates a change in the composition of the microbial community with an increase in NFC and WSC. This may be since LAB maintains a good range of acidity [25], which helps to increase the activity of bacteria and protozoa, thus increasing their numbers [6].

The effect of silage source on various microbial species and the characteristics of fermentation are linked to differences in the chemical composition between ERS. Generally, the ERS has a higher concentration of non-structural carbohydrates, also RMUL3 and RWhL3 contain higher concentrations of CP (Table 2) and degradable fiber fractions (Table 3). The diversity in physiology might be the reason why the significant effect of the silage
source on the numbers of protozoa was detected in our study. This may be because balanced
digestible nutrients from ERS set off a ruminal synergistic effect on the fractional rate of
degradation and the extent of fermentation, followed by better nutrient availability and
utilization efficiency for rumen microorganisms [1].

The use of microbial additives resulted in positive responses to the value of in-vitro DM
degradability. Reduced NDF and ADF content of ensiled materials may result from the action
of enzymes associated with bacteria [6], and the greater IVDMD found may reflect the
enzymatic hydrolysis effect [4]. Increased IVDOM, IVDCP and IVDNDF due to adding
molasses to silages are consistent with [26] reporting that the addition of molasses to the
silage increased digestibility due to increasing cell wall hydrolysis. The addition of whey or
MU to the silages increased the IVDCP compared with the control. They attributed this rise to
increasing the availability of soluble carbohydrates and nitrogen [5,28] in additives (MU, or
with whey) resulting in increased activity of proteolytic microorganisms in silage [4].

**Chemical composition, intake, and palatability**

Changes in the chemical composition of the tested diets are due to nutrient contents of ERS and
consumption. Although silage produced in warm climates tends to present greater
concentrations of NDF and less starch in comparison with that produced in temperate areas, the
digestibility of silage is expected to be associated with feed intake [26]. Higher consumption
and raise protein in ERS led to an increase in the protein content in the experimental diets. The
finding obtained in the current study on chemical composition is supported by [25] who found
that protein content and EE, were increased with feeding silage, and attributed that to silage
consumption and raise protein and EE content in silage. In contact, [5] reported that increasing
protein content and EE in the experimental diets are due to total intake and the levels of both in
the silage. According to [26] the restricted factor to forage intake will be the ruminal fill
provided by the fiber. The volume of the plant cell has been linked to the filling effect [25, 26].
Hence, this effect attributed to the lower intake of treatments containing ERS (i.e. RWL3, RMUL3, and RWhL3) compared with control one and may be ascribed to the interaction among filling, the rumen-distension capacity, and the energy density because no differences (P>0.05) were found between the treatments regarding the time used for feeding. Raising feed consumption and palatability of ERS compared to the control diet, attributed to the higher in-vitro degradability of OM, NDF, and CP, these results are typical of the findings of [25]. A similar intake of ERS was observed to that reported by [4], and may partially reflect their similar NDF concentrations. The NFC of the diets was higher for the treatments containing ERS (Table 2). Thus, the availability of more fermentable nutrients might have influenced the intake of ERS-based diets [1,3,25]. The finer chop length and the fiber content of the ERS may also have contributed to its improved intake, which also can be explained that by the compensating effect of the higher DM content [26]. The decrease eaten of UTRS is due to the bitter taste caused by the treatment, which corresponds to the low palatability. The increased chewing rate of UTRS compared to RMUL3 and RWhL3 is due to it being one of the means to stimulate saliva production when feeding on urea-treated feeds. Saliva contributes to regulating pH levels and is involved in the recycling of nitrogen to the rumen. Higher content of NDF as shown in Table 4 corresponds to [24] who found that increasing proportion of NDF and length of particle size of forage leading to the increased time spent chewing.

**Apparent Nutrient Digestibility**

Although molasses or whey [5] as additives increased silage quality and dry matter intake, they don't improve the digestibility of NDF and ADF. Might be, ERS feed with concentrate supplementation improved in-vivo digestibility values of DM, NDF, and ADF in most cases reflecting the inclusion of the concentrates in the diet according to [20], while relativity of ensiling effects was maintained. The considerably higher intake of the diet containing ERS compared to the control, at least partially reflecting the higher in-vitro OM and CP
degradability and shorter chop length of the former [7], likely resulted in a faster passage rate through the rumen [4]. The latter is the suggested reason for the absence of any difference in DM digestibility among diets containing ERS. The consumption of ERS meant that the scale of difference between ERS in IVDOM and IVDCP was reflected in differences of a similar magnitude when measured \textit{in-vivo}. The forages may have changes in the nutritive value due to the procedures during production, conservation, and post-opening management and biochemical and microbiology phenomena [9, 10]. The trend for a slightly higher \textit{in-vivo} digestibility for urea-treated and ensiled materials relative to untreated reflects a similar trend in \textit{in-vitro} degradability under conditions where DM intakes for these two feeds did not differ (P>0.05) [7,24,26]. Because intake is an important factor for milk production, not only the concentration of NDF but also, their digestibility a determinant of the nutritive value of corn silage [3].

\textbf{CONCLUSIONS}

The results of the current study recommend that the possibility of adding whey when ensiling rice straw. The data obtained indicate that adding whey gives better results compared to added molasses with urea. At the same time, adding lactic acid bacteria results in higher quality rice straw as ruminant feed and increases the nutritional value.

\textbf{CONFLICT OF INTEREST:} We certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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Table (1): Physico-chemical characteristics of 45-d re-growths of different types of ERS inoculated with LAB.

| Treat | RW          | RMU         | RWh         | ±SE | P< | Silage | LAB | Silage | LAB |
|-------|-------------|-------------|-------------|-----|----|--------|-----|--------|-----|
| RWL1  | 26.89       | 26.67       | 26.45       | 0.556 | ns  | ns     | ns  | ns     |     |
| RWL2  | 46.89       | 46.67       | 46.45       | 0.036 | ns  | *      | *   | *      |     |
| RWL3  | 46.89       | 46.67       | 46.45       | 0.036 | ns  | *      | *   | *      |     |
| RMUL1 | 46.89       | 46.67       | 46.45       | 0.036 | ns  | *      | *   | *      |     |
| RMUL2 | 46.89       | 46.67       | 46.45       | 0.036 | ns  | *      | *   | *      |     |
| RMUL3 | 46.89       | 46.67       | 46.45       | 0.036 | ns  | *      | *   | *      |     |
| RWhL1 | 46.89       | 46.67       | 46.45       | 0.036 | ns  | *      | *   | *      |     |
| RWhL2 | 46.89       | 46.67       | 46.45       | 0.036 | ns  | *      | *   | *      |     |
| RWhL3 | 46.89       | 46.67       | 46.45       | 0.036 | ns  | *      | *   | *      |     |

### Physical characteristics

| Treat | Colour          | Aroma         | Texture | Temp (°C) | Acidity (pH) | Fermentation | Microbes, (log10 cfu g⁻¹ FM) |
|-------|-----------------|---------------|---------|-----------|--------------|--------------|-------------------------------|
|       | Yellowish       | pleasant      | Firm    | 26.89     | 4.37          | LA           | Total bacteria                 |
|       | pleasant        | fruity        | Firm    | 26.67     | 4.13          | AC           | LAB                           |
|       | light-yellow    | fruity        | Firm    | 26.45     | 4.09          | Bu           | Aerobic bacteria              |
|       | pleasant        | alcoholic     | Firm    | 25.90     | 4.09          | LA/AC        | Molds                         |
|       | light-yellow    | fruity        | Firm    | 26.89     | 4.09          | NH₃-N (g kg⁻¹ TN) |                  |
|       | pleasant        | alcoholic     | Firm    | 26.45     | 4.21          | BC (mEq/kg DM) |                  |
|       | light-yellow    | fruity        | Firm    | 25.90     | 4.10          | FC           |                  |
|       | pleasant        | alcoholic     | Firm    | 25.90     | 4.08          | FS           |                  |

### Physical characteristics

- Colour: Yellowish
- Aroma: pleasant, fruity, alcoholic
- Texture: Firm
- Temperature (°C): 26.89, 26.67, 26.45
- Acidity (pH): 4.37, 4.13, 4.09

### Fermentation

- LA (mmol/l): 40.00, 42.00, 45.00
- AC (mmol/l): 14.38, 14.88, 16.00
- Bu (mmol/l): 1.69, 1.53, 1.51
- LA/AC: 1.30, 1.34, 1.14
- NH₃-N (g kg⁻¹ TN): 3.63, 3.72, 4.43
- BC (mEq/kg DM): 13.37, 13.53, 13.71
- FC: 38.08, 38.15, 38.30
- FS: 88.07, 97.94, 99.42

### Microbes, (log10 cfu g⁻¹ FM)

- Total bacteria: 9.28, 9.42, 9.56
- LAB: 2.82, 3.54, 3.73
- Aerobic bacteria: 5.46, 5.54, 5.63
- Molds: 4.12, 4.08, 4.04
| Yeasts | 4.03<sup>bc</sup> | 3.95<sup>cd</sup> | 3.83<sup>d</sup> | 4.21<sup>a</sup> | 4.17<sup>ab</sup> | 4.13<sup>ab</sup> | 4.17<sup>ab</sup> | 4.12<sup>bc</sup> | 4.08<sup>abc</sup> | 0.049 | * | * | * |
|--------|-------------------|------------------|------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-------------|-------|-------|-------|

RW = ensiled rice straw by water; RMU = ensiled rice straw by molasses & urea; RWb = ensiled rice straw by whey; RWL1 = ensiled rice straw with water and low level of LAB; RWL2 = ensiled rice straw with water and a medium level of LAB; RWL3 = ensiled rice straw with water and high level of LAB; RMUL1 = ensiled rice straw with molasses and urea + low level of LAB; RMUL2 = ensiled rice straw with molasses and urea + the medium level of LAB; RMUL3 = ensiled rice straw with molasses and urea + high level of LAB; RWhL1 = ensiled rice straw with whey and low level of LAB; RWhL2 = ensiled rice straw with whey and a medium level of LAB, and RWhL3 = ensiled rice straw with whey and high level of LAB.

Means within rows with unlike superscript differ significantly (p<0.05), FC = Fermentation coefficient, and FS = Flieg Score.
Table (2): Chemical composition of different types of ERS.

| Treat | RW | RMU | RWh | ±SE | P< Silage LAB Silage *LAB |
|-------|----|-----|-----|-----|--------------------------|
|       | RWL1 | RWL2 | RWL3 | RMUL1 | RMUL2 | RMUL3 | RWhL1 | RWhL2 | RWhL3 |
| DM    | 36.41<sup>c</sup> | 36.47<sup>b</sup> | 36.56<sup>c</sup> | 36.44<sup>bc</sup> | 36.48<sup>abc</sup> | 36.52<sup>b</sup> | 36.48<sup>abc</sup> | 36.48<sup>abc</sup> | 0.026 | ns   | *   | *   |
| OM    | 78.21<sup>d</sup> | 77.14<sup>e</sup> | 76.31<sup>f</sup> | 81.85<sup>a</sup> | 80.90<sup>b</sup> | 80.01<sup>c</sup> | 81.58<sup>a</sup> | 80.94<sup>b</sup> | 0.149 | *    | ns  | *   |
| CP    | 3.63<sup>b</sup> | 3.72<sup>h</sup> | 4.43<sup>g</sup> | 5.13<sup>f</sup> | 5.33<sup>e</sup> | 6.02<sup>d</sup> | 6.27<sup>c</sup> | 6.57<sup>b</sup> | 7.40<sup>a</sup> | 0.044 | *    | ns  | *   |
| EE    | 0.66<sup>e</sup> | 0.91<sup>c</sup> | 1.47<sup>d</sup> | 0.63<sup>e</sup> | 0.86<sup>ab</sup> | 1.40<sup>ab</sup> | 0.59<sup>e</sup> | 0.82<sup>d</sup> | 1.33<sup>b</sup> | 0.029 | ns   | *   | *   |
| Ash   | 21.79<sup>c</sup> | 22.86<sup>b</sup> | 23.69<sup>a</sup> | 18.15<sup>f</sup> | 19.10<sup>e</sup> | 19.99<sup>d</sup> | 17.99<sup>f</sup> | 18.42<sup>d</sup> | 19.06<sup>e</sup> | 0.149 | *    | ns  | *   |
| NDF   | 60.03<sup>a</sup> | 56.31<sup>c</sup> | 54.75<sup>f</sup> | 57.96<sup>b</sup> | 54.37<sup>ef</sup> | 52.86<sup>b</sup> | 55.89<sup>d</sup> | 52.42<sup>b</sup> | 50.97<sup>i</sup> | 0.126 | *    | *   | *   |
| NFC   | 13.89<sup>d</sup> | 16.21<sup>g</sup> | 15.65<sup>h</sup> | 18.13<sup>f</sup> | 20.33<sup>c</sup> | 19.72<sup>d</sup> | 19.26<sup>e</sup> | 21.78<sup>a</sup> | 21.24<sup>b</sup> | 0.155 | *    | *   | *   |
| WSC   | 2.79<sup>f</sup> | 2.85<sup>ef</sup> | 2.99<sup>g</sup> | 3.94<sup>d</sup> | 4.09<sup>d</sup> | 4.30<sup>f</sup> | 4.98<sup>b</sup> | 5.01<sup>b</sup> | 5.36<sup>a</sup> | 0.050 | ns   | *   | *   |

RW=ensiled rice straw by water; RMU=Ensiled rice straw by molasses & urea and RWh=Ensiled rice straw by whey; RWL1= ensiled rice straw with water and low level of LAB; RWL2= ensiled rice straw with water and medium level of LAB; RWL3= ensiled rice straw with water and high level of LAB; RMUL1= ensiled rice straw with molasses and urea+ low level of LAB; RMUL2= ensiled rice straw with molasses and urea + the medium level of LAB; RMUL3= ensiled rice straw with molasses and urea + high level of LAB; RWhL1= ensiled rice straw with whey and low level of LAB; RWhL2= ensiled rice straw with whey and a medium level of LAB, and RWhL3= ensiled rice straw with whey and high level of LAB.

Means within rows with unlike superscript differ significantly (p<0.05),
Table (3): Basic pattern fermentation, gas production and degradability of different types of ERS.

| Treat | RW | RM | RNA | RPM | RMN | RPMH | RPMHL | RPMHNL | ±SE | P< | Silage | LAB | Silage | LAB |
|-------|----|----|-----|------|------|-------|--------|--------|-----|-----|--------|-----|--------|-----|
|       | RWL1 | RWL2 | RWL3 | RMUL1 | RMUL2 | RMUL3 | RWHL1 | RWHL2 | RWHL3 |     |       |       |       |     |
| **Basic pattern fermentation** |           |           |           |           |           |           |           |           |     |       |       |       |     |
| pH   | 5.26<sup>a</sup> | 5.70<sup>cd</sup> | 6.14<sup>abc</sup> | 5.83<sup>bc</sup> | 6.11<sup>abc</sup> | 6.30<sup>ab</sup> | 6.40<sup>a</sup> | 6.52<sup>a</sup> | 6.46<sup>a</sup> | 0.165 | * | * | * | * |
| NH<sub>3</sub>-N (g kg<sup>-1</sup> TN) | 0.32<sup>h</sup> | 0.37<sup>g</sup> | 0.46<sup>f</sup> | 0.49<sup>e</sup> | 0.57<sup>d</sup> | 0.71<sup>c</sup> | 0.65<sup>b</sup> | 0.77<sup>b</sup> | 0.96<sup>a</sup> | 0.015 | * | * | * | * |
| SCFA’s (mmol/l) | 69.87<sup>e</sup> | 72.37<sup>f</sup> | 73.57<sup>e</sup> | 73.36<sup>e</sup> | 75.99<sup>d</sup> | 77.24<sup>c</sup> | 76.85<sup>c</sup> | 79.61<sup>b</sup> | 80.92<sup>a</sup> | 0.335 | * | * | * | * |
| AC (mmol/l) | 51.66<sup>e</sup> | 52.74<sup>de</sup> | 53.84<sup>cde</sup> | 54.24<sup>bcde</sup> | 55.38<sup>abde</sup> | 56.54<sup>abed</sup> | 56.83<sup>abe</sup> | 58.01<sup>ab</sup> | 59.23<sup>a</sup> | 1.246 | * | ns | * | * |
| Pr (mmol/l) | 23.71<sup>e</sup> | 24.22<sup>de</sup> | 24.74<sup>cde</sup> | 24.89<sup>cde</sup> | 25.43<sup>bcd</sup> | 25.97<sup>abc</sup> | 26.08<sup>ab</sup> | 26.64<sup>ab</sup> | 27.21<sup>a</sup> | 0.506 | * | ns | * | * |
| Bu (mmol/l) | 11.72<sup>h</sup> | 11.97<sup>gh</sup> | 12.22<sup>6g</sup> | 12.31<sup>ef</sup> | 12.57<sup>de</sup> | 12.83<sup>abc</sup> | 12.80<sup>b</sup> | 13.16<sup>ab</sup> | 13.44<sup>a</sup> | 0.107 | * | * | * | * |
| AC: Pr | 2.18 | 2.18 | 2.18 | 2.18 | 2.18 | 2.18 | 2.18 | 2.18 | 2.18 | 0.082 | ns | ns | ns | * |
| Bacteria (10<sup>6</sup>) | 6.75<sup>f</sup> | 6.89<sup>ef</sup> | 7.04<sup>def</sup> | 7.09<sup>de</sup> | 7.24<sup>d</sup> | 7.39<sup>bc</sup> | 7.43<sup>bc</sup> | 7.58<sup>ab</sup> | 7.74<sup>a</sup> | 0.098 | * | * | * | * |
| Protozoa (10<sup>3</sup>) | 4.75<sup>c</sup> | 4.85<sup>bc</sup> | 4.95<sup>abc</sup> | 4.99<sup>abc</sup> | 5.09<sup>abc</sup> | 5.20<sup>abc</sup> | 5.22<sup>abc</sup> | 5.33<sup>ab</sup> | 5.45<sup>a</sup> | 0.167 | * | ns | * | * |
| **Gas Production** |           |           |           |           |           |           |           |           |     |       |       |       |     |
| b (ml/kg OM) | 41.01<sup>b</sup> | 41.90<sup>ab</sup> | 43.14<sup>ab</sup> | 43.21<sup>ab</sup> | 43.39<sup>ab</sup> | 43.74<sup>ab</sup> | 43.18<sup>ab</sup> | 43.74<sup>ab</sup> | 44.23<sup>a</sup> | 0.954 | * | ns | ns | * |
| c (mg/l OMD) | 0.036 | 0.035 | 0.036 | 0.035 | 0.035 | 0.035 | 0.036 | 0.038 | 0.037 | 0.037 | 0.003 | ns | ns | ns | * |
| **Degradability of (OM, NDF and CP %), Metabolizable energy, Microbial protein and Relative feeding value** |           |           |           |           |           |           |           |           |     |       |       |       |     |
| IVOMD (%) | 38.31<sup>e</sup> | 38.69<sup>e</sup> | 42.56<sup>cd</sup> | 40.30<sup>de</sup> | 40.71<sup>de</sup> | 44.78<sup>bc</sup> | 45.72<sup>bc</sup> | 46.18<sup>b</sup> | 50.79<sup>a</sup> | 1.069 | * | * | * | * |
| IVNDFD (%) | 34.48<sup>e</sup> | 34.28<sup>de</sup> | 37.97<sup>cd</sup> | 34.81<sup>cde</sup> | 35.16<sup>d</sup> | 38.67<sup>c</sup> | 38.29<sup>bc</sup> | 41.70<sup>bc</sup> | 45.87<sup>a</sup> | 0.438 | * | * | * | * |
| IVCPD (%) | 32.30<sup>e</sup> | 33.20<sup>de</sup> | 36.24<sup>c</sup> | 33.80<sup>de</sup> | 34.14<sup>d</sup> | 37.55<sup>c</sup> | 37.81<sup>c</sup> | 40.38<sup>b</sup> | 43.50<sup>a</sup> | 0.517 | * | * | * | * |
| ME (MJ/kg DM) | 5.89<sup>e</sup> | 5.95<sup>de</sup> | 6.10<sup>ed</sup> | 6.13<sup>de</sup> | 6.17<sup>bc</sup> | 6.25<sup>abc</sup> | 6.31<sup>abc</sup> | 6.34<sup>ab</sup> | 6.41<sup>a</sup> | 0.065 | * | ns | * | * |
| MCP (g/kg DM) | 1.23<sup>e</sup> | 1.24<sup>e</sup> | 1.37<sup>cd</sup> | 1.30<sup>de</sup> | 1.31<sup>de</sup> | 1.44<sup>bc</sup> | 1.47<sup>bc</sup> | 1.49<sup>bc</sup> | 1.63<sup>a</sup> | 0.034 | * | * | * | * |
| RFV | 86.47<sup>f</sup> | 95.57<sup>g</sup> | 99.76<sup>h</sup> | 91.39<sup>h</sup> | 100.82<sup>d</sup> | 105.15<sup>c</sup> | 96.67<sup>h</sup> | 106.45<sup>b</sup> | 110.95<sup>a</sup> | 0.354 | * | * | * | * |

**RW**=ensiled rice straw by water; **RMU**= ensiled rice straw by molasses & urea and **RWh**= ensiled rice straw by whey; **RWL1**= ensiled rice straw with water and low level of LAB; **RWL2**= ensiled rice straw with water and a medium level of LAB; **RWL3**= ensiled rice straw with water and high level of LAB; **RMUL1**= ensiled rice straw with molasses and urea + low level of LAB; **RMUL2**= ensiled rice straw with molasses and urea + medium level of LAB; **RMUL3**= ensiled rice straw with molasses and urea + high level of LAB; **RWHl1**= ensiled rice straw with whey and low level of LAB; **RWHl2**= ensiled rice straw with whey and a medium level of LAB, and **RWHl3**= ensiled rice straw with whey and high level of LAB.

**IVOMD** = Organic matter degradability, **IVNDFD** = Neutral detergent fiber degradability, **IVCPD** = Crude protein degradability, **ME** = Metabolizable energy (MJ/kg DM), **MCP** = Microbial crude protein g/kg DM and **RFV** = Relative feeding value, **b** = potential gas production (ml/kg OM) and **c** = the gas production rate constant for the insoluble fraction (h<sup>-1</sup>). Means within rows with unlike superscript differ significantly (p<0.05).
Table (4): Chemical composition, Body weight, Feed intake, palatability, Feeding behavior, of experimental diets.

| Treat | Ingredients | CFM | UTRS | Control | RWL3 | RMUL3 | RWhL3 | ±SE |
|-------|-------------|-----|------|---------|------|-------|-------|-----|
| Chemical composition (%) | | | | | | | | |
| DM    |             | 89.72 | 51.01 | 66.75<sup>a</sup> | 56.76<sup>b</sup> | 55.34<sup>c</sup> | 54.90<sup>d</sup> | 0.156 |
| OM    |             | 91.08 | 82.99 | 86.28<sup>a</sup> | 81.92<sup>d</sup> | 83.93<sup>c</sup> | 84.45<sup>b</sup> | 0.078 |
| CP    |             | 13.89 | 5.45  | 8.88<sup>c</sup> | 8.03<sup>d</sup>  | 8.81<sup>b</sup>  | 9.64<sup>a</sup>  | 0.030 |
| EE    |             | 2.71  | 0.44  | 1.36<sup>c</sup> | 1.94<sup>a</sup>  | 1.86<sup>ab</sup> | 1.80<sup>b</sup>  | 0.027 |
| Ash   |             | 8.92  | 17.01 | 13.72<sup>d</sup> | 18.08<sup>a</sup> | 16.07<sup>b</sup> | 15.55<sup>c</sup> | 0.078 |
| NDF   |             | 36.27 | 57.85 | 49.07<sup>a</sup> | 47.73<sup>b</sup> | 46.99<sup>c</sup> | 45.89<sup>d</sup> | 0.103 |
| ADF   |             | 19.73 | 45.30 | 34.90<sup>a</sup> | 31.52<sup>b</sup> | 31.16<sup>c</sup> | 30.43<sup>d</sup> | 0.095 |
| NFC   |             | 38.21 | 19.26 | 26.97<sup>c</sup> | 24.22<sup>d</sup> | 26.26<sup>b</sup> | 27.11<sup>a</sup> | 0.083 |
| WSC   |             | 7.92  | 3.39  | 5.23<sup>c</sup> | 4.86<sup>c</sup>  | 5.58<sup>b</sup>  | 6.25<sup>a</sup>  | 0.063 |
| Body weight (kg) | -- | -- | 56.59 | 56.59 | 56.14 | 56.59 | 0.831 |
| Feed intake (kg) and palatability (%) of ERS | | | | | | | |
| Feed Offer(kg) | -- | -- | 1.698 | 1.698 | 1.684 | 1.698 | 0.025 |
| Actual Feed consumed (kg) | -- | -- | 1.219<sup>c</sup> | 1.324<sup>b</sup> | 1.381<sup>b</sup> | 1.492<sup>a</sup> | 0.021 |
| Feed Residues(kg) | -- | -- | 0.479<sup>a</sup> | 0.374<sup>b</sup> | 0.303<sup>c</sup> | 0.206<sup>d</sup> | 0.014 |
| Palatability (%) | -- | -- | 71.75<sup>d</sup> | 78.00<sup>c</sup> | 82.00<sup>b</sup> | 87.88<sup>a</sup> | 0.729 |
| The feeding behavior for ERS | | | | | | | |
| Eating (min/d) | -- | -- | 178<sup>b</sup> | 184<sup>ab</sup> | 191<sup>a</sup> | 191<sup>a</sup> | 2.430 |
| Ruminating (min/d) | -- | -- | 494 | 493 | 491 | 490 | 3.761 |
| Chewing (min/d) | -- | -- | 772<sup>a</sup> | 766<sup>ab</sup> | 765<sup>b</sup> | 755<sup>b</sup> | 3.791 |

CFM= Concentrate Feed Mixture; UTRS=Urea treated rice straw; RWL3= ensiled rice straw with water and high level of LAB; RMUL3= ensiled rice straw with molasses and urea + high level of LAB, and RWhL3= ensiled rice straw with whey and high level of LAB.

Means within rows with unlike superscript differ significantly (p<0.05).
Table (5): Apparent digestibility and energy partitioning of different diets

| Item       | Control | RWL₃ | RMUL₃ | RWhL₃ | ±SE |
|------------|---------|------|-------|-------|-----|
| **Apparent digestibility coefficients (%)** |         |      |       |       |     |
| DM         | 60.78   | 62.34| 63.31 | 65.52 | 1.840|
| OM         | 62.07<sup>b</sup> | 63.24<sup>ab</sup> | 64.15<sup>a</sup> | 65.63<sup>a</sup> | 0.506|
| CP         | 52.28<sup>b</sup> | 56.68<sup>ab</sup> | 57.53<sup>a</sup> | 59.32<sup>a</sup> | 1.434|
| EE         | 64.56<sup>b</sup> | 65.02<sup>ab</sup> | 68.17<sup>a</sup> | 69.43<sup>a</sup> | 1.415|
| NDF        | 51.33   | 53.46 | 54.85 | 56.19 | 1.593|
| ADF        | 43.90   | 45.31 | 46.03 | 46.78 | 1.442|
| **Nutritive value** |         |      |       |       |     |
| TDN (%)    | 48.55<sup>c</sup> | 51.72<sup>b</sup> | 52.00<sup>b</sup> | 54.27<sup>a</sup> | 0.415|
| DCP (%)    | 2.32<sup>d</sup> | 3.09<sup>c</sup> | 3.46<sup>b</sup> | 4.39<sup>a</sup> | 0.087|

CFM= Concentrate Feed Mixture; UTRS=Urea treated rice straw; RWL₃= ensiled rice straw with water and high level of LAB; RMUL₃= ensiled rice straw with molasses and urea + high level of LAB, and RWhL₃= ensiled rice straw with whey and high level of LAB; TDN (%) =DOM%+(DEE%×1.25), DCP=digestible crude protein.

Means within rows with unlike superscript differ significantly (p<0.05).