ASSESSMENT OF THE NUTRITIONAL COMPOSITION OF MAIZE STOVER SILAGE ENRICHED WITH LOCAL DISTILLATE RESIDUE AND ITS FEASIBILITY AS WINTER FODDER

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ABSTRACT: *To address the shortage of nutritional feed for the cattle during winter season, maize stover was enriched with 0%, 10%, 20%, and 30% of local distillate residue (LDR) in the portable plastic bags (PPBs). The physical characteristic, pH, nutrient composition, and aerobic stability of the silage were determined at 60 days of ensiling. The palatability of the silage was determined by feeding the Jersey cows at the College of Natural Resources (CNR) dairy farm, at Lobesa, Punakha. The experimental design adopted was completely randomized. All the treatments had acceptable physical characteristics regarding colour, smell, and texture. The pH for all the treatments varied from 4.52 – 3.12, indicating adequate fermentation. Dry matter (DM) content of the silage was 21.84%, 21.79%, 18.79%, and 18.02% while crude protein (CP) content was 8.83%, 12.25%, 17.51%, and 46.83% for the T0, T1, T2 and T3 respectively. The crude fiber content decreased from 81.32%, 73.54%, 33.99%, and 29.79% with the increased inclusion of LDR in the silage. The moisture content was highest for T3 at 81.98% and decreased as the inclusion rate of the LDR reduced. Maize stover silage enriched with LDR exhibited better aerobic stability and lesser likelihood of aerobic deterioration. The palatability percent for the silage with 30% of LDR was high and was considered more palatable and accepted by the Jersey cows. It was concluded that LDR is a suitable residual by-product for ensiling with maize stover, as it enhances the nutrient composition, improves the physical characteristic, increases the palatability of the feed, and provides better aerobic stability against deterioration.*

Keywords: Ensiling; Local distillate residue; Maize stover; Nutrient composition; Palatability; Winter fodder

1. INTRODUCTION

Livestock farming significantly contributes to food security, employment opportunities, and economic stability (Gyeltshen et al. 2017). In Bhutan, livestock farming is an important component of the integrated and subsistence farming system. Livestock production primarily depends on the quality of feed and fodder throughout the season. In Bhutan, livestock farmers rely on forests, fallow croplands, and agricultural by-products as livestock feed (Wangchuk, 2008). By-products like maize stover and distillate residue have the potential to feed livestock efficiently (Amuda et al. 2017). However, they are often underutilized as animal feed a due to lack of technical knowledge by small-scale farmers, on how best to effectively use them (Amuda et al. 2017).

Maize stover contains high crude fiber but low digestibility and crude protein content (Ferraretto et al. 2022). On the other hand, distillate residue has high crude protein content, and high digestibility but low crude fiber (Ridla & Uchida, 1994). According to Koc et al. (2010), distillery grain is a suitable by-product for ensiling and, when ensiled with a whole maize plant, it improves the overall quality of silage. Therefore, the findings of this study provide insights into the nutrient composition, physical characteristics, aerobic stability, and palatability of maize stover silage enriched with local distillate residue as a feasible winter fodder.

2. MATERIALS AND METHODS

2.1 Study area

The experiment was carried out at Kilkhorthang gewog under Tsirang Dzongkhag. It has an altitude that ranges from 900 to 1600 meters above sea level (RGoB, 2018). Tsirang has a temperate highland tropical climate with a dry winter climate. The yearly temperature is 26.75ºC and it is 11.15% higher than Bhutan's average temperature. Tsirang typically receives about 180.8 millimeters of precipitation and has 147.56 rainy days (40.43% of the time) annually (BT Climate Zone, 2024). The principal crops grown in Tsirang dzongkhag are paddy and maize (RGoB, 2018).

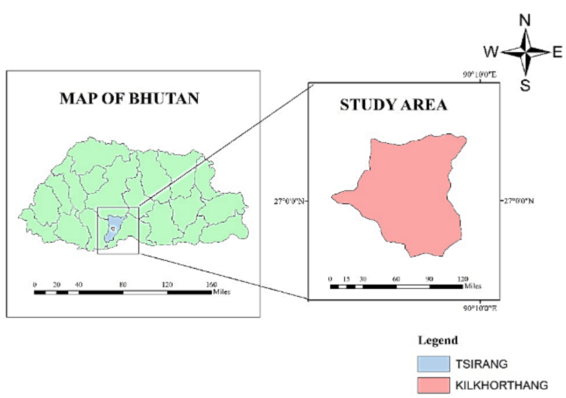

Figure 1: Study area of Kilkhorthang gewog, Tsirang

2.2 Source of maize stover and local distillate residue

The harvesting and ensiling of the silage were carried out at Kilkhorthang Gewog, Tsirang. For the silage preparation, a total of 250 kg of fully matured local maize stover was harvested from the farmers in Tsirang. Additionally, 20Ltr millet-based local distillate residues were collected from the traditional alcohol brewing farmer in the same region. After 60 days of the fermentation period, the silage was transported to CNR College for conducting feeding trials and comprehensive parameter assessment.

2.3 Preparation of silage

For the preparation of the silage, maize stover was chopped into pieces (3-4 cm) to facilitate good compaction and fermentation during ensiling. The chopped maize stover was wilted for 10-12 hours under the sun, to achieve the moisture content of 65-70% in maize stover. After harvesting, the silage was ensiled within two days of chopping and wilting to prevent quality deterioration. PPBs having a capacity of 45-50kg were made using medium-sized transparent polythene plastics. The maize stover and the local distillate residue of the measured ratio were mixed properly to ensure an even distribution of the distillate residue in a huge bowl. The portable plastic bag was then filled with chopped maize stover mixed with different ratios of local distillate residue in the proportion specified below in Table 1 and was compressed by hand. The remaining excess air was removed using an electric vacuum suction machine (230V). And the open end was tightly sealed with the tape. The ensiled plastic bag was stacked and stored at room temperature (21-22°C) for a period of 60 days.

2.4 Experimental design and group for palatability trial

There was a total of four treatments. Under each treatment, there were three replicates each. Each replicate (Portable plastic bag) was filled with 20kg of silage. The experimental design adopted was completely randomized design. T0 was prepared with 0% local distillate residue and served as a control group. The control group was required to provide baseline data and compare the effects of adding LD R to the maize stover and ensiling it.

For the feeding trial, jersey cows at the CNR dairy farm were used to determine the palatability of the silage. Four Jersey cows were randomly selected for the feeding trial. The selected cows were used for evaluating the silage intake for 20 days. Experimental groups of maize stover enriched with different ratios of local distillate residue are given below in Table 1.

Table 1: Silage combination

Treatment	Maize stover (%)	LDR (%)
T0	100%	0%
T1	90%	10%
T2	80%	20%
T3	70%	30%

2.5 Silage quality

The silage was opened after ensiling for 60 days. The overall appearance, smell, texture, and pH of the silage were evaluated based on the criteria developed by Ososanya and Olorunnisomo (2015). These assessments were conducted under the supervision of experienced researcher, Dr. Penjor. The criteria are given below the Table 2.

2.6 Laboratory analysis of the nutrient composition of silage

The nutrient analysis of maize stover silage enriched with LDR was carried out at the laboratory of CNR following the guidelines developed by Moktan and Tenzin (2017). The dry matter (DM) and moisture were determined by drying in a hot air oven at 120°C for 12 hours. Ash was determined by igniting the sample in the muffle furnaces at 400°C for 3 hours. Crude protein (CP) and Nitrogen content were determined using the Kjeldahl method. The fat analysis was done using a Soxhlet extractor and the fiber analysis was done through Weendes' method using Fibra Plus. The pH of the silage sample was determined by using a Portable digital pH meter, following the procedure developed by Clemson University (2024).

2.7 Aerobic stability test

The aerobic stability was performed with the methodology proposed by Basso *et al*. (2012), which involves monitoring and observing the silage's temperature and its ability to resist the spoilage during exposure to the air. It is a key factor in ensuring that

Table 2: Criteria for the physical quality of silage

Physical Properties	Very bad	Bad	Going bad	Moderate	Good	Excellent
Color	Very dark	Dark	Dark Brown	Deep brown	Brown	Light brown
Smell	Offensive	Poor	Almost pleasant	Fairly pleasant	Pleasant	Very pleasant
Texture	Slimy	Very soft	Soft	Moderately firm	Firm	Very firm
pH	>6.5	6.1 – 6.5	5.6 - 6.0	4.6 – 5.5	4.0 – 4.5	<4.0

**CP: crude protein, DM: dry matter, LDR: local distillate residue* silage provides well-preserved nutrients to the animal with minimal amounts of mould, spores and toxins.

To assess the aerobic stability, samples of silage from each treatment group were mixed thoroughly to ensure homogeneity, and three kilograms of the fresh sample content were collected inside the small polythene plastic bag. The samples in the polythene plastic bag were left uncovered. The sample was kept at room temperature of 20°C-21°C and the changes in the temperature were recorded using a thermometer. The initial temperature of the silages was recorded and further daily observation and changes in the temperature were recorded for a period of 20 days. Increase in temperature indicates microbial activity and the potential to spoilage.

2.8 Palatability test

The feeding trial was conducted for 20 days at the CNR dairy farm to assess the palatability of the silage. The Jersey cows were used for the determination of the palatability of the silage. Each cow was provided with 2 kg of the respective silage and the feeding was carried out once a day, in the evening. The palatability percentage was calculated using the formula provided by Ososanya and Olorunnisomo (2015) as follows:

$$\%\text{palatability} = \frac{\text{Total feed provided-Total leftover}}{\text{Total feed provided}} \text{ x100}$$

2.9 Data analysis

The data was tabulated in Microsoft Excel 2013 Spreadsheet and was analyzed using the SPSS (Statistical Package for Social Sciences) version 23 software for further analysis. The differences between the mean of treatments were analyzed using one-way ANOVA (Analysis of Variance). The significance level at $P < 0.05$ was used to compare the mean differences between the treatments.

3. RESULTS AND DISCUSSION

3.1 Nutritional Composition of Maize stover and LDR before being ensiled

The raw maize stover had high fiber and dry matter but low crude protein. Crude protein was high in local distillate residue but fibre and dry matter was low. The chemical composition of the maize stover and local distillate residue before being ensiled are presented in Table 3.

3.2 Silage quality

The silage in PPBs was opened after 60 days of ensiling. All the silages prepared were in good condition. All the silage colors were considered relatively good as most of the treatments had a moderately yellow-brownish color, as mentioned by Trisnadewi and Cakra (2020), good quality silage is light brown (yellowish) or greenish color. According to the criteria, T3 was considered to have the best color among the treatments as mentioned by Kitaw *et al*. (2024), that silage with yellowish-brown color is the main characteristic of quality silage. The smell of the silage was pleasant among all treatments and there was no significant ($p < 0.10$) difference among the groups.

Table 3: Chemical composition of maize stover and local distillate residue before ensiling

Ensilage material	CP	DM	Fiber	Fat	Ash	Moisture
Maize stover	7.3	24.32	87.42	0.03	12.97	75.72
LDR	54.13	14.93	32.11	0.04	10.44	85.08

According to Tahuk et al. (2020), good silage has the characteristic of clear texture like natural material that is dense textured and natural green, therefore T2 and T3 were considered the best texture among the groups.

The silage containing LDR had a significantly lower pH than that of the control group ($p < 0.00$). This present result was similar with the result reported by Ridla and Uchida (1994), and Yuan *et al.* (2012), that the silage containing distillery grains was well preserved and had lower pH and higher lactic acid concentration than the silage made only from barley straw. The physical characteristics and the pH of the silage are given in Table 4.

3.3 Nutrient composition

The enriching of LDR in maize stover silage had a significant impact on its nutrient composition, specifically on CP, Fiber, Moisture, and DM content. T3 with 30% of LDR and T2 with 20% of LDR had the lowest DM. Similarly, Yuan et al. (2012), reported that the DM content of the barley straw silage was significantly low when enriched with wet hulless-barley distillers' grain (WHDG). The moisture content of the silage was significant among the treatments ($p < 0.01$) and was consistently increasing with the addition of local alcohol residue. The increase in moisture content was consistent with the increased addition of LDR, as mentioned by Ososanya and Olorunnisomo (2015), that moisture content of the silage increased with increased addition of the distillers' grain in the maize cob silage.

T3 with 30% of LDR had significantly high ($p < 0.01$) CP content. The result was similar to Ridla and Uchida (1994), and Dai et al. (2022), who found a significant increase in CP of the silage ensiled with distillery grains. According to Yuan *et al.* (2012), the increase in the CP content of the silage was due to the addition of distillers' grain which has high CP content. The crude fiber content was significantly ($p < 0.02$) varying among the treatment groups, T3 had the lowest crude fiber (29.79%). This finding aligned with Yuan et al. (2012), who observed that the addition of the (WHDG) significantly decreases the Neutral Detergent Fiber and Acid Detergent Fiber content of the silage containing 30% of WHDG. The nutrient composition of maize stover silage enriched with different percentages of LDR is given below in Table 5**.**

3.4 Aerobic stability of silage

The aerobic stability of the maize stover silage containing LDR was enhanced significantly compared to the maize stover ensiled alone and this finding was similar to Mjoun et al. (2011), who observed that silage containing distillers' grains were aerobically stable for more than 296 hours on average

Table 4: Physical characteristic and pH of maize stover ensiled with LDR

Parameter	T0	T1	T2	T3
Colour	Light brown	Yellowish Green	Yellowish Green	Brownish Yellow
Smell	Pleasant with Light Acidic smell	Pleasant with Alcoholic smell	Pleasant with Alcoholic smell	Pleasant with Strong Alcoholic smell
Texture	Very Firm	Firm	Moderately Firm	Moderately Firm
pH	4.4	4.05	3.89	3.11

***T0: Maize stover alone, T1: Maize stover + 10% LDR, T2: Maize stover + 20% LDR, T3: Maize stover + 30% LDR*

Table 5: Nutrient composition of maize stover enriched with LDR (means ± SD)

Nutrient Composition	T0	T1	T2	T3	*P*
Dry Matter	21.84 ± 1.36[b]	21.79 ± 0.34[b]	18.79 ± 1.79 [a]	18.02 ± 1.61[a]	0.011
Moisture	78.13 ± 1.41[a]	78.22 ± 0.33[a]	81.21 ± 1.37[b]	81.98 ± 1.61[b]	0.011
Crude Protein	8.83 ± 1.13 [a]	12.25 ± 1.09[a]	17.51 ± 2.22[b]	46.83 ± 3.22[c]	0.016
Fiber	81.32 ± 3.93[b]	73.54 ± 1.24[b]	33.99 ± 2.15[a]	29.79 ± 7.05[a]	0.024
Fat	0.01 ± 0.0[a]	0.013 ± 0.0[a]	0.013 ± 0.01[a]	0.200 ± 0.20[a]	0.761
Ash	11.79 ± 0.18[a]	11.45 ± 1.23[a]	10.69 ± 0.50[a]	10.63 ± 0.66[a]	0.233

**Common superscripts within the row are not different at p < 0.05*

T3 with 30% of LDR exhibited better aerobic stability among the treatments. Enhanced aerobic stability of silage containing distillate residue was due to lower pH and higher propionic acid concentration (Mjoun et al. 2011).

According to Wang et al. (2020), improved aerobic stability in the silage was linked to high lactic acid production, low pH values, and NH3-contents. On the contrary, a recent study by Ferraretto et al. (2022), concluded that no effect was observed in the aerobic stability of the WBG (wet brewers' grain) and DGC (dry ground corn) silage.

Although a definite underlying mechanism could not be proposed, the improved aerobic stability of the silage containing distillers' grain may have contributed to its' lower pH and higher propionic acid concentration (Mjoun et al. 2011). The change in temperature of maize stover enriched with different ratios of LDR during aerobic exposure is presented below the Figure 2.

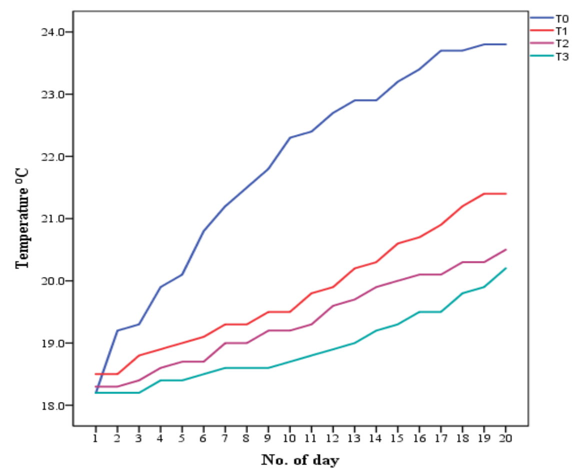

Figure 2: Changes in temperature of maize stover ensiled with different ratios of local distillate residue during aerobic exposure

3.5 Palatability

Among the treatments, T3 with 30% of LDR had the highest palatability percent. Jersey cows showed significantly high palatability toward maize stover silage enriched with LDR. High palatability was due to the good fermentative profile of the silage, as mentioned by Silva and Santos (2016), that silage with a good fermentation process results in adequate lactic acid, low acetic,

Table 6: Palatability of Jersey cow fed with Maize stover silage (kg) enriched with varying percent of local distillate residue (Mean ± SD)

Palatability	T0	T1	T2	T3	*P*
C1	2.60 ± 0.09[a]	2.75 ± 0.04[b]	2.83 ± 0.13[bc]	2.88 ± 0.02[d]	0
C2	2.69 ± 0.07[a]	2.74 ± 0.04[ab]	2.81 ± 0.08[b]	2.82 ± 0.03[b]	0
C3	2.63 ± 0.08[a]	2.72 ± 0.10 [ab]	2.86 ± 0.07[bc]	2.79 ± 0.11[c]	0
C4	2.52 ± 0.46[a]	2.86 ± 0.07[b]	2.86 ± 0.05[b]	2.89 ± 0.05[b]	0.07
P%	87.08%	94%	94.05%	95.61%	-

*Total P: total palatability. P%: Palatability percent. C1: Jersey cow 1, C2: Jersey cow 2, C3: Jersey cow 3, C4: Jersey cow 4.

and butyric acid concentration, which influence the adequate palatability of the silage. Chea et al. (2015), further substantiated that the addition of additives to silage not only improved fermentation but also increased palatability for cattle compared to non-additive silage, enhancing odor, color, flavor, and texture. As per feeding records and the subsequent results obtained, the palatability means of each Jersey cow are given in Table 6.

4. CONCLUSION

Maize stover silage enriched with 30% LDR had better physical characteristics. The nutrient composition of the silage was greatly enhanced, particularly CP, fiber, moisture, and DM content. The CP and moisture content was significantly high in T3 with 30% LDR, and the fiber and DM content was lowered. Maize stover silage enriched with LDR had a lower pH level (3.11-4.05). Significant improvement in the aerobic stability of silage enriched with LDR was observed. The palatability of the silage was significantly enhanced, with up to 30% of LDR inclusion being optimal for improving palatability. In conclusion, LDR is a suitable residual by-product for enriching and when ensiled with maize stover, it enhanced the nutrient composition, improves the physical characteristics, increase the palatability of the feed and better aerobic stability against the deterioration.

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