ABSTRACT

Objective: Our objective was to determine the effects of cut height and inoculant application on brown midrib (BMR) whole-plant corn silage (WPCS) quality.

Materials and Methods: Corn was harvested at 2 cut heights: low-cut height (LC, 30.5 cm) and high-cut height (HC, 56 cm). Three commercially available inoculants were used as treatments: Lactobacillus plantarum and Pediococcus pentosaceus (SA), Propionibacteria freudenreichii and Pediococcus pentosaceus (P2), and Lactobacillus buchneri and Pediococcus pentosaceus (B500). Mini silos were opened at 5 fermentation time points: 0, 2, 5, 30, and 90 d.

Results and Discussion: Gross yield and DM yield of BMR WPCS decreased for HC compared with LC. The HC increased the concentrations of BMR WPCS DM, CP, and starch and predicted milk yield; decreased the concentration of NDF and ADF; and tended to increase NDF digestibility in 30-h in vitro digestion. The greater nutritive value of the HC possibly allows for an increased quantity of forage to be included in the TMR and decreases the amount of ground corn needed to be added to the diet, potentially providing an economic benefit. The HC had lower acetic acid concentration compared with LC for CON and B500. The HC tended to have lower total acids and lactic acid compared with LC for all treatments. There was an interaction of height × length of storage for the fermentative profile. The increased acid concentrations during ensiling were expected and the greater acids concentration for LC compared with HC was probably due to more water-soluble carbohydrates for LC, which should have improved fermentation.

Implications and Applications: The HC yielded a WPCS with better nutritional value; however, the fermentative profile was reduced compared with LC. Our results indicate that in the present conditions, the use of these particular inoculants did not improve WPCS fermentation profile.

Key words: Lactobacillus plantarum, Pediococcus pentosaceus, Propionibacteria freudenreichii, Lactobacillus buchneri, volatile fatty acid profile

INTRODUCTION

Milk production systems are very challenging for producers and nutritionists; therefore, several tools are being studied to improve animal feed and production. Whole-plant corn silage (WPCS) is the most common forage used in diets for dairy cows worldwide (Ferraretto et al., 2018), with it typically making up 40 to 60% of the forage DM in the diet (NASEM, 2021). Whole-plant corn silage normally has a relatively high energy content; however, energy availability depends on its quality. Studies have focused on brown midrib (BMR) WPCS because of its lower lignin content and correspondingly greater fiber digestibility, which can be effective, especially for high-producing cows (Cherney et al., 1991).

It is well understood that increasing the cut height at harvest increases the nutritive value of the WPCS. A review of 11 studies that evaluated WPCS cut height reported a decreased DM yield followed by an increase in silage quality at the high cut height (Wu and Roth, 2003). In addition, the fermentative profile of the WPCS can be modified by adjusting the cut height.

The use of microbial inoculants can speed fermentation by rapidly dropping pH and avoiding undesirable fermentation such as clostridial and enterobacterial growth. Some inoculants contain Lactobacillus buchneri, a heterofermentative bacteria, that through the production...
of acetic acid from lactic acid inhibits the population of lactate-assimilating yeasts and, subsequently, contributes to aerobic stability. Other inoculants such as Lactobacillus plantarum, a homofermentative bacteria, contribute to greater lactic acid production, providing fast pH reductions (Muck, 2004). Propionic acid-producing bacteria have been investigated to help to reduce yeast and mold levels throughout the ensiling process (Kleinschmit et al., 2005). Inoculation of a corn silage with propionic acid bacteria at ensiling did not affect lactic acid, VFA, water-soluble carbohydrates, or the pH of WPCS (Higginbotham et al., 1998). Therefore, our objective was to investigate the effects of cut height and inoculants on BMR WPCS. We hypothesized that with inoculants added, corn silage should be stable during the fermentation process and have a decreased chance of having undesirable fermentation occurring when fed.

**MATERIALS AND METHODS**

**Field Preparation**

Before planting, plots were fertilized with dairy manure and tilled with a chisel plow and field cultivator. On April 23, 2019, experimental plots were treated with urea-ammonium nitrate fertilizer URAN −32 (32-0-0; Nutrien) at a rate of 533.18 L/ha and herbicides Resicore (Dow AgroSciences) and Atrazine (Syngenta) at a respective rate of 2.8 and 1.1 kg/ha. On May 18, 2019, 10 d before planting, experimental plots were treated once more with URAN −32 (32-0-0), Resicore, and Atrazine, with the same rates of application and same equipment. After planting, plots were treated with the herbicide Resicore (Dow AgroSciences) at a rate of 2.8 kg/ha and the herbicide Atrazine (Syngenta) at a rate of 1.1 kg/ha using a John Deere 4054 tractor (Deer & Company). This treatment was repeated on June 11, 2019. Due to the presence of weeds on the fields, on June 19, 2019, plots were treated with 0.35 kg/ha of Status (BASF) and 0.14 kg/ha of Zidua (BASF) using an 8203 TerraGator (Ag-Checm Equipment Company).

**Corn and Growing Conditions**

The corn hybrid used was a brown midrib (BMR; P1180XR, Pioneer) that was planted on May 28, 2019, at the University of Illinois Urbana-Champaign (40°04′58.8″N, 88°13′″W) at a seeding density of 79,000 seeds/ha. Comparative relative maturity for this hybrid is reached at 114 d. The hybrid of corn is marketed for having an outstanding digestibility score, root strength, and milk or beef per ton. The field was set up with twelve 0.21-ha plots, with seeds planted 16 rows at a time using a John Deere 8370 tractor and a John Deere 1990 Central Commodity System planter (Deere & Company). During the growing season, the average daily temperature was 23.4 ± 5°C with total precipitation of 21.41 cm (Illinois State Water Survey, Prairie Research Institute, Champaign, IL).

**Harvest**

Once corn reached reproductive stage 5, corn plants were collected, chopped, and tested for DM until all plots were 31 to 35% DM. Crops were collected every other day to test for DM. Plots were paired, and 5 plants were collected for each pairing. Crops were then chopped using a wood chipper (Bear cat model 80 fitted with a wet discharge screen) and put in a 100°C oven for 12 to 24 h. Collection time occurred at 0700 h, and crops were collected in an “X” formation to get a representative sample of the entire plot. The BMR corn was chopped and processed using a John Deere 8370 (Deere & Company) tractor and a Dion F-41 Silage Chopper (Dion-Ag Inc.), and a kernel processor (1-mm roll gap) was used to improve the digestibility of the corn kernels. Corn was harvested 4 rows at a time at a theoretical chop length of 2 cm. Each plot consisted of 16 rows with 8 rows harvested at a low cut height (30.5 cm) and 8 rows harvested at a high cut height (56 cm). Chopped corn was loaded into H & S forage wagons (H and S Manufacturing Co. Inc.). Wagons were weighed on a truck scale (Mettler Toledo) and off loaded into horizontal Ag Bags (Ag Bag Systems) with a diameter of 2.74 m and length of 45.72 m.

**Samples at Harvest**

To collect a representative sample of the entire plot, approximately 10 kg of freshly cut corn was collected every 60 s from each plot for LC and HC as harvested silage was being loaded into horizontal Ag Bags. Once all 12 plots were harvested, silage was placed on a large tarp and mixed with pitchforks and shovels for approximately 5 min. The BMR corn from LC and HC was then separated into 4 piles on 4 separate tarps to apply 3 commercially available inoculants (Lallemand Animal Nutrition): CON (water; no inoculant), SA (Lactobacillus plantarum and Pediococcus pentosaceus), P2 (Propionibacteria freudenreichii and Pediococcus pentosaceus), and B500 (Lactobacillus buchneri and Pediococcus pentosaceus). Individual inoculant was prepared in a 946-mL spray bottle according to the instructions listed on the package. Inoculant was sprayed for 5 min while piles were being mixed with a pitchfork. One large bag for each group (CON, SA, P2, and B500) was collected. Treatments were composited in an identical form. A weighted 0.5-kg sample of BMR corn silage was scooped and placed into a vacuum-seal bag (20.32 cm × 27.94 cm). Using a vacuum sealer (Food Saver V845 Vacuum Packaging System, Food Saver), 3 bags per replicated (120 in total) were heat sealed. To evaluate the effects of time, each treatment replication (3 bags) was stored for 1 of 5 storage times: 0, 2, 5, 30, or 90 d. Each time point was replicated 3 times per chop height and inoculant application, totaling 30 mini silos per inoculant treatment adding to 120 mini silos in total. All silos were stored in a dark laboratory room, with an average temperature of 21°C. On d 0, a total of 24 mini silos were removed and frozen at −20°C for later nutrient
butyric acid. Ammonium-N, pH, and VFA score were also determined for lactic acid, acetic acid, propionic acid, and butyric acid were analyzed using a Perkin Elmer XL Gas Chromatograph with a Supelco packed column (2 m x 2 mm Tightspec ID, 4% Carbowax 20M phase on 80/120 Carbopack B-DA). Lactic acid was analyzed using a YSI 2700 SELECT Biochemistry analyzer with a L-Lactate membrane. A VFA score was developed by the commercial laboratory to assist producers and advisors. The score weights the positive effect of lactic and acetic acid with the negative effect of butyric acid to arrive at one score; a score of 8 to 10 indicates good quality silage and less than 3 indicates poor silage (Dairy One, 2015). Predicted milk yield was calculated according to the Milk 2006 spreadsheet (Schwab et al., 2003). For the calculations we considered DM, CP, NDF, starch, NDF digestibility in 30 h (NDFD 30 h), ash, and DM yield tons/ha).

**Statistical Analysis**

Statistical analysis was performed using SAS (v9.4 SAS Institute Inc.).

Corn plant yield was analyzed as a split-plot design in time using the MIXED procedure of SAS using the following model:

\[
y_{hij} = \mu + B_i + H_j + e_{hij}
\]

where \( y_{hij} \) = the observations of dependent variables, \( \mu \) = the overall mean, \( B_i \) = the random effect of the \( i \)th block, \( H_j \) = the fixed effect of the \( j \)th cut height (LC or HC), and \( e_{hij} \) = the random residual error. The method for degrees of freedom was Kenward-Rogers (Littell et al., 1998).

The WPCS wet chemistry, fermentative profile, and in vitro digestibility results were analyzed as a split-plot design in time using the MIXED procedure of SAS using the following model:

\[
y_{hijk} = \mu + B_i + H_j + T_k + D_{ik} + (HT)_{jk} + (HD)_{ik} + (TD)_{kj} + e_{hijk}
\]

where \( y_{hijk} \) = the observations of dependent variables, \( \mu \) = the overall mean, \( B_i \) = the random effect of the \( i \)th block, \( H_j \) = the fixed effect of the \( j \)th cut height (LC or HC), \( T_k \) = the fixed effect of the \( k \)th ensiling treatment (CON, SA, P2, B500), \( D_{ik} \) = the fixed effect of ensiling length (day: 0, 5, 30, 60, 90 d), \( (HT)_{jk} \) = the interaction between cut height and inoculant, \( (HD)_{ik} \) = the interaction between the \( i \)th cut height and the \( k \)th day, and \( e_{hijk} \) = the random residual error. The method for degrees of freedom was Kenward-Rogers (Littell et al., 1998). Results are reported as LSM with corresponding SEM for fixed effects of cut height and inoculant treatment. Treatment LSM were separated using the difference of LSM. Residual distributions were evaluated for normality and homoscedasticity. Statistical significance was declared at \( P \leq 0.05 \) and trends at 0.05 < \( P \leq 0.10 \).
RESULTS AND DISCUSSION

Harvest practices such as cut height have shown to be a good management alternative to improve WPCS nutritive value and nutrient digestibility, even though there is a decrease in corn silage yield. In the current study, gross yield and DM yield of BMR WPCS were decreased by 17.5% (P < 0.01) for HC (23.1 × 10^3 kg and 7,400 kg/ha) compared with LC (28.0 × 10^3 kg and 8,600 kg/ha). Due to the increase (P < 0.01) in DM from 30.4 to 32.3% for LC and HC, respectively, DM yield was reduced by only 14.0% when LC was compared with HC. These data are consistent with those of Ferraretto et al. (2018), who reported a difference in DM yield for low cut (16.9 cm) and high cut (52.3 cm) (17.3 and 15.3 Mg of DM/ha, respectively). The decrease in DM yield, however, is accompanied by an improvement in the nutritive value of the BMR WPCS. This increased predicted milk yield (Aoki et al., 2013; Adeosgan et al., 2019). Diepersloot et al. (2022) reported that increasing the cut height from 25 to 65 cm increased starch content and NDF digestibility and decreased NDF and lignin. Several studies demonstrated that by increasing the cut height, the DM and starch concentrations of BMR WPCS increased while the concentrations of fiber content decreased (Lewis et al., 2004; Kung et al., 2008). Overall, increasing the cut height improved WPCS nutritive value and predicted milk yield, which agrees with our study (1,365 and 1,246 kg/t DM for HC and LC, respectively). Studies have also reported that increasing the cut height from 25 to 65 cm improved fiber digestibility (Diepersloot et al., 2022). Optimizing BMR WPCS nutritive value is important because it will affect animal intake, nutrient utilization, and performance.

Table 1. Mean chemical composition of corn silage treated without or with inoculants in different cut height and ensiled days

<table>
<thead>
<tr>
<th>Item</th>
<th>Treatment¹</th>
<th>Height¹</th>
<th>P-value²</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM, %</td>
<td>CON</td>
<td>SA</td>
<td>P2</td>
</tr>
<tr>
<td></td>
<td>31.4</td>
<td>31.1</td>
<td>31.4</td>
</tr>
<tr>
<td>CP, %</td>
<td>9.58</td>
<td>9.70</td>
<td>9.64</td>
</tr>
<tr>
<td>NDF, %</td>
<td>33.3</td>
<td>34.0</td>
<td>33.2</td>
</tr>
<tr>
<td>ADF, %</td>
<td>16.4</td>
<td>16.6</td>
<td>15.8</td>
</tr>
<tr>
<td>Starch, %</td>
<td>34.3</td>
<td>34.2</td>
<td>34.7</td>
</tr>
<tr>
<td>Ash, %</td>
<td>4.64</td>
<td>4.61</td>
<td>4.66</td>
</tr>
<tr>
<td>NDFD 30 h, %</td>
<td>59.9</td>
<td>58.8</td>
<td>59.9</td>
</tr>
</tbody>
</table>

¹Treatments were CON (no addition of inoculants), SA (Lactobacillus plantarum and Pediococcus pentosaceus), P2 (Pediococcus pentosaceus and Propionibacteria freudenreichii), and B500 (Pediococcus pentosaceus and Lactobacillus buchneri), ensiled at 2 separate cut heights: low cut (LC; 30.5 cm) and high cut (HC; 56 cm) ensiled during 0, 2, 5, 30, or 90 d for brown midrib corn.

²P-values were obtained for inoculant (Trt), height, inoculant × height (Trt × height), and inoculant × days ensiled (Trt × day). Day effect for all variables was P < 0.0001. Day effect for all variables except for NDF and starch was P > 0.24. There was no height × day effect (P > 0.24).

³NDFD 30 h = NDF digestibility in 30 h.

Figure 1. Crude protein 2-way interaction of treatment × days ensiled for CON (no addition of inoculants), SA (Lactobacillus plantarum and Pediococcus pentosaceus), P2 (Pediococcus pentosaceus and Propionibacteria freudenreichii), and B500 (Pediococcus pentosaceus and Lactobacillus buchneri) ensiled for 0, 2, 5, 30, or 90 d after harvest. Error bars indicate the SEM.
lage inoculants at ensiling that contain heterofermentative (B500 and P2), homofermentative (B500, SA, and P2), or a mixture of heterofermentative and homofermentative bacteria (B500 and P2) could enhance silage fermentation of BMR WPCS, harvested at LC and HC. There was a tendency for an interaction of treatment × days ensiled for CP (Figure 1; \( P = 0.06 \)). We hypothesized that the small difference was probably due to less fermentation and less concentration of the protein left in the silage.

There was a tendency for an interaction of treatment × height for total acids (Figure 2A; \( P = 0.10 \)). There was an interaction of treatment × height for acetic acid (Figure 2B; \( P < 0.01 \)). The HC had lower acetic acid concentration (0.86% and 1.36%) compared with LC (1.01% and 1.48%) for CON and B500, respectively; however no differences among the other treatment combinations were reported. The treatment × days ensiled relevant interactions are reported in Supplementary Figure S1 (Supplementary Material; https://doi.org/10.15232/aas.2022-02365).

We observed a tendency for an interaction of treatment × height for lactic acid (Figure 2C; \( P = 0.10 \)). There was an interaction of treatment × height for lactic acid:acetic acid ratio (Figure 2D; \( P = 0.04 \)), ammonia (Figure 2E; \( P < 0.01 \)), and pH (Figure 2F; \( P < 0.01 \)). The HC had lower lactic acid:acetic acid ratio (3.56%) compared with LC (4.07%) for CON. The HC had lower ammonia concentration (2.73%) compared with LC (3.0%) for CON; however, no differences were reported for the other inoculants.\n
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**Figure 2.** Two-way interaction of treatment × height for CON (no addition of inoculants), SA (*Lactobacillus plantarum* and *Pediococcus pentosaceus*), P2 (*Pediococcus pentosaceus* and *Propionibacteria freudenreichii*), and B500 (*Pediococcus pentosaceus* and *Lactobacillus buchneri*) ensiled at 2 separate cut heights: low cut (LC; 30.5 cm) and high cut (HC; 56 cm). (A) Total acid (\( P = 0.10 \)), (B) acetic acid (\( P < 0.01 \)), (C) lactic acid (\( P = 0.10 \)), (D) lactic acid:acetic acid ratio (\( P = 0.04 \)), (E) ammonia-N, % of total N (\( P < 0.01 \)), and (F) pH (\( P < 0.01 \)). Error bars indicate the SEM.
Forages and Feeds

plant treatments. The HC had higher pH (4.40, 4.43, and 4.38) compared with LC (4.36, 4.34, and 4.34) for CON, P2, and B500, respectively. Overall, in the current study, the HC decreased the concentration of acetic acid, lactic acid:acetic acid ratio, and ammonia concentration. The HC also tended to decrease total acids and lactic acid, and HC increased pH compared with LC. The decrease in the WPCS fermentative profile and consequently an increase in silage pH in the HC found in the present study is most likely due to a combination of greater DM content, lower water-soluble carbohydrates (fermentable sugar), and therefore less fermentation, decreasing acid production and increasing pH (Pahlow et al., 2003; Kalebich et al., 2017). The HC had a small decrease in ammonia concentration compared with LC (0.3 percentage units), which is unlikely to affect WPCS quality. Our study shows that inoculant application did not improve the fermentative profile of BMR WPCS. Treatment CON increased acetic acid, and tended to increase total acids, and lactic acid compared with inoculant application. Ammonia concentration and pH of WPCS in the present study were not affected by inoculant application. However, our data show that a good fermentation occurred (Kung et al., 2018) in all treatments. Studies that have evaluated microbial inoculants on WPCS have shown inconsistent results. Filiya (2003), reported an improvement in the fermentative

Figure 3. Two-way interaction of height × days ensiled at 2 separate cut heights: low cut (LC; 30.5 cm) and high cut (HC; 56 cm) and ensiled for 0, 2, 5, 30, or 90 d after harvesting. (A) Total acid ($P < 0.01$), (B) acetic acid ($P < 0.01$), (C) lactic acid ($P < 0.01$), (D) lactic acid:acetic acid ratio ($P = 0.07$), (E) VFA score ($P < 0.01$), and (F) pH ($P < 0.01$). Error bars indicate the SEM.
profile of the WPCS. In contrast, other studies show small (Diepersloot et al., 2022) or no effect (Kang et al., 2009) of inoculant application on the WPCS fermentative profile.

There was an interaction of height × days ensiled for total acids (Figure 3A; \( P < 0.01 \)), acetic acid (Figure 3B; \( P < 0.01 \)), and lactic acid (Figure 3C; \( P < 0.01 \)). The HC had lower total acids concentration (3.6, 3.6, 6.0, and 7.1%) compared with LC (4.0, 5.1, 6.7, and 8.8%) on d 2, 5, 30, and 90, respectively. The HC had lower acetic acid (1.18 and 2.37%) compared with LC (1.38 and 2.56) on d 30 and 90, respectively. The HC had lower lactic acid (3.22, 4.18, 4.72, and 4.73) compared with LC (3.63, 4.64, 5.31, and 6.22) on d 2, 5, 30, and 90, respectively. There tended to be an interaction for height × days ensiled for lactic acid:acetic acid ratio (Figure 3D; \( P = 0.07 \)). There was an interaction of height × days ensiled for VFA score (Figure 3E, Table 2; \( P < 0.01 \)) and pH (Figure 3F; \( P < 0.01 \)). The HC had a lower VFA score (8.16 and 7.64) compared with LC (8.52 and 8.37) on d 2 and 90, respectively. The HC had higher pH (3.95 and 3.98) compared with LC (3.87 and 3.9) on d 30 and 90, respectively. The increase in the VFA profile of the WPCS and decrease in pH was expected during ensiling. Our data suggest that the fermentative profile and pH were affected by cut height through an interaction with days ensiled. This may be due to the fact that there is more bacteria proliferation and consequently more fermentation occurring with the increase in ensiled days for the LC because it has more water-soluble carbohydrates available than HC. Future research is needed to elucidate how to increase or at least maintain the fermentative profile of WPCS when increasing the cut height.

### APPLICATIONS

Increasing the cut height of BMR WPCS improves its nutritive value, as HC increased starch, tended to increase NDFD 30 h, and decreased ADF and NDF contents. Inoculant application on BMR WPCS did not improve corn silage fermentation profile. The inoculant application on BMR corn harvested at 56 cm (HC) did not create a better fermentation environment for corn ensiled as WPCS. Altogether, these results can be helpful in the decision-making process surrounding WPCS nutritive value, specifically regarding harvest cut height of corn.

### ACKNOWLEDGMENTS

This project was partially supported by the USDA National Institute of Food and Agriculture (Washington, DC; NC-2042) and Lallemand Animal Nutrition (Milwaukee, WI). Special appreciation is extended to the Dairy Focus Team at the University of Illinois, along with the University of Illinois Dairy Research Unit staff (Urbana, IL) for assisting with data collection.

### LITERATURE CITED


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**Table 2. Mean VFA profile of corn silage treated without or with inoculants in different cut height and ensiled days**

<table>
<thead>
<tr>
<th>Item</th>
<th>Treatment</th>
<th>Height</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CON</td>
<td>SA</td>
<td>P2</td>
</tr>
<tr>
<td></td>
<td>LC</td>
<td>HC</td>
<td>SEM</td>
</tr>
<tr>
<td>Total acids, % DM</td>
<td>4.91a</td>
<td>4.49bc</td>
<td>4.38b</td>
</tr>
<tr>
<td>Acetic acid, % DM</td>
<td>0.94a</td>
<td>0.55c</td>
<td>0.79b</td>
</tr>
<tr>
<td>Lactic acid, % DM</td>
<td>3.97a</td>
<td>3.94a</td>
<td>3.59b</td>
</tr>
<tr>
<td>Lactic acid:acetic acid</td>
<td>3.81a</td>
<td>9.21b</td>
<td>8.00c</td>
</tr>
<tr>
<td>VFA score</td>
<td>6.88a</td>
<td>7.35b</td>
<td>7.08b</td>
</tr>
<tr>
<td>Ammonia-N, % of total N</td>
<td>2.87a</td>
<td>2.53b</td>
<td>2.73a</td>
</tr>
<tr>
<td>pH</td>
<td>4.38a</td>
<td>4.36b</td>
<td>4.39a</td>
</tr>
</tbody>
</table>

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a–dValues within a row having different superscripts differ (\( P < 0.05 \)).

1Treatments were CON (no addition of inoculants), SA (Lactobacillus plantarum and Pediococcus pentosaceus), P2 (Pediococcus pentosaceus and Propionibacteria freudenreichii), and B500 (Pediococcus pentosaceus and Lactobacillus buchneri), ensiled at 2 separate cut heights: low cut (LC; 30.5 cm) and high cut (HC; 56 cm) ensiled during 0, 2, 5, 30, or 90 d for brown midrib corn.

2P-values were obtained for inoculant (Trt), height, inoculant × height (Trt × height), and height × days ensiled (height × day). Day effect for all variables was \( P < 0.0001 \). Trt × height effect for all variables was \( P < 0.01 \) but, for total acids, lactic acid, and VFA score, was \( P > 0.05 \). Trt × day effect for all variables was \( P < 0.01 \).

VFA score was developed by the commercial laboratory to assist producers and advisors. The score weighs the positive effect of lactic and acetic acid with the negative effect of butyric acid to arrive at one score; a score of 8 to 10 indicates good-quality silage, and less than 3 indicates poor silage (Dairy One, 2015).


