# Calcium Oxide and Calcium Hydroxide Treatment of Corn Silage

## A.S. Leaflet R2774

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### Summary and Implications

Nutrient analysis of Calcium Oxide (CaO) and Calcium Hydroxide ($Ca(OH)_2$) treatment of corn silage will show a reduced neutral detergent fiber (NDF) levels, increased calcium, increased crude protein and a slightly improved in-vitro digestibility of these feedstuffs due to the strong base degrading the plant fiber. Treated corn silage does appear to ferment eventually, but not as rapidly as non treated corn silage. The moisture present in the harvested forage is adequate for the reaction to take place and provides a heat sink for the heat generated from the reaction to prevent combustion.. Additional work including feeding trials would help determine any real potential benefit.

### Introduction

The use of a strong base mixed with a fibrous feedstuff has been shown to reduce the fiber fraction of high fiber, low quality feedstuffs like cornstalks to make them more digestible and less dependent on grain supplementation when used for ruminant ration formulation. With this thought in mind it was proposed that this same concept could be applied to the treatment of whole plant corn silage in an attempt to improve the digestibility of this feedstuff further as well. Previous demonstrations with treated corn silage had shown some effect on fiber and this was an attempt to collect additional data and document effect on digestibility of fiber and the fermentation process and potential dry matter loss of corn silage. A strong base such as CaO was used in the past and therefore was proposed to be used for the treatment of corn silage. CaO has been known to be quite reactive in some situations leading to combustion of the treated material and it was therefore proposed that $Ca(OH)_2$ also should be tried since this compound seems less likely to lead to combustion, but may not be as effective. Therefore, $Ca(OH)_2$ was used in the field demonstration portion of this trial and compared with the controlled CaO results.

### Material and Methods

Corn silage was harvested from the same field and of the same variety. Half of this material was mixed with CaO powder at a rate of five percent on a dry matter basis (using a feed mixing wagon) and the other half was left untreated. A pH measure was taken on the samples and the untreated and treated samples were, weighed, measured for dry matter concentration, packed into 50 gallon barrels with 4 barrels per treatment, a HOBO auto-recording thermocouple terminal was placed into the barrels and the barrel tops were sealed with water bags to exclude air. Temperatures were recorded every 15 minutes over the next month and pH was measured bi-weekly. After one month the silage samples were weighed, dry matters recalculated and a grab sample was sent to Dairyland Laboratory of Arcadia WI for a nutrient and in-vitro digestibility analysis.

An additional on-farm demonstration worked with corn silage treated with $Ca(OH)_2$ at 7% of dry matter at harvest. The $Ca(OH)_2$ was added at the forage blower during the ensiling process by pouring the dry powder on the forage as it entered the blower (see Figure 1). The treated material was stored in an up-right silo. ,. (60’x18’). It should be noted that this method of application kept up with the pace of commercial harvesting and did not slow down the process nor did it require any special equipment. Samples of this silage were taken prior to treatment and then at 1 and 2 months after storage and tested at Dairyland Laboratory of Arcadia WI as the CaO corn silage using a 30 hour in-vitro digestibility analysis. The previous recorded work had used a 48 hour test. This silage was to be used for dairy cows however and the 30 hour test would be more reflective of the digestibility that may occur in the dairy cow.

**Figure 1. Application of $Ca(OH)_2$ at forage blower.**

## Results and Discussion

### Calcium Oxide Treatment

When treating the corn silage with CaO in the first demonstration, the treated silage took on a greenish tint after mixing and heat could be felt radiating from the treated silage in a few minutes. The silage was 41% moisture and no additional water was added. Table 1a provides a summary of the nutrient results observed in the control and CaO treated corn silage. Table 1b provides a summary of the pH change and Chart 1 indicates the temperature movement of the CaO treated and control samples. It was planned to measure DM loss on the control and treated silage. Leaks on the water bag seal on top of the barrels prevented getting an accurate measure of DM at the end of the trial on the treated barrels. This measure was taken on the control silage and calculated to be a one percent DM loss. On the treated material this DM loss calculated to be 21 to 30 percent, but this may not have been accurate due to the water bag seal leak and subsequent spoilage in some barrels. The HOBO temperature recorder documented that when the feedstuff had moisture introduced after some time in storage a resurgence in material temperature occurred and a probable subsequent DM loss. Therefore it appears wise to protect this treated feedstuff from moisture since it is not stable and appears to quickly degrade.

On average, the treatment did decrease NDF and increase digestibility of fiber although not to the degree observed in the lower digestible feedstuffs of other trials. There was a large range in the change in digestibility within the small number of samples so it was hard to predict from this trial the effect on digestibility. NDF reduction was large enough to expect a larger increase in in vitro digestibility but it did not occur. It is noteworthy that a DM loss does occur from the treatment as indicated above which unfortunately was not documented as planned. The gains in some of the nutrient fractions such as crude protein percent are considerably greater than a treatment DM loss would explain. This crude protein increase was observed in other demonstrations with other feedstuffs treated with CaO and stored by sealing out air. It will require additional work to document if this increase in protein is consistent and what is causing the increase. Phosphorus was reduced by ten percent, which is even more difficult to explain. If a dry matter loss occurred it would be logical that the P fraction would increase. The pH is considerably higher in the treated material as would be anticipated from adding the base, but the pH does decrease over time as shown in Table 1b. Normally the lactic and acetic acid are a product of fermentation and a low pH, however the CaO treated material actually yields higher levels of these acids. It could be hypothesized the fermentation is buffered resulting in a longer fermentation with more acid production. The quantity of available fermentable carbohydrate could also increase as a result of the base reacting with the less fermentable NDF This increased quantity of acids produced in the treated silage may improve the energy of the feedstuff beyond what the normal predictive equations estimate. The acids are volatile and lost in sample processing excluding them to some degree in laboratory TDN and NE estimates therefore making an animal feeding trial of merit in determining a more correct energy value from treatment.
It was apparent that the CaO treated silage increased rapidly in temperature, peaking at 104 degrees F 6 hours post treatment. This temperature was held at this level for about 6 hours and then gradually declined finally equaling the control about 6 days (124 hours) after the initial treatment. The control silage reached a peak temperature about 7 hours after ensiling and held this temperature (89 degrees F) also for about 6 hours. The control silage increased much more gradually and decreased much more quickly, completing the ensiling process almost 2 days sooner than the treated silage.

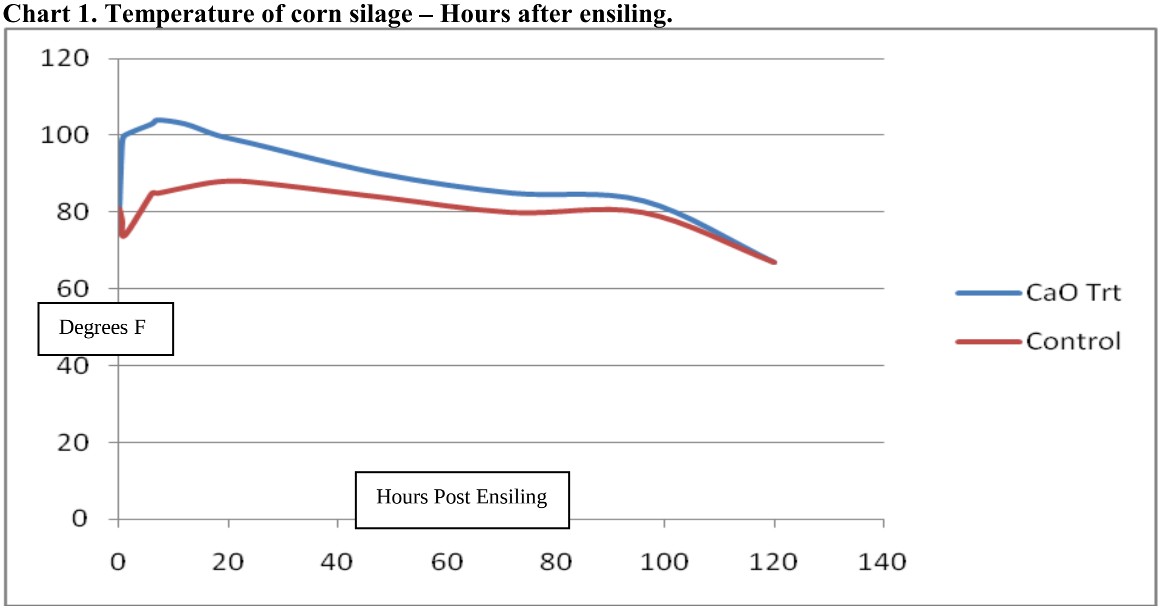
**Table 1a. Nutrient content of corn silage with and without CaO treatments.**

| Percent | CaO Treated range of measure | Control range of measure | % Difference between average of treated and control |
|---|---|---|---|
| Cr. Protein | 11.7 – 12.8 | 7.6 – 8.0 | 57 |
| Cr. Protein Solubility | 25.1 – 28.2 | 13.8 – 26.7 | 37 |
| Lignin | 3.8 – 6.9 | 3.3 – 4.5 | 33 |
| ADF | 21.9 – 25.6 | 18.8 – 23.3 | 15 |
| NDF | 27.4 – 27.9 | 34.0 – 38.5 | -23 |
| NFC | 41.2 – 46.5 | 47.5 - 51.6 | -8 |
| Ca | 3.31 – 3.89 | .30 - .33 | 1125 |
| P | .21 - .22 | .23 - .26 | -10 |
| Lactic Acid | .01 – 7.66 | 1.13 – 4.30 | 40 |
| Acetic Acid | 2.88 – 16.33 | .01 - .11 | 185 |
| In-vitro Digest. | 85.3 – 89.0 | 79.6 – 84.8 | 7 |
| NDF Digest. | 46.3 – 60.4 | 47.1 – 55.6 | 6 |

**Table 1b. pH changes after ensiling.**

| | Day 0 | Day 3 | Day 6 | Day 9 | Day 28 |
|---|---|---|---|---|---|
| Control | 6.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| CaO Treatment | 11.6 | 9.4 | 7.6 | 7.1 | 6 |

**Chart 1. Temperature of corn silage – Hours after ensiling.**




**Calcium Hydroxide Treatment**

Corn silage treated with $Ca(OH)_2$ did not produce the greenish color noted with the CaO treatment nor did the temperature of this material peak much more than 10 degrees (F) above the outdoor air temperature after treatment. Application of the $Ca(OH)_2$ at the blower did not seem to slow down the productivity of the harvest Table 2 provides a summary of the corn silage prior to and after treatment. In this demonstration there is not a control of the untreated silage after fermentation since all the silage going in to storage was treated. The nontreated silage was taken directly from the field and sent via US mail to the lab thus allowing some fermentation to take place in transit. The treated silage was sample after two months in storage. The resulting analysis is provided in Table 2. Like a CaO treatment; NDF is reduced, CP, Ca and in-vitro digestibility increase. It was observed that with NIR lab analysiss that the level of expected Ca in the treated silage was not evident, however with wet chemistry analysis the Ca level was near expected levels. Possibly NIR calibrations would not estimate the higher level of Ca in the feedstuff that is beyond a normal calibration level for that given feedstuff, therefore it is this author's reccommendation to test the Ca level using a wet chemistry method. The extent of the differences between treated and nontreated samples may not be quite as pronounced as the CaO treatment lead to, but the results are similar . It also appears that fermentation of the treated silage did occur although we do not know at what rate. From a practical standpoint, the $Ca(OH)_2$ may be safer to work with than CaO especially if combustion of the forage could occur, however the reduced application rate of using CaO in place of $Ca(OH)_2$ can not be ignored since a considerable lower quantity of product needs to be handled. The lower heat production and lack of green color in the treated forage may or may not affect the chemical reaction.

**Table 2. Nutrient content of corn silage with and without $Ca(OH)_2$ treatments.**

| Percent | $Ca(OH)_2$Treated | Control | % Avg. Difference |
|---|---|---|---|
| DM | 40.36 | 35.9 | |
| pH | 4.83 | 4.57 | |
| Cr. Protein | 7.06 | 6.09 | 16 |
| Cr. Protein Solubility | 15.6 | 17.7 | -12 |
| Lignin | 3.6 | 2.9 | 24 |
| ADF | 23.2 | 24.6 | -6 |
| NDF | 34.8 | 44.8 | -22 |
| NFC | 48.9 | 43.08 | 9 |
| Ca | 2.88 | .22 | 1209 |
| P | .22 | .22 | 0 |
| Lactic Acid | 2.27 | * | - |
| Acetic Acid | 3.44 | * | - |
| In-vitro Digest. | 83.4 | 80.2 | 4 |
| NDF Digest. | 52.4 | 55.7 | 6 |

*It should be noted that the silage making up the Control sample here was harvested 2 days prior (start of harvest) to the treated sample appearing on this page (taken 10 feet from the top of the silo). Daily harvest temperatures were in the 60 to 70 degree F range.

## What Alkali Treatment is Worth

As mentioned earlier, the trial conducted was of small scale with few samples. The nutrient profile tendencies observed here were in line with previous trials. The nutrient analysis values obtained from a forage testing lab should not be disregarded, but treatment does change the forage beyond the normal laboratory NIR calibrations and therefore the results may not be completely accurate. Calcium levels for example were shown to fall into this category but energy values may also be in this category as well since the high level of acids produced may not be taken into account energetically. Therefore although it does appear that lower quality forages respond better to alkali treatments based on in-vitro digestibility results this has not been verified with feeding trials. On a conservative analysis of the treatment's value, one ton of $Ca(OH)_2$ is capable of treating 28,571 pounds of corn silage dry matter (about 71,000 lbs as-is). In this trial the elevated crude protein and in-vitro digestibility brought on was equivalent to providing 600 pounds of soybean meal with this silage and 2300 pounds of limestone. If the $Ca(OH)_2$ is valued at $350 per ton and the soybean meal is $150 for the 600 pounds replaced and the limestone is valued at $290 we observed a $90 advantage. This is a rough estimate since commodity prices change frequently, but none the less, an advantage if increased Ca, energy and crude protein concentration are needed. The CaO treatment seemed to yield a greater advantage, but the loss in dry matter still needs to be factored into the equation to realize the true benefit.

## Acknowledgements

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