Fermentation Analysis of Silage: Use and Interpretation

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Introduction

Animal productivity is dependant on the nutrient composition of the ration presented to the animal as well as on the quality of feed ingredients. In assessing animal productivity the nutritionist must determine if the ration is the factor limiting productive potential. In order to do this one must have an accurate assessment of feed quality and delivery. Having as complete a set of information on the feeds and delivered ration as possible will assist the nutritionist in making this determination and allow for the identification of limiting factors. Often the nutritionist or consultant is challenged to push animal performance beyond what may be an undetermined performance barrier established by feed quality and delivery issues.

This paper will review the evaluation of forage fermentation. This is one key aspect of forage quality. Specific information provided on averages and ranges for various feed nutrients and quality assessments were determined by Cumberland Valley Analytical Services, Inc. (CVAS) by wet-chemistry. The dataset is representative of feeds from across the United States.

Use of Fermentation Analysis

There are those that argue that while the fermentation analysis is interesting, it is of little value, providing no information that can be used directly in the ration balancing process. While it is generally true that the fermentation data have little direct application, this challenge avoids the true value of the analysis. The fermentation report is meant to provide a comparative evaluation that allows the user to better characterize the silage, and to lend insight into possible DM intake and performance problems. A silage at 30% DM that has 1.5% butyric acid and 18% ammonia nitrogen as a percentage of total nitrogen will be utilized differently than a silage at the same DM level that has no butyric acid and 9% ammonia nitrogen. The degree or extent of an adverse fermentation can be better determined by the fermentation analysis than by visual and olfactory observation alone.

A second and perhaps more important application of the fermentation report is as a “report card” on the management of the silage making process. The fermentation end-products are a summary of all conditions that affected the silage making process, including plant maturity, plant moisture, sugar content, epiphytic (indigenous) bacteria activity, additive use, ambient temperature, packing, and face management (Kung and Shaver, 2001). Significant breakdowns in the management of the silage making process will show up as silage with less desirable fermentation characteristics. The farm adviser can use the information gained from the fermentation analysis to document on a third party basis the quality of the silage and to challenge a farmer to better silage making practices. Quality forage is the basis of profitable animal production. The type and degree of fermentation will significantly affect the amount of DM recovery from the silage making process.

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Silage Fermentation Basics

The number one goal of silage making is to reduce oxygen and increase acidity rapidly so that lactic acid bacteria grow to stabilize and preserve or "pickle" the forage. By 2-3 days after ensiling, cell juices are available as a food source for silage bacteria, oxygen should be eliminated, and silage pH should have declined to a level at which the lactic acid bacteria can grow (5.5-5.7). The lactic acid bacteria begin to multiply, make lactic acid ($C_3H_6O_3$) and some acetic acid ($C_2H_4O_2$), and increase silage acidity. After about six weeks, silage should reach a final low pH (4.3-4.5 in legume silage and 3.8-4.0 in corn silage).

Herbage that is ensiled properly exhibits rapid pH drop where homo-fermentative bacteria predominate. Lactic acid should be a significant end-product of these fermentations. Fermentations that yield more lactic acid typically result in the lowest dry matter losses. Silages that have high levels of acetic, propionic, butyric or iso-butyric imply conditions where DM recovery from the silage making process may be poor. Generally, in well-preserved silage, at least 65-70% of the total acid will be lactic acid or 4-7% lactic acid (%DM). Acceptable silages generally contain <3% acetic acid, <0.1% butyric acid, and <0.5% propionic acid. Figures 1 and 2 show the fermentation acids by DM range for corn silage and legume silage analyzed at CVAS in 1999-2000.

High Moisture Silages

The amines and acids that are produced in greater quantities during the fermentation of wet silages can depress intake. When researchers added acids or silo effluent to forage, they decreased intake by as much as 40%. One study ranked the intake potential of grass stored as hay at 78%, dry silage (>40% DM) at 86%, and wet silage (<30% DM) at 68%. Intake of frozen (then thawed) chopped corn was found to be 10% higher than the same corn as silage (Erdman, 1993).

Highly Fermented High Moisture Silages

High levels of silage acids indicate that an extensive fermentation occurred in the silo. Many feeding situations utilize silages with high acid content with no apparent problems. Feed bunk management, ration parameters, and associative effects of feedstuffs often determine whether high silage acid levels may be a problem in any given feeding situation. Silage acids are neutralized by the cow's own saliva or by supplementary buffers in the ration. If these silage acids are not neutralized, they will contribute to the total acid pool in the rumen. Increasing the lactic acid content of grass silage increases the loading of lactic acid in the rumen, but little of this acid probably accumulates because it is degraded by the rumen lactate-utilizing bacteria and transformed into volatile fatty acids. Unless the ruminal capacity to degrade lactic acid is compromised, high lactic acid levels in silages should not cause a significant increase in ruminal lactic acid concentrations and should not increase rumen acidosis. Much greater quantities of acid are produced by the rumen fermentation, especially when lush grass or high grain diets are fed. Addition of supplemental buffers such as sodium bicarbonate or sodium sesquicarbonate can help to reduce silage acid levels going into the cow. In studies with early lactation cows at the University of Maryland, when corn silage was neutralized with a buffer before feeding, cows ate 2.1 pounds more of it per day and produced 6.2 pounds more milk per day (Erdman, 1993).

If forage nutrients are converted to acids in the silo, less energy remains for the cow to use. Not all nutrition models would actually predict this energy loss when calculating ration energy. With high acidity silage, it may be important to do so. There are differences in the utilization of

fermentation acids by the rumen. Acetic acid is not fermented in the rumen, whereas one form of lactic acid is fermented by rumen bacteria under normal conditions (Muck, 1998).

Although higher lactic acid levels are usually considered to be better for silage preservation, lactic acid may be a problem in silages where it exceeds ten percent of DM. This rarely happens in North America but is more common in Europe. When wet grasses (<30% DM) with a high amount of sugar are ensiled, perhaps as direct-cut silage, they can undergo an extensive silo fermentation and can contain high levels of lactic acid. In one study with direct-cut ryegrass silage, it had a pH of 3.8 and 17.5% lactic acid (McDonald, 1991 as cited by Harrison et al., 1994).

Wet silages that have undergone a long fermentation sometimes contain higher levels of acetic acid (>3% DM). Ammoniated silages also often have higher levels of acetic acid because of their longer fermentation (Kung and Shaver, 2001). Acetic acid smells like vinegar. Very high levels of acetic acid (>5% DM) have been suggested to cause intake problems, however research has not consistently found this to be true and the mechanism by which acetic acid might compromise intake is not understood (Seglar and Mahanna, 2001). The acetic acid itself may not be a problem, but may be a marker. Silages treated with *Lactobacillus buchneri* for improving aerobic stability often have higher levels of acetic acid but, in this case, it doesn't seem to cause any problems (Kleinschmit et al., 2005, Kung et al., 2003). These silages often exhibit the presence of an alcohol, 1,2 Propandiol, at levels from 0.2 to 3% DM.

Propionic acid levels are typically very low in silages (<0.25% DM) but addition of propionic acid as a silage preservative (2 to 4 lbs/ton) raises propionic acid levels up slightly (0.15-0.30% DM) (Kung and Shaver, 2001). Propionic acid has a sharp sweet smell and taste.

Poorly Fermented High-Moisture Silages -- Clostridial Fermentations

Forages ensiled at less than 32% DM have a greater risk for clostridial growth. Clostridia bacteria are one of the most common undesirable bacteria that may persist in unstable silage that has no oxygen. They produce butyric acid and break down protein. Butyric acid smells like rancid butter and silage often has an olive green color after a clostridial fermentation. Clostridia usually are associated with hay-crop silage that has a pH of 5.0-5.5. With clostridia, there will be higher silage dry matter losses, poor silage palatability, and a higher level of ammonia nitrogen. It is suspected that the protein breakdown products, such as ammonia, amines, and amides, may be responsible for limiting intake. Butyric acid itself may not significantly impact intake, but may be a marker for protein degradation products. Tveit et al. (1992) found that the correlation between amine concentration and butyrate was very low (<0.21). Since clostridia may be amino acid fermenters or lactate fermenters, this makes sense.

A fermentation problem can be defined as one where butyric acid is greater than 0.25% of DM. CVAS data indicates that below 32% DM, there is a probability of 55% or less that a fermentation success would be observed in hay-crop silage. Above 32% DM, the probability of success jumped to 74% or more. Conditions that determine whether clostridial activity occurs include the DM of the crop, buffering capacity, and water-soluble carbohydrate (WSC) level (Muck, 1998). Legumes can be put up under wetter conditions successfully if the WSC level is high and other conditions necessary for good fermentation are met. It must be noted, however, that the less mature haycrop forage that may offer higher WSC also often has higher buffering capacity (Mahanna, 1993), which makes it more resistant to pH change and offers clostridia more opportunity to proliferate.

Soluble protein has been used to evaluate retention of protein quality in fermented silage. Forage evaluation data compiled by CVAS indicates that there is significant variation in the quality of protein in the soluble fraction. In Figure 3, one can observe a very strong relationship between moisture level of legume forage and the ammonia nitrogen as a percentage of total nitrogen. This would be expected as there are more clostridial and proteolytic organisms active at higher moisture levels. However, there is little correlation between soluble protein and moisture level (Figure 3) indicating that the soluble protein test is not sensitive to the quality of the protein in the soluble fraction. It would not be a good predictor of ammonia or proteolytic activity during the forage wilting and fermentation process. The R^2 on the correlation between soluble protein and ammonia is less that 0.01% for data from CVAS (Ward, 2001).

While there is no current effort to look at ammonia or non-protein nitrogen (NPN) as independent variables in most ration balancing programs, there may be justification to give more consideration to evaluating ammonia in forages. Ammonia is often categorized along with smaller proteins such as amino acids and peptides. These components are buffer soluble as well as true protein such as albumins and globulins (Asplund, 1994). Ammonia is utilized differently than peptides and true proteins. Ammonia has value as a nitrogen source for bacteria, but there is an energy and metabolic cost to the animal with excessive ammonia intake.

Poorly Fermented Forages and Aerobic Stability Issues

Forages that are ensiled too dry (>50% DM) or ensiled during cold weather often have a restricted fermentation. This silage with its limited amount of fermentation acids is often unstable, has higher DM losses, and is more likely to undergo secondary heating when exposed to air. Yeasts are responsible for much of the secondary heating of silages exposed to air and associated DM losses. Yeasts convert sugar to alcohol, raising silage pH. Yeast end products, such as ethanol, methyl acetates, and ethyl acetates may limit DM intake (Seglar, 1999). Good silages typically have ethanol concentrations less than 1-2% DM (Kung and Shaver, 2001).

Silages that are higher in lactic acid with minimal acetic and propionic acid, or what we consider "better" fermentations, may actually be more aerobically unstable. Lactic acid is not a good anti-mycotic. A certain amount of acetic acid is desirable in order to minimize possible growth of yeast and mold organisms. Poor fermentations with elevated butyric acid levels are actually much more aerobically stable.

Considerations in Using Laboratory Evaluations

Critical in making use of laboratory information for diagnostic purposes is having an understanding of the expected levels for the item that is evaluated, and what levels are considered to be a problem. If we are provided with a crude protein equivalent from ammonia in an alfalfa silage at 9%, we gain little value from that information unless we know that 9% falls within a typical range that is non-problematic. The laboratory should be able to provide you information on the average and range for a nutrient that is tested. This paper provides as reference the average and distribution for a number of nutrients. Variation between laboratories in procedures may lead to differences in interpretation of results. It is important again to know the average and range for a given nutrient from the laboratory that produced the results. When comparing numbers over time try to stay with the same laboratory and focus more on differences than on absolute numbers.

Significance of Moisture to Fermentation Outcome

The significance of level of moisture in providing conditions opportune to various epiphytic organisms cannot be overstated. Fermentation end products are significantly related to moisture level because of the epiphytes supported at those moisture levels. Figures 4 and 5 show fermentation data for corn silage and legume silage broken out by dry matter range. Most evaluations vary significantly by DM of the plant material, with the exception of pH and ammonia in corn silage.

pH, Total Acid Level, and Titratable Acidity

pH has traditionally been used to evaluate the quality of fermentation. It is a fast and inexpensive test and can easily be run at the farm. While pH in a broad sense can aid in differentiating between a good and poor fermentation, it is limited in the information that it can provide. The relationship between pH and the amount of acids in a feed material is not as strong as one might expect. The pH measures the hydrogen ion concentration or the ratio of hydrogen to hydroxyl ions (H+ to OH-). A forage fermentation may have a high ratio of hydrogen ions to hydroxyl ions but not have a large quantity of hydrogen ions (low pH, low acid level). pH is affected by the buffering capacity of the silage. In corn silage that has little buffering capacity, it does not take a lot of acid to reduce the pH to 4. Buffering capacity is higher in legume silage than corn silage or grass silage.

Two different silages can have the same pH but different concentrations of acids. In Figure 4, average pH and total fermentation acids are graphed by DM range in corn silage. Average pH levels by dry matter range do not vary by more than 0.14 pH units from <26% to 38% DM. In that same range total acids range from 10.5% to 6.4%. pH is somewhat more descriptive in legume forages (Figure 5), but only varies by 0.47 pH units between 24% and 52% DM. In that same range, total fermentation acids varied from 11% to 4.5%.

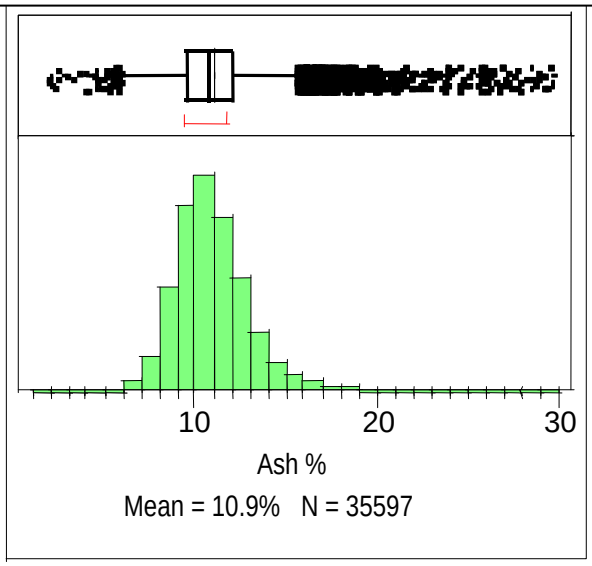
As an evaluative tool, pH is also limited in that it cannot tell us about the rate of change to arrive at a terminal pH (Mahanna, 1993). The faster the drop in pH, the more dry matter that is conserved in the fermentation process.

Titratable acidity is an evaluation that has perhaps minimal value when pH and total acid levels are available. Titratable acidity for our use is defined as the milli-equivalents of base (0.1 M NaOH) necessary to titrate the pH of a silage sample to 6.5. It measures the total of all hydrogen ions neutralized in order to bring pH to 6.5 and would account for the strength of the acids present. Titratable acidity is highly correlated with total acid levels in corn silage and high-moisture corn but not as highly correlated with total acid levels in legumes because of their greater buffering capacity.

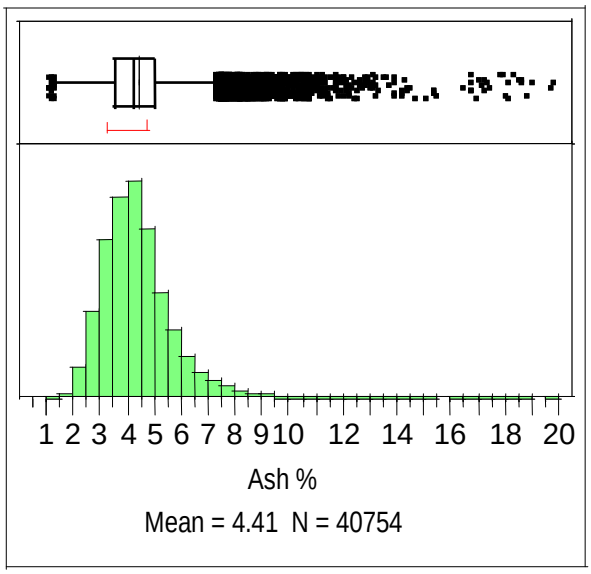
Ash Content of Silages

Higher ash content indicates that soil born yeasts and clostridial organisms may have been incorporated into the silage material compromising the fermentation and aerobic stability of the silage. Elevated ash levels are due primarily to soil contamination. This is often accompanied by high iron levels. Causes of high ash content include mowers set too low, splash on windrows from rain, raking with tines set to low, flooding of standing crops, and incorporation of soil during bunker filling or feed-out. Ash values in corn silage analyzed at CVAS average 4.4% and often will range over ten percent due to contamination. The mean of legume silage ash values is 10.9% with many samples over 15%.

Ash Content of Legume Silages Tested at CVAS



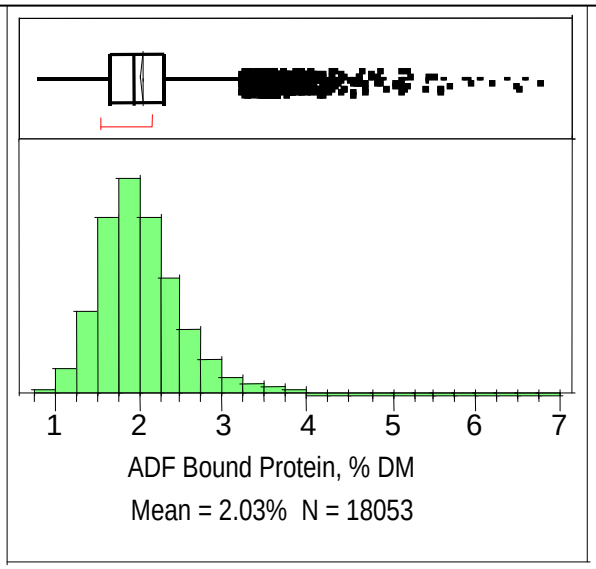
Ash Content of Corn Silages Tested at CVAS



Using ADF Bound Protein as a Quality Index

Excessive heating of forages leads to what is known as the Maillard reaction where sugars are condensed with amino acids and become part of the lignin complex. Van Soest (1982) makes the statement concerning the evaluation of heat damage: "Its assay as a guide to quality of processed feeds cannot be underestimated nor overlooked." This process of heat damage may severely reduce the availability of protein and digestible carbohydrate in a feed. ADF bound protein (%DM) (also known as ADF-CP or ADIN) values above 2% in legume silage indicate a potential problem with excessive heating. Poor bunk face management which exposes more silage surface area to air can increase ADF bound protein in silage (Ruppell et al., 1995).

ADF Bound Protein (%DM) in Legume Samples Tested at CVAS



In evaluating any given fermentation analysis, it is important to compare it to standard goals for stable silage as well as to compare it to sample averages for similar DM levels. What would be an expected fermentation outcome at 38% DM in a legume silage would not be the same if material were ensiled at 30% DM. It is important to note that forage fermentation is a dynamic process and the outcome is influenced by the interaction of many different factors. Fermentations may vary considerably from "average" values but still be reasonably efficient and provide for excellent stability.

Goals and Typical Fermentation Profiles of Haylages

Endproduct	Goal	Legume Silage (28-32% DM)	Legume Silage (32-36% DM)	Legume Silage (36-40% DM)	Grass Silage (32-36% DM)
Titratable Acidity (meq/g)		4.63	4.38	3.97	4.45
Lactic Acid (%DM)	4-7%	4.87%	5.26%	4.95%	4.72%
Acetic Acid (%DM)	< 3%	3.80%	2.96%	2.15%	2.05%
Propionic Acid (%DM)	< 0.5%	0.33%	0.15%	0.09%	0.13%
Butyric Acid (%DM)	<0.1%	0.91%	0.15%	0.15%	0.34%
Total Acids (%DM)		9.9%	8.7%	7.4%	7.2%
pH	< 4.5	4.91	4.84	4.70	4.57
Lactic Acid (%Total Acids)	65-70%	49.1%	60.4%	67.0%	65.2%
NH_3N (%Total Nitrogen)	<10%	16.40%	11.99%	9.59%	9.12%

Adapted from Kung and Shaver, 2001, Mahanna, 1997, Mahanna and Chase, 2003, Seglar, 2003

Goals and Typical Fermentation Profiles of Corn Silage and HM Corn

Endproduct	Corn Silage Goal	Corn Silage (28-32% DM)	Corn Silage (32-36% DM)	HM Corn Goal	HM Corn (68-72% DM)
Titratable Acidity (meq/g)		8.95	7.22		1.12
Lactic Acid (%DM)	4-7%	5.16%	4.75%	1-3%	0.96%
Acetic Acid (%DM)	< 2%	3.49%	2.48%	< 1%	0.33%
Propionic Acid (%DM)	< 0.5%	0.35%	0.19%	<0.1%	0.04%
Butyric Acid (%DM)	< 0.01%	0.03%	0.03%	< 0.01%	---
Total Acids (%DM)		9.05%	7.40%		1.4%
PH	< 3.9	3.88	3.88	< 4.2	4.38
Lactic Acid (%Total Acids)	65-70%	57.25%	63.85%		68.5%
NH_3N (%Total Nitrogen)	< 7%	8.58%	8.51%	< 5%	5.20%
1,2 Propandiol (when present)		1.30%	1.18%		

Adapted from Kung and Shaver, 2001, Mahanna, 1997, Mahanna and Chase, 2003, Seglar, 2003

Silage Fermentation Examples

If we *qualitatively* evaluate silage and determine fermentation characteristics, we can say more about production potential than simply analyzing for nutrient content. When purchasing forages, the challenge is to weigh nutrient content and fermentative quality characteristics appropriately. Evaluation of silage fermentation analyses is a somewhat subjective process. Silage fermentations often do not fall into clear-cut categories of "good" or "bad". The approach should be one of evaluating various fermentation data to attempt to understand not only animal acceptability but also why a forage fermentation evolved as it did.

Below are a number of actual fermentation evaluations of forages. We will entertain a discussion of fermentation quality and relate possible scenarios that would have driven these fermentations. Some nutrient data is presented as well as it assists in characterizing the forage.

Corn Silage Examples

	1	2	3	4
DM%	30.40	40.80	27.20	23.30
CP (% DM)	8.20	7.60	8.70	4.40
ADF (%DM)	26.40	23.60	30.40	34.60
NDF (%DM)	44.20	39.20	52.10	57.70
pH	3.78	4.04	3.85	4.21
Total VFA	9.20	3.70	12.20	1.62
NH_3N (%Total N)	7.40	4.80	12.40	1.10
Lactic Acid (%DM)	6.10	2.60	5.00	0.34
Acetic Acid (%DM)	2.70	0.90	5.80	0.70
Propionic Acid (%DM)	0.15	---	1.20	0.15
Butyric Acid (%DM)	---	---	0.20	0.43

Corn silage #1 represents a typical fermentation at 30% dry matter. Lactic acid is 6.1% and acetic acid is 2.7%. It is probably the preferred fermentation of the four examples provided. While it is often stated that you would want a higher proportion of lactic to acetic acid, this is often not a reasonable outcome at higher moisture levels. Generally, the ratio of lactic to acetic acid is highly correlated to the level of moisture in the silage. Propionic acid is low and NH_3N (%Total N) is less than 10%. Corn silage #2 was ensiled at too low moisture to generate a

significant fermentation that will provide for aerobic stability. Lactic acid is at an acceptable level and the ratio of lactic to acetic acid is high, but there is probably not enough lactic or acetic acid to minimize yeast activity. pH is high for corn silage at 4.04. Corn silage #3 was ensiled at too high a moisture level. Total VFA levels are high and the acetic acid is very high. This fermentation probably proceeded slowly and would incur significant dry matter losses. Propionic acid is quite high and is an index of a poor fermentation. NH_3N (%Total N) is higher than 10%. Corn silage #4 presents an unusual fermentation and nutrient scenario. Moisture is very high and all fermentation levels appear quite low. Protein appears inordinately low and fiber levels are high. This is the type of sample analysis that we might find at the front end of a bunker silo or from along the sides. Moisture has passed through the silage mass and leached out soluble materials. The silage should be sampled once it has been fed out or removed to the point of being stable. This type of silage will feed poorly.

Legume Silage Examples

	1	2	3	4	5
DM%	36.30	28.20	31.30	27.40	54.50
CP (% DM)	23.40	22.50	19.40	19.20	20.40
ADF (%DM)	32.60	34.70	41.60	39.40	38.60
NDF (%DM)	39.20	43.40	49.80	47.20	47.30
pH	4.65	4.33	5.21	6.60	5.80
Total VFA	8.90	10.80	11.60	12.20	3.60
NH_3N (%Total N)	8.50	6.20	15.40	32.50	4.40
Lactic Acid (%DM)	5.40	9.40	4.20	1.40	3.10
Acetic Acid (%DM)	3.20	1.20	4.40	5.30	0.40
Propionic Acid (%DM)	0.33	0.20	0.90	1.10	---
Butyric Acid (%DM)	---	---	2.10	4.40	---

The first legume silage sample represents a typical and reasonable fermentation for a dry matter of 36%. pH is low (probably as low as can be expected for legume silage), NH_3N (%Total N) is less than 10%, propionic acid is low, and butyric acid is not detectable. There is a reasonable but not excessive level of acid for aerobic stability. Legume silage #2 was ensiled too wet. The resulting fermentation proceeded well for the level of moisture and probably started with a high level of soluble carbohydrate to fuel the fermentation and with aggressive packing. There is no detectable butyric acid, NH_3N (% Total N) is low at 6%, and the ratio of lactic acid to acetic acid is quite high. However, lactic acid is very high and there may have been more dry matter loss than ideal. This is an unusual but positive fermentation outcome for material ensiled this wet. Legume silage #3 was ensiled too wet as well and probably had less soluble carbohydrate at ensiling that silage #2. Ammonia nitrogen is high, butyric acid is high at 2.1%, as is acetic and propionic acid. This material underwent a clostridial fermentation and would present significant feeding challenges, especially for fresh and early lactation cattle. Legume sample #4 was ensiled at the same moisture as sample #2, but with a much different outcome. pH is very high to almost neutral, ammonia nitrogen is extremely high as is the level of butyric acid. This clostridial fermentation probably resulted in the utilization of lactic acid by clostridial bacteria resulting in a very low level of lactic acid. It would be advisable to not feed material of this poor of a quality. Legume sample #5 was ensiled too dry and there is probably not sufficient acid for aerobic stability. This sample may have experienced heat damage from being ensiled too dry.

Grass Silage Examples

	1	2	3	4
DM%	31.80	56.20	16.10	26.40
CP (% DM)	13.50	15.50	14.20	13.80
ADF (%DM)	30.90	35.50	38.90	45.50
NDF (%DM)	50.60	58.80	53.90	61.90
pH	3.97	4.76	6.03	7.86
Total VFA	6.80	4.43	12.63	0.69
NH_3N (%Total N)	6.59	6.45	48.20	9.44
Lactic Acid (%DM)	5.40	3.80	0.20	0.46
Acetic Acid (%DM)	1.40	0.63	3.80	0.23
Propionic Acid (%DM)	---	---	1.82	---
Butyric Acid (%DM)	---	---	6.81	---

Grass silage #1 represents a good fermentation for a 32% dry matter sample with a low pH. pH in well-fermented grass silage samples will run lower than in similar moisture legume samples as there is not as much buffering capacity. Typically, total VFA levels will run slightly lower in grass silage samples of comparable moisture as there is less soluble carbohydrate. Adequate packing of grass silage samples can be more difficult than legumes and will result in higher levels of heat damaged protein, as in sample #2, which was ensiled too dry. Sample #3 represents a sample that was ensiled entirely too wet and underwent a clostridial fermentation. Ammonia nitrogen on a crude protein basis represents almost one-half of the protein in the sample. This material should probably not be fed. Sample #4 was ensiled too wet. The material appears to be quite mature and would have provided minimal soluble carbohydrate to drive a fermentation. In fact, this material does not appear to have fermented to any degree and has undergone spoilage as a result. pH is actually basic at 7.86. Volatile fatty acid levels are very low. Silages with minimal VFA levels and high pH levels are implicated at times in supporting organisms that can be quite toxic to cattle.

Effect of Fermentation Time on Corn Silage

Often, producers and nutritionists believe that corn silage is fairly well fermented after three weeks of fermentation and it is O.K. to start feeding it. We analyzed 19,185 corn silage samples between 25 and 45% DM that were submitted to Cumberland Valley Analytical Services, Inc. from farms in New York between January, 2004 and February, 2008. All samples were analyzed using the near-infrared (NIR) technique. We looked at how the fermentation profiles varied according to the month of the year that the samples were sent to CVAS. Month of sample submittal was assumed to relate to length of crop fermentation. We figured that all samples started their fermentation process some time between August and October.

In our study, lactic acid, pH, and titratable acidity did not reach maximum levels until 4 months after ensiling. Acetic acid levels continued to increase until 6 months after ensiling. pH was significantly higher in September, October, November, and even December. Soluble CP was lower during the first three months post-ensiling and reached a plateau after 4 months. Ammonia was lower during the first six months post-ensiling. Soluble CP and ammonia may be related to starch degradability. In Figures 6, 7, and 8, the fermentation cycle starts as the percentage of unfermented or marginally fermented samples received by the lab is at a peak. The graphs show that to occur in November. The graphs show as well that measures of fermentation in corn silage generally plateau in March.

Summary

Fermentation analysis is a diagnostic tool that will allow the nutritionist to better characterize problem forages and their possible contribution to intake problems. Fermentation analysis can be used as a management "report card" on the silage making process. It allows the advisor and producer to focus on potential weaknesses in management that may need to be corrected. Evaluation of fermentation end-products is a common research tool, but the field person needs to be careful in using fermentation analysis to draw conclusions about treatments and practices. The outcome of a forage fermentation is significantly related to dry matter level at ensiling due to the epiphytic organisms that are supported. Total acids, as well as types of acids present, are significantly correlated to dry matter level. Not following good silage making practices may lead to excessive heating during fermentation that may degrade significantly protein and carbohydrate quality. Incorporation of soil into the forage material should be avoided as it may lead to poorer fermentations.

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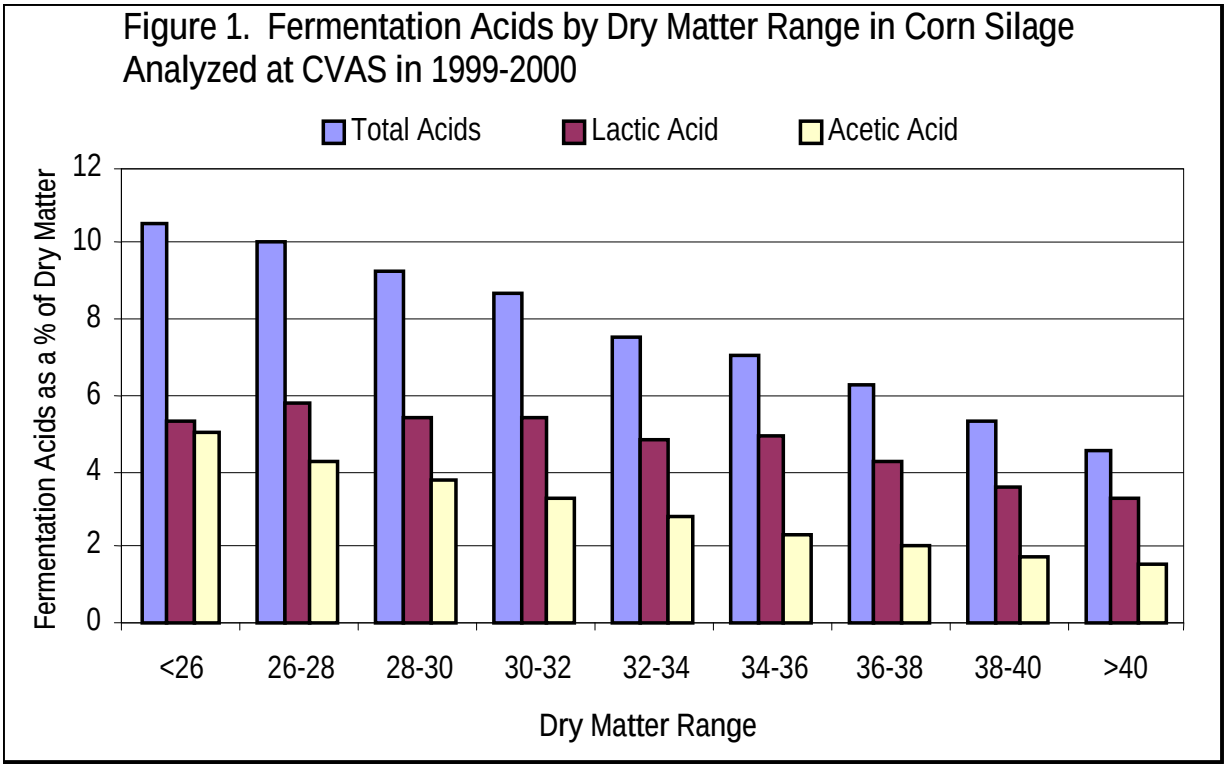


Figure 2. Fermentation Acids by Dry Matter Range in Legume Silage Analyzed at CVAS in 1999-2000

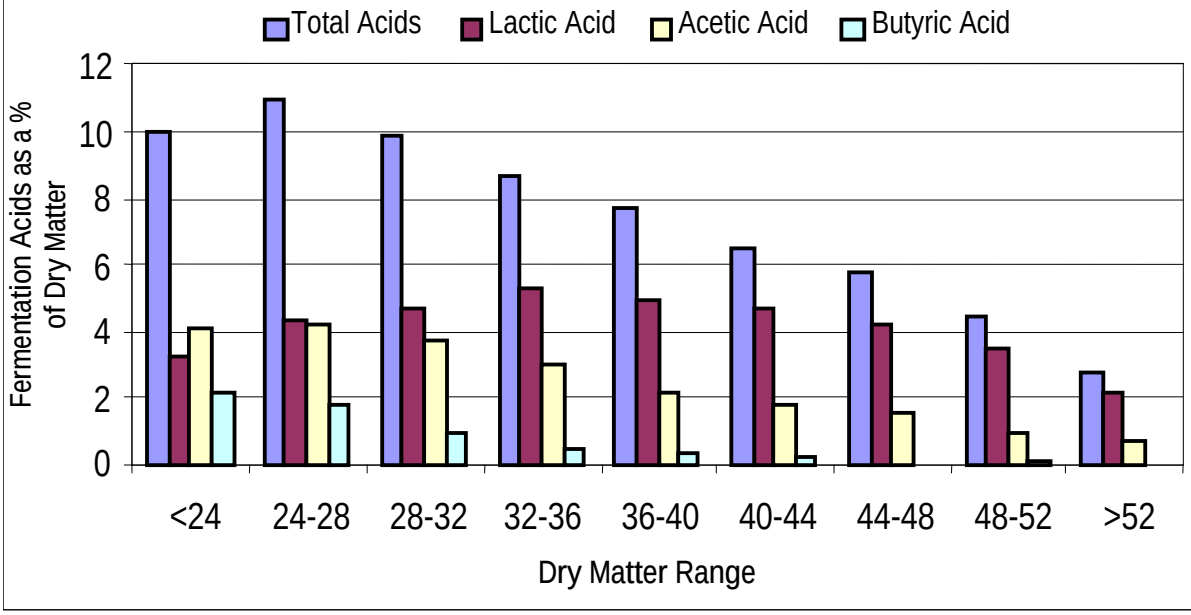
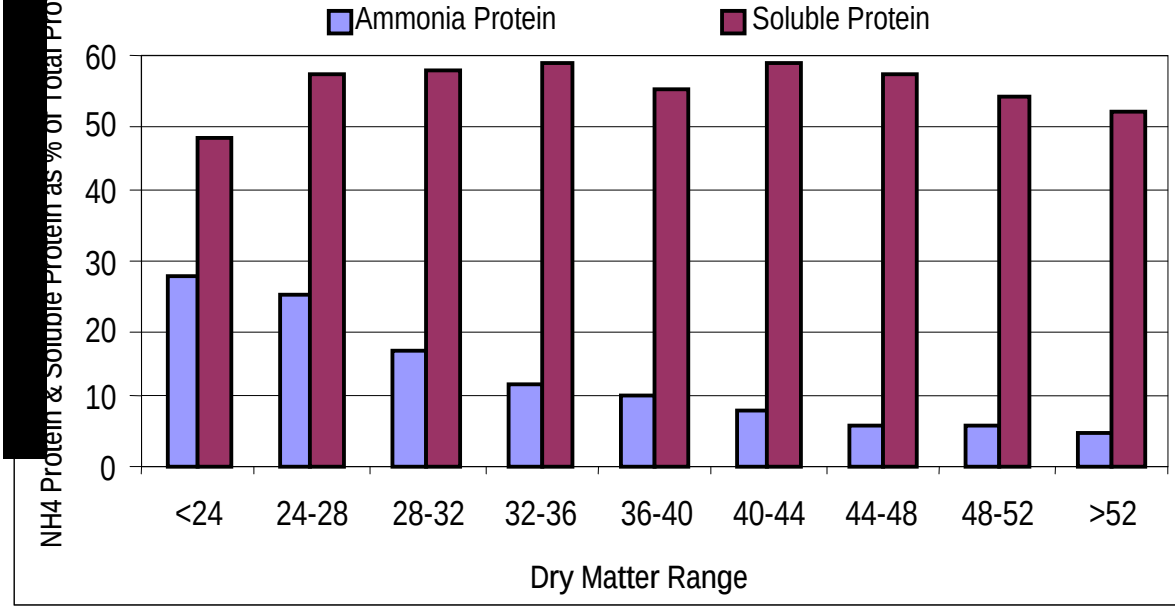


Figure 3. Ammonia Protein and Soluble Protein by Dry Matter Range in Legume Silage Analyzed at CVAS in 1999-2000



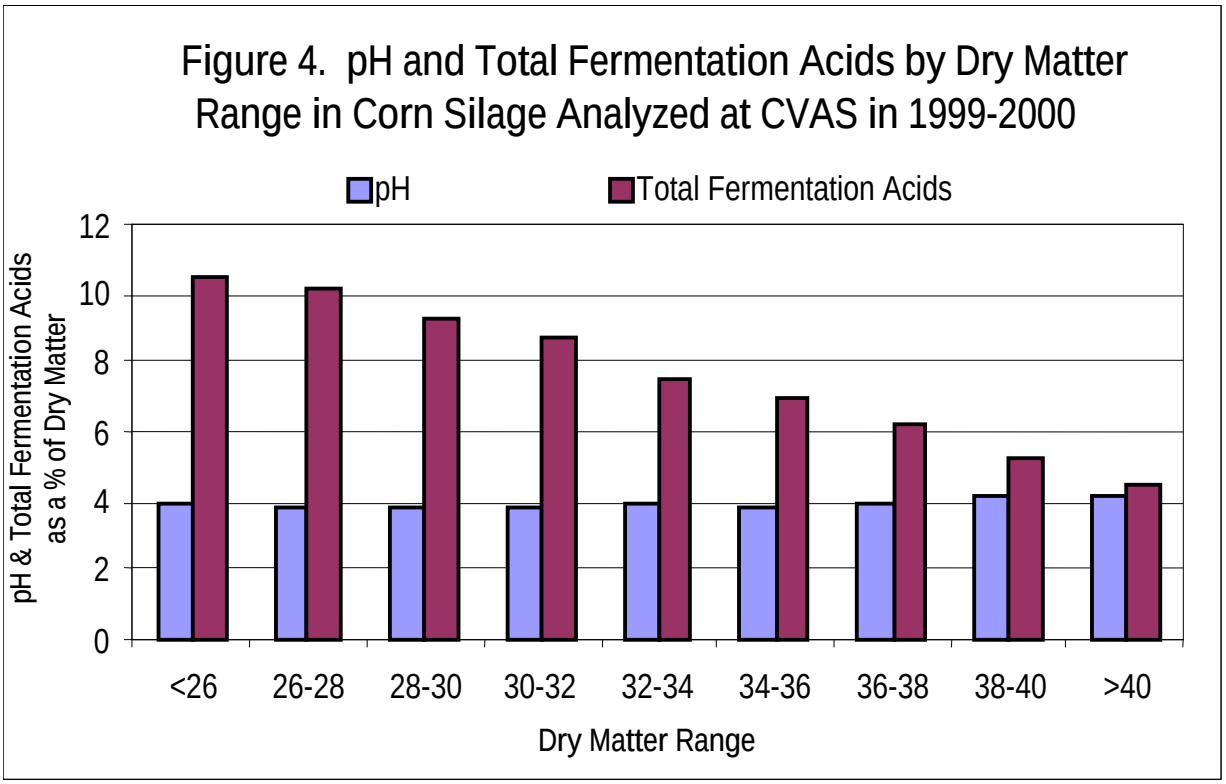


Figure 4. pH and Total Fermentation Acids by Dry Matter Range in Corn Silage Analyzed at CVAS in 1999-2000
pH
Total Fermentation Acids
pH & Total Fermentation Acids as a % of Dry Matter
0
2
4
6
8
10
12
<26
26-28
28-30
30-32
32-34
34-36
36-38
38-40
>40
Dry Matter Range

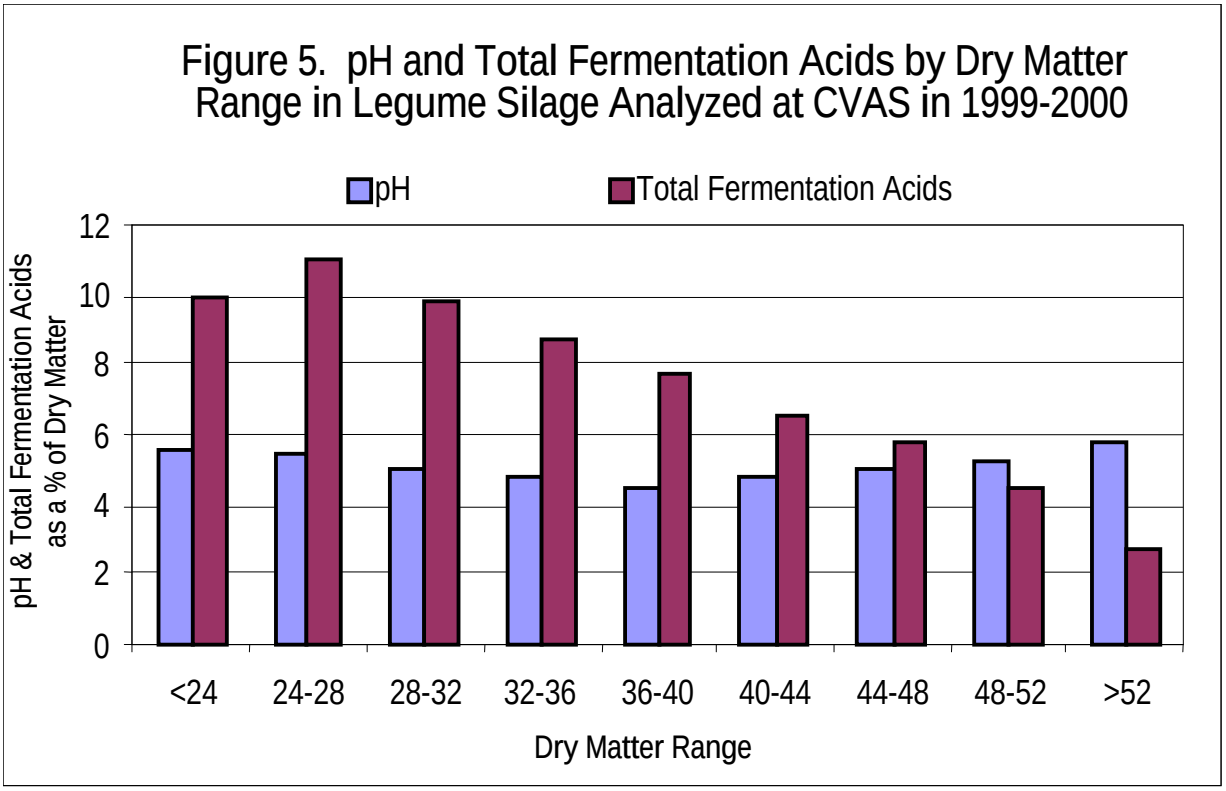


Figure 5. pH and Total Fermentation Acids by Dry Matter Range in Legume Silage Analyzed at CVAS in 1999-2000
pH
Total Fermentation Acids
pH & Total Fermentation Acids as a % of Dry Matter
0
2
4
6
8
10
12
<24
24-28
28-32
32-36
36-40
40-44
44-48
48-52
>52
Dry Matter Range

Figure 6. Measures of Fermentation of Corn Silage Over A Fermentation Cycle

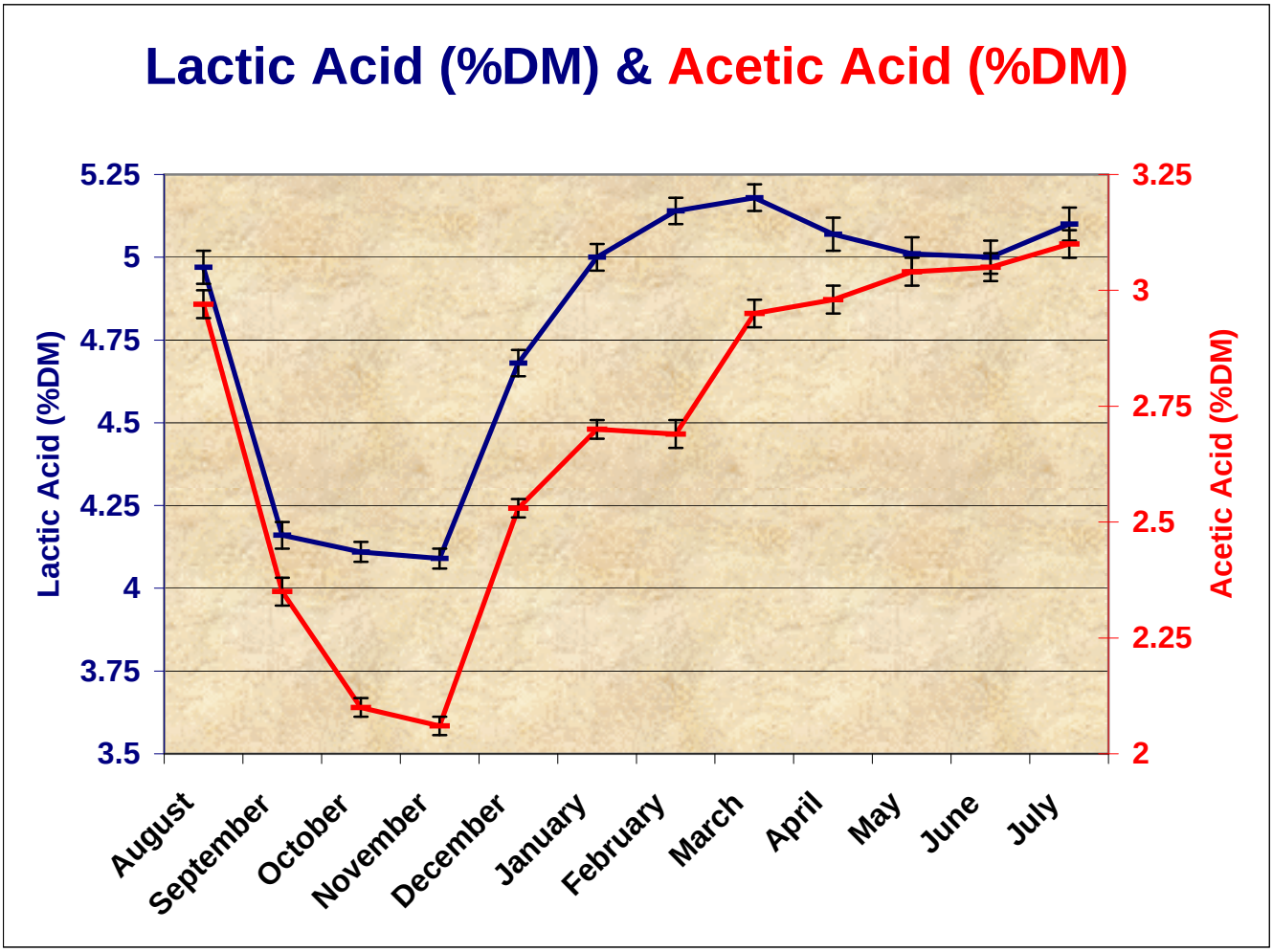


Figure 7. Measures of Fermentation of Corn Silage Over A Fermentation Cycle

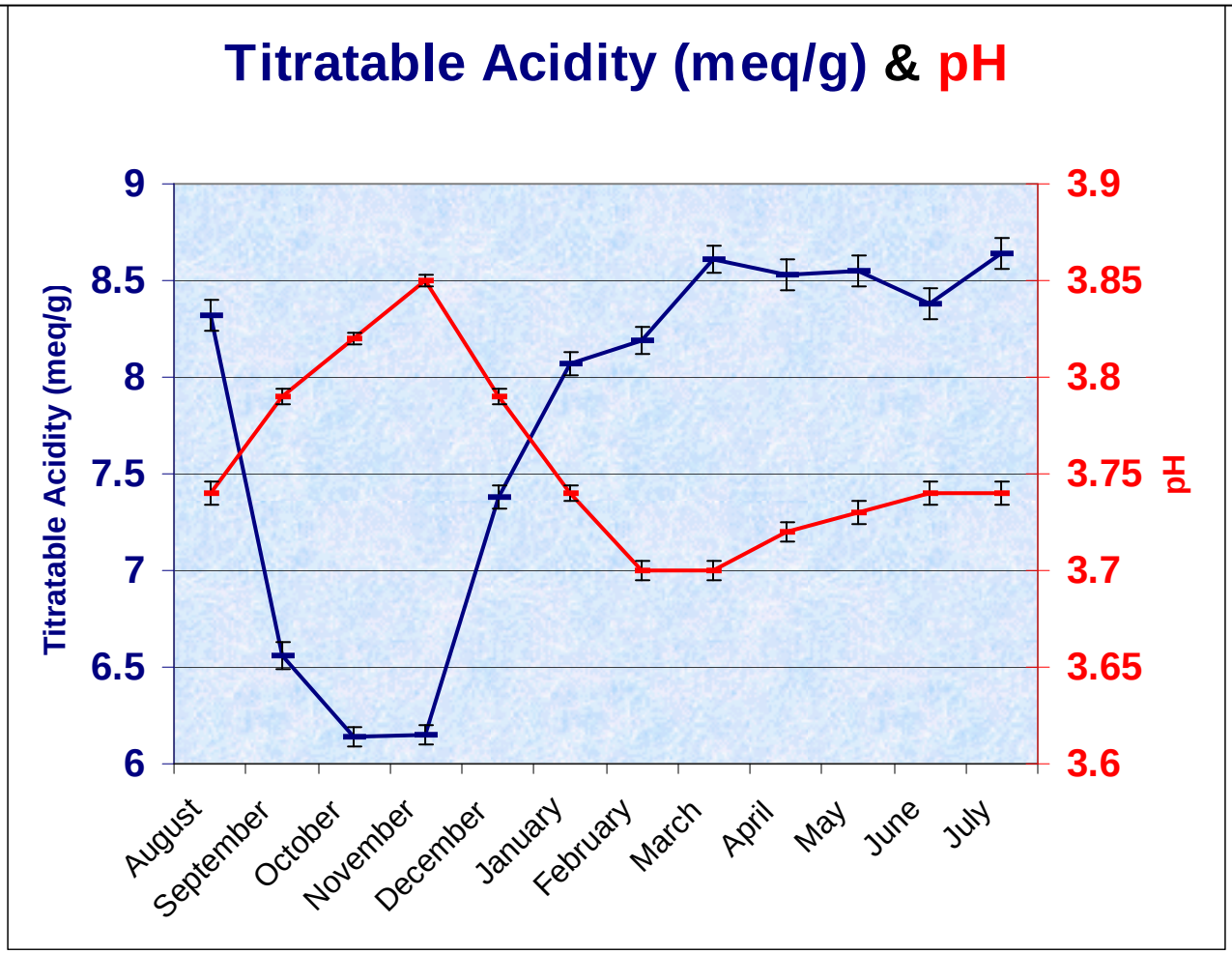


Figure 8. Measures of Fermentation of Corn Silage Over A Fermentation Cycle