

Near Infrared Reflectance Spectroscopy Comparison of Dairy One and AgriNIR Forage  
Analyzer

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David Vander Schaaf

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## **ABSTRACT**

The objective of this experiment was to determine how closely related two different near infrared reflectance spectroscopy machines were in analyzing the components of corn silage and alfalfa hay. Near infrared reflectance spectroscopy (NIRS) is a method of analyzing the composition of forages in a fast and repeatable way by exposing a sample to near infrared light and recording which wavelengths are absorbed and which are not. All of the major components of corn silage and alfalfa hay have known absorption rates of near infrared light. By calculating which wavelengths of light are absorbed and which ones are reflected back, a value can be assigned for how much of each component a feed has. Corn silage and alfalfa hay samples were taken between July 3, 2013 and August 7, 2013. There were a total of 79 corn silage samples taken from 36 dairies. Dairies that had multiple samples taken from them were separated by at least 3 weeks to allow for a new part of the pile to be exposed and tested. There were a total of 76 samples of alfalfa hay that were sampled. These samples came from 25 different dairies. The same lot of hay was never tested twice in this experiment. All samples were tested in the AgriNIR Forage Analyzer first. The same sample was then taken and analyzed by Dairy One Forage Analyzing Laboratory. There was a large difference in the results between the two machines. They had disagreement in their test results and the disagreement varied by component. Several components had a low correlation between the two machines, so the disagreement was not linear. Other components had a high correlation, but they had a large difference in actual values.

Key words: Near infrared reflectance spectroscopy, corn silage, alfalfa hay, forage testing

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## INTRODUCTION

Due to the high cost of commodities and byproducts, feeding forages is becoming a very cost effective way to feed cattle. Dairy cows require a very precise ration in order to maximize their efficiency and production. Rations must be balanced for several different nutrients, and that is only possible if there is a known value for the forages (Sirois 2000). The most cost effective way to analyze forages is through the use of near infrared reflectance spectroscopy (NIRS). This method uses near infrared light to analyze the chemical composition of feed samples with very little sample preparation (Norris 1989). This method takes roughly two days (Abrams 1989). There are several advantages for using NIRS to analyze feeds, some of which include cost, speed and smaller sample size (Undersander 2006; Park et al. 1998). The other common method is wet chemistry. This method uses chemical reactions to get very precise measurements of the chemical composition. It is more expensive, takes longer and it requires the use of hazardous chemicals (Park et al. 1998).

Near infrared reflectance spectroscopy is used to determine the major nutrients that make up forages. The major nutrients for corn silage and alfalfa hay that are needed to be known in order to balance a ration are dry matter, protein, ADF, NDF, crude fat and ash. Starch is also evaluated for corn silage but not alfalfa. This study evaluates the relationship between two machines that test these components. The AgriNIR is a portable NIRS machine that can be taken onto a farm for an evaluation that takes a few minutes. This machine is compared against Dairy One Forage Laboratory in Ithaca, NY.

The goal of this study was to evaluate the differences between the test results from the AgriNIR and Dairy One when looking at several samples of corn silage and alfalfa hay.

## **REVIEW OF LITERATURE**

### **Near Infrared Reflectance Spectroscopy**

In the past few decades, scientists have made great progress in identifying the nutritional requirements for many types of cattle. Nutritionists work on developing a ration to suit the needs of specific animals. To formulate a ration, a nutritionist needs to know what the feedstuffs are made of. Most of the commodities that are fed maintain a relatively constant value and are determined by a milling company. Forages vary from farm to farm and even change throughout a stack or pile. The variations in the components that make up forages vary so greatly that it affects the composition of a total mixed ration (TMR) significantly. Nutritionists need to know what the composition of the forages that they are feeding in order to accurately formulate a ration. One of the quickest and most accurate ways to analyze forages, and other feeds, is through the use of near infrared reflectance spectroscopy (Sirois 2000).

Near infrared reflectance spectroscopy (NIRS) is a method of analyzing the chemical composition of feed with little preparation (Norris 1989). This method of analysis has been used to determine the composition of food, pharmaceuticals, and beverages since the 1980's (Restaino et al. 2009). However, the technology was used to evaluate forage quality as early as 1976 (Undersander 2006). The Association of Official Analytical Chemists (AOAC) recognizes NIRS as a way to evaluate feeds (Undersander 2006; Sirois 2000). Using NIRS, scientists can get quick and accurate test results for analyzing feeds (Park et al. 1998).

Analyzing feed by using NIRS requires measuring wavelength intensity of rear infrared light on a sample and determining the absorption and reflectance of the light. Infrared light is light that is made up of wavelengths that are just beyond what the human eye is capable of seeing. These wavelengths range from 700-3000 nanometers (nm), but the wavelengths used to

scan samples actually range from 1200-2500 nm (Norris 1989). A computer is able to determine which wavelengths are reflected back and which ones are absorbed by the material being examined (Undersander 2006). Hydrogen that is bonded to other atoms such as C, O<sub>2</sub>, N<sub>2</sub>, and S vibrates in a unique way and its vibrational pattern can be indirectly measured by how much infrared radiation it absorbs (Park et al. 1998). Properties of a sample can be determined because the each chemical that makes up the nutrients has a different absorption rate of infrared light (Norris 1989). To run a NIRS test, samples are packed into a container and two different wavelengths of light are shined upon a sample. One wavelength is set to be a maximum wavelength absorption point, and another is set to be the minimum wavelength absorption point. The ratio of the absorption of each of these two wavelengths is referenced against a known value, and a nutrient value is assigned (Norris 1989).

To determine the nutrient value, a vast number of reference samples must be analyzed by both wet chemistry and NIRS (Sirois 2000). Wet chemistry is the traditional method of sampling feeds. Running chemical tests on samples is the most accurate way to determine what is in a sample, and these tests are needed as references to NIRS to accurately calibrate the machine and analyze components of feeds (Park 1998). Near infrared reflectance spectroscopy is approved to measure moisture, nitrogen and ADF according to the AOAC (Undersander 2006). This method does not measure minerals directly, but it estimates them based off of know correlations to levels of other nutrients in a given sample (Sirois 2000).

There are advantages and disadvantages to using NIRS to analyze forages. The following table lists the advantages and disadvantages for both NIRS and wet chemistry; it uses references from Park et al. (1998), Undersander (2006) and Sirois (2000).



Table 1. Advantages and disadvantages of NIRS and wet chemistry

	NIRS	Wet Chemistry
Advantages:	Speed, accuracy, multiplicity of analyses, small sample size, non-consumption of the sample, reduced cost, no chemicals	Accuracy
Disadvantages:	Expensive and time consuming to develop calibrations	Slow, consumption of sample

The advantage of using NIRS is that the samples can be tested in a matter of minutes and produce an accurate result (Park et al. 1998; Undersander 2006; Sirois 2000). The results are capable of being repeated to provide confidence in the results given. If a laboratory uses the reference methods provided by the AOAC, their standard of error is low. Undersander (2006) states that the standard deviation for errors for CP was 0.2%, 0.5% for ADF, and 0.6% for NDF. This means that samples can be tested several times and the range of the results will be within those values 66% of the time. The other key part to NIRS is that there are no chemicals used in this process (Liu et al. 2011). Samples do not need to be mixed with chemicals to calculate reactions, so samples are not ruined during the analysis and they can be retested at a later time. Also, only a few grams are needed to test in the NIRS machine, but it is still recommended that a larger sample is provided for consistency (Park et al. 1998; Undersander 2006; Sirois 2000).

The key disadvantage to using this machine is that it is expensive to calibrate. NIRS machines must have a large number of reference samples that are tested by both NIRS and wet chemistry. Samples are scanned by NIRS and then they are tested with wet chemistry to determine a true value. The value given by wet chemistry is matched to the absorption curve by NIRS and a correlation is formed (Park et al. 1998; Undersander 2006; Sirois 2000). As the

number of samples increases, the confidence in the correlation increases. Samples that can be scanned by NIRS can only be properly tested by using the same correlation that was created for that exact type of material. Corn silage cannot be scanned using the curves for alfalfa hay. Forages vary greatly in their composition from one field to another (Restaino 2009). This variation is the result of several factors. Some of these factors include species of the plant, maturity of the plant when it was harvested, the climate that it was grown in, the way that it was harvested, how it was ensiled or stored, and what kind of fertilizer or inoculant was used (Park 1998). The composition of forages varies from region to region, and in order to have accurate NIRS tests, calibrations should include plants from every region, or calibrations should be specific to a certain area (Sirois 2000).

### **Sampling:**

Laboratories will properly test whatever sample is provided for them, but this does not mean that the results are an accurate representation of what the forage in the pile or stack consists of. If the sample sent to the laboratory does not represent the average of the pile or stack being tested, then the test results will not reflect what the composition of the pile is (Abrams 1989). If proper technique is used to collect a sample, then the test results will be valid for the pile (Sirois 2000). The following are sampling techniques that will ensure an accurate analyzation of a hay stack or silage pile. First, to get an accurate assessment of the amount of fiber and leaves in a stack of hay, a Penn State Corer should be used. This will take a cross section of a bale, and getting parts from many different plants (Abrams 1989). Bales should be cored from the small end of the bale so that it will cut through different flakes within the bale and not just sample one part (Sirois 2000). To get a representative sample of the entire lot of hay,

cores must be taken from 20 different bales. This will account for variation within a field due to different environmental factors. Some parts of a field could be exposed to more sunlight, water, or oxidation due to the air exposure after it is baled (Abrams 1989). A study done by Martin et al. (1988) showed that samples from 20 different alfalfa bales from the same lot of hay varied considerably in their nutritional value. Protein within a single field ranged from 18.2-22.4%, ADF ranged from 28.6-36.9%, NDF ranged from 33.7-54.1%, and relative feed value varied from 103-184. This shows that samples should be taken from several different spots in the stack and a blended sample should be analyzed (Sirois 2000). After the coring probe is full, a wooden rod should be used to clear out the contents of the probe. Everything should be emptied directly into a plastic bag which is then sealed and sent to a laboratory for analysis (Abrams 1989; Sirois 2000). When sampling hay, hay should not be grabbed by hand, cut with a scissors, or pulled from the feed bunk. These techniques do not get a representative sample of the hay because they allow for the fine material, which contains a majority of the nutrients, to fall out. They also allow for contamination from other materials (Sirois 2000).

Sampling silage is done in a slightly different way. Because silage has more moisture in it, a coring device is not as effective at taking out samples. Samples are taken by hand from the face of a silage pile in no less than 6 locations (Abrams 1989). This should include samples from the top of the pile, the middle and the bottom. This will give a more accurate representation of what the pile truly is made up of (Sirois 2000). The silage should be packed in a plastic bag, sealed and delivered to a laboratory for analyzation. If the amount of silage is too large to put in a bag, the sample should be mixed and a subsample should be taken (Abrams 1989).

When laboratories analyze a sample, it is important that they do it the same way every time because NIRS is affected by both physical and chemical properties of a sample. If samples

are prepared in different ways, different calibrations for the NIRS machine must be made for each technique. A study was done that showed that samples of forages dried in paper bags could not use the same calibration as samples that were dried in cloth bags (Marum et al. 1979). Near infrared can test for dry matter, but it is most accurate for dry matter that is below 85% (Undersander 2006; Petisco et al 2009). Most samples are dried by an oven or by a microwave to 90-94 percent dry matter. Oven drying takes about one day, and microwave drying takes a few minutes but it is susceptible to charring the sample. Samples are then ground with a cyclone mill through a 1-mm screen (Abrams 1989). A 0.75- 1.75 g sub sample is taken from the uniform ground sample and placed in small box with a quartz window on the front, and a removable back made from rubber or foam core (Abrams 1989). The NIRS machine and samples must maintain a normal room temperature of 25 +/- 5 C. Also, relative humidity should be 60 +/- 2 percent (Abrams 1989). Samples are scanned and the computer calculates which light waves are reflected and absorbed. It then gives the results of the composition of the feed (Sirois 2000).

## **MATERIALS AND METHODS**

### **Materials**

The AgriNIR Forage Analyzer was provided by Dinamica Generale (Montova, Italy). Sample bags were provided by Dairy One Forage Lab, and all sampling was done at Dairy One Forage Lab (Ithaca, NY). Samples were shipped in standard boxes purchased from Federal Express (Oakdale, CA). Corn silage samples were taken from 36 dairies and alfalfa hay samples were taken from 25 dairies spread throughout the Central Valley in California. These dairies span from Tipton to Galt in California. The hay corer and bucket to mix corn silage samples were both provided by Progressive Dairy Solutions (Oakdale, CA). All funding for forage sampling was provided by Progressive Dairy Solutions.

### **Samples**

There were 25 dairies where individual hay stacks were sampled for analysis, and 36 dairies where corn silage piles were sampled. Corn silage piles were tested multiple times to increase sample size, but there was always three weeks in between samplings to allow for a new portion of the pile to be exposed. No hay stacks were tested more than one time. All samples were taken between July and August of 2012. All corn silage samples were from the crop that was harvested the previous year and had been in the pile for over nine months. All hay samples originated from the western region of the United States. All corn silage samples came from the Central Valley in California. There were a total of 79 corn silage samples and 76 alfalfa hay samples.

## Methods

Corn silage samples were gathered on site at the silage pile. Samples were taken from at least 7 spots on the face of the pile. The samples were mixed together in a bucket and a sub sample was taken out. This sub sample was placed in the *fodder box* and tested in the AgriNIR machine. Results were printed out of the machine and recorded. The same sample that was in the box was removed and placed directly in a bag that was sealed and shipped overnight to Dairy One Forage Lab (Ithaca, NY). Figure 1 shows what the AgriNIR machine looked like.



Figure 1. AgriNIR Forage Analyzer machine that was used to test all of the samples.

Alfalfa hay samples were gathered by coring 10 bales of hay through the small side of a bale. The coring device that was used was a Penn State Corer that was attached to a drill. Five to

seven bales were probed and the hay was placed directly in the *fodder box*. Samples were tested in the AgriNIR machine and results were recorded. The exact sample that was tested inside the AgriNIR was placed inside a bag and shipped overnight to Dairy One Forage Lab (Ithaca, NY).

All samples tested in the AgriNIR machine were tested three times and an average of the tests was recorded. Each sample was tested under its respective feed type family to ensure accurate test results. After each sample was tested, the fodder box, which held the feed being sampled, was cleaned with a paper towel to remove any residue left behind.

All samples were sent to Dairy One Forage Lab (Ithaca, NY) to compare with the results given by the AgriNIR machine. The sampling protocol for Dairy One is as follows:

1. Wet samples (silage) are dried at 60 C for 4 hours followed by grinding through a cyclone mill fitted with a 1mm screen
  2. Dry samples (hay) are not oven dried and ground directly through a cyclone mill fitted with a 1mm screen
  3. Dried ground samples are stored in glass mason jars. Samples are stirred 25 – 30 times prior to analyses.
  4. A 3 gram subsample is taken from the jar and packed into a ring cup.
  5. The ring cup is loaded into the instrument (Foss Model 6500) and scanned 32x in approximately 60 seconds.
  6. Results are determined using the LOCAL function of ISI Scan software.
- (Sirois 2000).

## **STATISTICAL ANALYSIS**

Statistical Analysis for the data received was processed using the SAS software. All samples that were tested were used besides one corn silage sample had its starch levels removed from the model because AgriNIR could not give a reading for it. This sample had a starch level that was far outside the normal value and the AgriNIR machine could not give a test result for it.

## **RESULTS AND DISCUSSIONS**

There were a total of 79 corn silage samples that were tested, and 76 samples of alfalfa hay. All corn silage samples were tested and compared for their dry matter, starch, ADF, NDF, crude fat and ash. Alfalfa was tested for the same components with the exception of starch.

### **Corn Silage**

The first statistical test that was performed compared the test results of the AgriNIR Forage Analyzer to the results from Dairy One by determining the Pearson Correlation Coefficient of each variable. Each individual component was analyzed and correlated to the result given by the other machine. Table 2 lists the correlations of dry matter, starch, protein, ADF, NDF, ash, and crude fat. The dry matter results suggest that both machines strongly correlated to each other. The results for starch, ADF and NDF have a correlation coefficient between 0.62-0.64 shows that the machines have medium correlation to each other. Protein, ash and fat were not strongly correlated to each other at all; they were all below 0.38.



**Table 2.** Inter-machine, Dairy One versus AgriNIR, correlation of components tested against same component for corn silage

Item	Component						
	Dry Matter	Starch	Protein	ADF	NDF	Ash	Crude Fat
Pearson Correlation Coefficient	0.86071	0.62062	0.22010	0.64346	0.63987	0.38732	0.26856
r-value	<0.0001	<0.0001	0.0513	<0.0001	<0.0001	0.0004	0.0167

There was a strong correlation between machines for dry matter. The  $R^2$  value shows that about 74% of the variance is described by the regression line that has been fitted to this graph. Figure 2 shows the individual results graphed against the result from the same sample tested on the other machine. This test is different than the test of standard deviations for the differences between machines because it shows if the relationship between the machines is still present even if it is not a 1:1 variation of error between results.

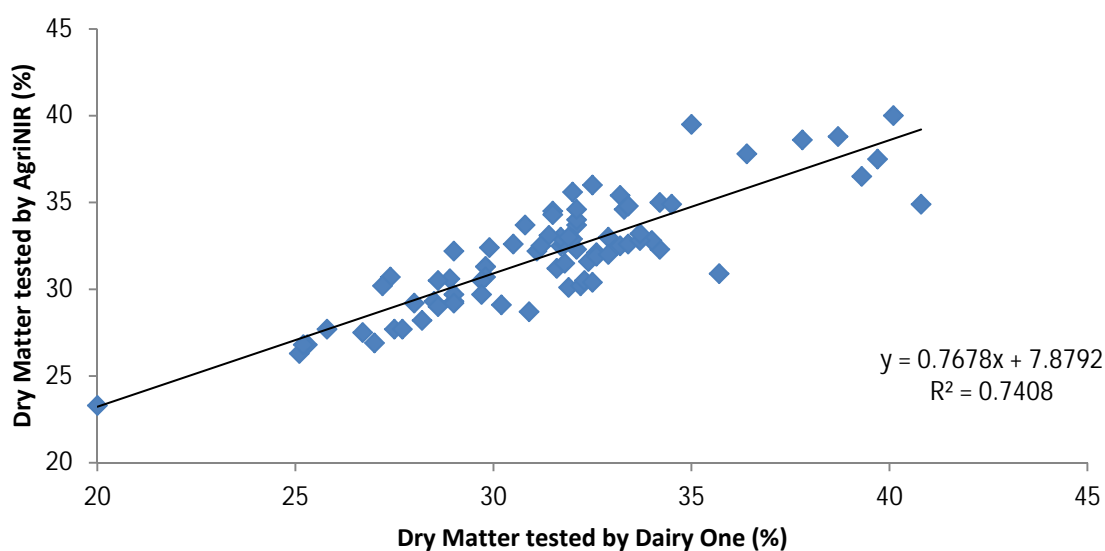


Figure 2. Scatter plot of the test results for dry matter of corn silage from Dairy One and AgriNIR.

Dry matter test results for corn silage had a very strong correlation, but starch did not.

Figure 3 shows the correlation for the results of starch. The results have a very wide distribution and the  $R^2$  value is very low and the trend line only describes about 39% of the samples. This shows that the machines do not agree very well for starch.

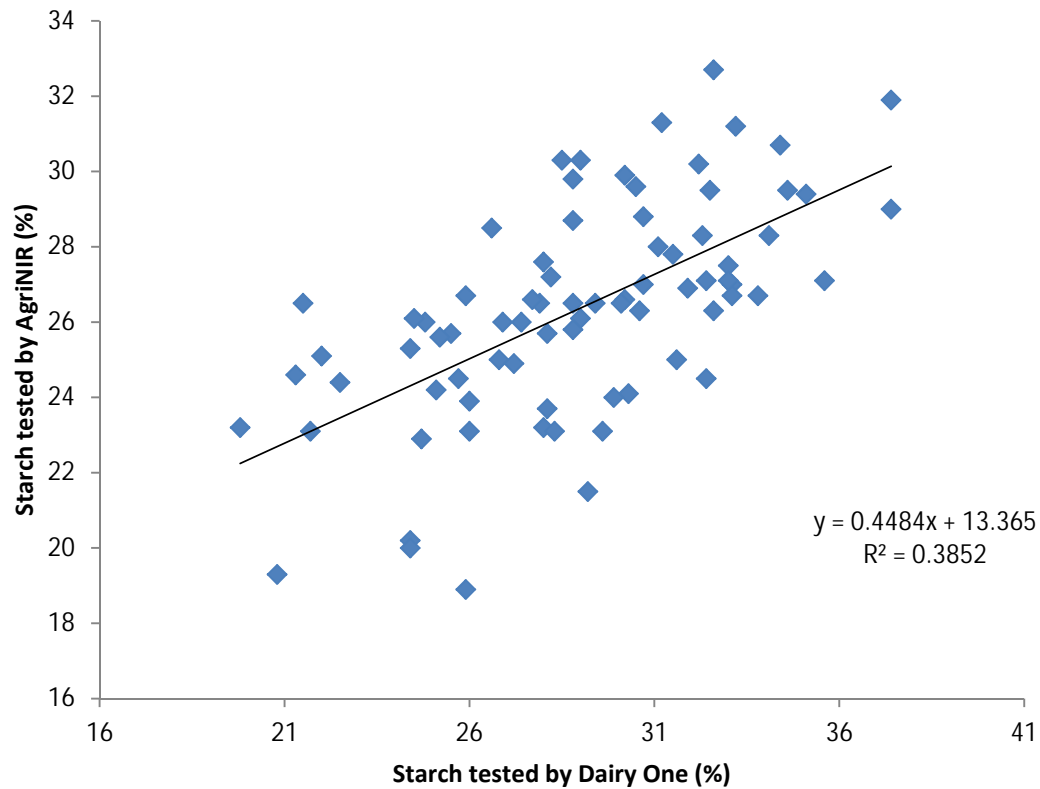


Figure 3. Scatter plot of test results for starch levels (%) for corn silage from Dairy One and AgriNIR.

All of the samples that were tested by Dairy One were compared and a statistical analysis was performed (Table 3). This table shows what the entire population of samples looks like.

**Table 3.** Simple statistics of all Dairy One Lab results for corn silage

	Component						
	Dry Matter	Starch	Protein	ADF	NDF	Ash	Crude Fat
Mean	31.45443	28.92949	7.60633	28.73671	45.90886	6.53203	3.7557
Std Dev	3.58246	3.91090	0.75809	2.73736	3.68466	0.96146	0.4405
Sum	2485	2257	600.9	2270	3627	516.03	296.7
Minimum	20.0	19.8	6.0	22.7	37.1	4.59	2.5
Maximum	40.8	37.4	10.7	34.8	55.1	9.9	4.8

The same analysis that was performed for the results from Dairy One was performed on the results given by the AgriNIR Forage Analyzer (Table 4).

**Table 4.** Simple statistics of all AgriNIR results for corn silage

	Component						
	Dry Matter	Starch	Protein	ADF	NDF	Ash	Crude Fat
Mean	32.02911	26.3	7.36962	28.36835	44.59241	4.85063	3.35570
Std Dev	3.19564	2.84988	0.32080	2.46392	2.99002	0.51562	0.20428
Sum	2530	2078	582.2	2241	3523	383.2	265.1
Minimum	23.3	18.9	6.7	23.8	38.9	4.0	2.8
Maximum	40.0	32.7	8.1	35.3	52.1	6.6	3.9

The standard deviations for the results given by Dairy One are consistently larger for every component. This suggests that the AgriNIR is less sensitive to large variation in the range of composition of corn silage. The results for Dairy One have a wider range than those from AgriNIR. This does not necessarily mean that Dairy One is more or less accurate, just that it gives results that are less constrained to a given range than the AgriNIR.

## Alfalfa Hay

The two sets of results given by Dairy One and the AgriNIR Forage Analyzer were compared and correlations were calculated. Table 5 lists the correlations and the r-value for each component. The correlations for dry matter, protein and NDF were the highest, ranging from 0.72-0.77. This shows that the machines were in the closest agreement in these areas. Acid detergent fiber and ash both had a medium correlation and crude fat had a very low correlation. This showed that the machines were not in agreement for these components.

Table 5. Inter-machine, Dairy One versus AgriNIR, correlation of components tested against same component for alfalfa hay

	Dry Matter	Protein	ADF	NDF	Ash	Crude fat
Pearson Correlation Coefficient	0.7187	0.73239	0.60374	0.76881	0.59988	0.30562
r-value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0073

The correlation of the ADF results from Dairy One and AgriNIR was very low. Figure 4 shows a scatter plot of the results from each tester. The plot has a wide distribution. The  $R^2$  value is very low and the trend line only describes about 36% of the data. This means that the machines do not agree on the levels of ADF.

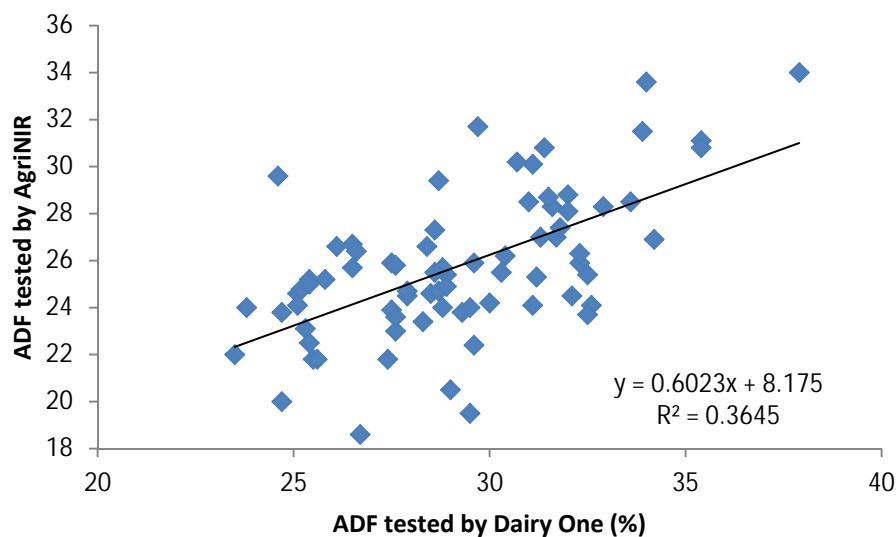


Figure 4. Scatter plot of Dairy One ADF test results against ADF from AgriNIR.

The results given by Dairy One were compared to each other and statistics were calculated. Table 7 lists the results for alfalfa hay.

Table 7. Simple statistics of all Dairy One Lab results for alfalfa hay

	Component					
	Dry Matter	Protein	ADF	NDF	Ash	Crude Fat
Mean	91.26711	23.37368	29.21842	37.09211	10.15974	2.36711
Std Dev	0.82161	2.39229	3.09213	4.53825	1.01411	0.28161
Sum	6936	1776	2221	2819	772.14	179.9
Minimum	88.9	11.2	23.5	29.5	8.05	1.8
Maximum	92.6	27.2	39.9	58.6	12.45	3.2

The results given by AgriNIR Forage Analyzer were compared to each other and statistics were calculated. Table 8 lists the results for alfalfa hay from AgriNIR.

Table 8. Simple statistics for all AgriNIR results for alfalfa hay

	Component					
	Dry Matter	Protein	ADF	NDF	Ash	Crude Fat
Mean	90.13684	22.06184	25.77368	35.15263	11.25	2.22105
Std Dev	1.93817	2.43803	3.08482	4.20874		
					0.81413	0.22350
Sum	6850	1677	1959	2672	855	168.8
Minimum	85.9	10.8	18.6	23.4	9.4	1.8
Maximum	96.5	26.1	34.0	53.2	13.8	2.9

When looking at the total results that each machine gave, the standard deviations for dry matter and protein were greater for AgriNIR. Dairy One had a higher standard deviation for the rest of the tests. Once again, Dairy One is less limited to the range of the results that it can give than what the AgriNIR is. It is capable of determining if a sample of hay is really high or really low in one area.

## Dairy One versus AgriNIR

If one were to assume that Dairy One is an accurate standard to which other machines could be tested against, then a test could be performed to see how closely other machines match up to its results. The AgriNIR Forage Analyzer's results were compared to Dairy One to see if it could produce the same results within a small standard of error.

The test results were compared side by side and a difference was calculated for each test between the machines. A standard deviation was calculated from the differences of each machine. The standard deviations for corn silage were as follows: dry matter 1.8, starch 3.1, protein 0.7, ADF 2.2, NDF 2.9, ash 0.9, crude fat 0.4. This means that the results from the

AgriNIR varied from the results from Dairy One more in some areas than in others. Protein, ash and fat were all within a small variance while dry matter, starch, ADF and NDF varied considerably more.

The results given from the corn silage tests would be within 3.2% units for dry matter, 6.2% units for starch, and 4.4% units for ADF in 95% of the samples. These are three very important factors when assessing the quality of corn silage and this variation in components would be the difference between very high and very low quality of corn silage. This shows that the AgriNIR cannot be used to give similar test results as Dairy One.

The results for alfalfa hay from the two different labs were compared against each other as well. The difference between the two testers was calculated and a standard deviation was calculated for this difference. The standard deviations for the difference in the results for each component are as follows: dry matter 1.4, protein 1.8, ADF 2.7, NDF 3.0, ash 0.8, and crude fat 0.3. This shows that the variance between the machines is smallest for ash and crude fat. There is a medium deviation for dry matter and protein, and a large deviation for ADF and NDF.

This means that in 95% of the samples, one could expect a variation in test results as high as 3.6% units for protein, and 5.4% units for ADF. These two components are important in determining the value of alfalfa hay. California TDN is the standard of quality in alfalfa hay in California, and it is solely based on the ADF test results. This variation is too great to accurately assess the quality of alfalfa hay.

If Dairy One is considered to be the standard of which AgriNIR is tested against, then AgriNIR is not accurate enough to be used as a replacement tester.

## CONCLUSION

This study included a large number of samples that were tested in both the AgriNIR and Dairy One. This test showed the differences between the machines and the differences of results within each machine. The AgriNIR tester and Dairy One had differing correlations and low r-values for the results of most components and in both forages. In corn silage there was a high correlation, above 0.86, for the results given by the two machines for dry matter. Starch, ADF, and NDF had a correlation of about 0.63. Ash, crude fat, and protein had a low correlation, below 0.38. When comparing the two machines against each other, they had a standard deviation of their difference for each value as follows: dry matter 1.8, starch 3.1, protein 0.7, ADF 2.2, NDF 2.9, ash 0.9, and crude fat 0.4.

When looking at the results of the alfalfa hay tests, there were differing correlations for each component. Dry matter, protein, and NDF all had the highest correlation, which was above 0.71. Ash and ADF had a correlation of about 0.6. Crude fat had the lowest correlation between machines at 0.3. The standard deviation of the difference between the machines for each component was as follows: dry matter 1.4, protein 1.8, ADF 2.7, NDF 3.0, ash 0.8, and crude fat 0.3.

Based on the tests that were performed, the AgriNIR cannot be used as a substitute for Dairy One. There were very low correlations between machines for some components. The standard deviation of the difference between machines showed that the values given by AgriNIR vary too greatly from Dairy One to serve as an accurate forage tester. This held true for both corn silage and alfalfa hay. In the future, more tests can be done as the data base for the AgriNIR increases and it becomes more accurate. Also, sample preparation such as drying or grinding should be looked into as ways to get more consistent and accurate results.



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