Final Report

Project Name:

IMPROVING ENVIRONMENTAL SUSTAINABILITY OF BEEF FARMS IN ONTARIO BY MEASURING NEUTRAL DETERGENT FIBER DIGESTIBILITY

Project Number: SRO310-18

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EXECUTIVE SUMMARY

A total of 220 forages were collected from 116 farms from 19 counties in Ontario. The forages collected were barley, corn, alfalfa/red clover silages. Cattle and forage information was collected from all participants for future evaluation and reference. Cattle information obtained included; herd size, health and management. Forage information obtained included; seed variety, seed identification, fertilization and herbicide rates, harvesting dates and type and duration of storage. Nutrient profiles, neutral detergent fibre (NDF) values and *in vitro* digestibility NDF, NDFD) values for 48 hours have been determined for all the forages. The *in vitro* NDFD values determined from corn and alfalfa silage provided the necessary database to develop the calibrations required for the development of near infrared spectroscopy (NIRS) prediction of NDFD.

The development of the NIRS included preparation of over 1,200 total data points which included a minimum of 4 replications per forage sample. Twenty four hour NDFD values where also developed but not included in this report. The *in situ* NDFD method was also compared with the *in vitro* NDFD analysis. Reliable equations where developed using corn silage and alfalfa/grass silage as the main forage. Because of the variance across the province estimates of methane reduction was limited.

PROJECT OBJECTIVES AND MILESTONES

Objectives:

- validation of near infra-red equations using live animal digestibility measures
- develop neutral detergent fiber digestibility (NDFD) prediction equations for selected Ontario forages using near infra-red spectroscopy (NIRS)
- analyze results in comparison to other North American equations
- reformulate rations with participating beef and dairy farmers
- modify predictive model for estimating greenhouse gas emissions to beef cattle
- determine result of implementing NDFD analysis on greenhouse gas emissions

Milestones:

Dec. 31, 2004:

- enroll/inform beef and dairy farmers to participate in project

- develop NIRS measure of NDFD
- validate NIRS accuracy against live animal digestibility experiments

Dec. 31, 2005:

- apply mathematical model of greenhouse gas emissions for beef and dairy cattle
- collect and analyze on-farm data
- complete NIRS equation validation as above

May 1, 2006:

- publish results
- communicate results directly to Ontario beef producers

EXPERIMENTAL PROCEDURE

Materials and methods

Forages

Barley, corn, red clover and alfalfa silages were the forages used for in vitro digestion. The silages were dried at 60˚C and ground to pass a 1 mm screen using a Retzsch Grinding Mill (Retzsch GmbH, Rheinische StraBe 36, 42781 Haan, Germany).

DM samples were weighed at 0.25 g +/- 0.01 g and placed into 4.5 cm x 5.0 cm ANKOM Dacron bags in quadruplicate. Bags were made with N-free, white polyester monofilament fabric with 57 µ pore size. Bags were heat sealed and exposed to in vitro digestion for 24 and 48 hours using an ANKOM DAISY II incubator. The incubator contained four 4 litre glass jars, which rotated for the duration of digestion in the incubator maintained at 39.5˚C. Each jar contained 20-25 sample bags.

Two laboratory standards, corn silage and haylage, as well as, a blank ANKOM bag were incubated in each jar of every digestion run in order to test for variation between the jars during the digestion of the forages. These standard forage samples were prepared by the same method used to prepare the forages analyzed.

Solutions

The buffer solution contained 16 g of NH_4HCO_3 and 140 g of $NaHCO_3$ in 4 l of deionized water. (Deionized water from reverse osmosis (RO) system supplied by Biolab Equipment Canada Ltd., Oakville, Ont.).

The macromineral solution contained 22.8 g of anhydrous Na_2HPO_4 , 24.8 g of anhydrous KH_2PO_4 , and 2.4 g of $MgSO_4\ 7H_2O$ in 4 l of deionized water.

The micromineral solution contained 13.2 g of $CaCl_2\ 2H_2O$, 1.0 g of $CoCl_2\ 6H_2O$, 10.0 g of $MnCl_2\ 4H_2O$ and 8.0 g of $FeCl_3\ 6H_2O$ in 100 ml of deionized water.

The reducing agents contained solutions A and B and were prepared before each in vitro digestion run. Solution A contained 2.50 g of C3H7NO2S HCl (Cystein-HCl) dissolved in 188 ml of deionized water and 16.0 ml of 1.0 N NaOH. Solution B contained 2.50 g of Na2S 9H2O dissolved in 188 ml of deionized water.

The reagents and solutions were added to each of the 4 digestion jars as follows:

400 ml of buffer solution, 400 ml of macromineral solution, 2 ml of micromineral solution, 2.0 ml of 0.1% aqueous resazurin, 4.0 g of tryptone and 718 ml of distilled water. Solutions A and B with reducing agents were mixed and 80 ml of this solution was added to each of the four jars. Pre-weighed bags containing forage samples were added to the jars. The jars were purged with CO2 for approximately 1 minute and placed in the prewarmed incubator.

Rumen fluid was collected from a dry, non-pregnant and fistulated Holstein cows. The cows were fed a diet of mixed hay and mineral premix. The fluid was obtained by using a probe and collected into a prewarmed thermos. The rumen fluid was transferred into a prewarmed blender and macerated for approximately 20 seconds. The rumen fluid was strained through 4 layers of cheese cloth into another prewarmed thermos. 400 ml of strained rumen fluid was added to each jar. All jars were purged with CO2 again for approximately 1 minute before being placed into the incubator for digestion.

After digestion was completed, (24hr or 48hr) each jar was drained of solution and the bags from each individual jar were rinsed together in trays containing distilled water. The bags from each jar were rinsed 6 times until the rinse water was clear. The bags were frozen until further fiber extraction could be completed.

The bags were thawed and placed in the ANKOM (200) Fiber Analyzer. The samples were exposed to NDF extraction, without sodium sulfite (Van Soest et al., 1991). Forage NDF values were determined by using the following equations for: NDF48 (NDF 48 hours after fiber digestion) = dry sample weight – residue blank corrected weight/dry sample weight x100, NDFO (NDF original, prior to digestion with rumen fluid) = sample weight-residue weight/sample weight x100 and dNDF (the amount of forage digested) = NDFO-NDF48 . The values determined from these equations were used to determine the final forage digestibility percentages, NDFD1 (final digestibility value %) = dNDF/NDFO x 100 for each forage analyzed.

Ankom Materials and Methods

In Vitro True Digestibility using the DAISYII Incubator

Reagents

(a) Buffer Solution A

KH_2PO_4 – 10.0 g/litre

$MgSO_4 \cdot 7 H_2O$ – 0.5 g/litre

NaCl – 0.5 g/litre

$CaCl_2 \cdot 2H_2O$ – 0.1 g/litre

Urea (reagent grade) – 0.5 g/litre

(b) Buffer Solution B

Na_2CO_3 – 15.0 g/liter

$Na_2S \cdot 9H_2O$ – 1.0 g/litre

(c) Rumen fluid inoculum

(d) Neutral Detergent Reagents (See ANKOM method for determining neutral detergent fibre)

Apparatus

(a) ANKOM Technology - DAISYII Incubator

(b) Filtration device – ANKOM Technology – F57 Filter bags

(c) Impulse bag sealer – ANKOM Technology – 1915/1920 Heat sealer

(d) Graduated cylinders - 1 L & 500 ml

(e) Thermos – (2)

(f) Cheese cloth for filtering

(g) ANKOM200/220 Fibre Analyzer

Procedure

Preparation of Filter Bags and Sample:

Pre-rinse F57 filter bags in acetone for 3 – 5 minutes and completely air-dry. The acetone rinse removes a surfactant that may inhibit microbial digestion. Weigh each F57 filter bag and record weight (W1). Zero the balance and weight 0.25 g of sample (W2) directly into filter bag. NOTE: A sample size of 0.5 g is acceptable for 48-hour digestion studies; however, recent studies suggest greater precision using 0.25 g. Heat seal each bag and place in the DaisyII Incubator digestion jar (up to 15 samples per jar). Samples should be “evenly”

distributed on both sides of the digestion jar divider. Include at least one weighed and sealed blank bag for correction factor (C1).

Preparation of (combined) Buffer Solution:

(a) Pre-warm (39°C) both buffer solutions (A & B). In separate container add ~266 ml of solution B to 1330 ml of solution A (1:5 ratio). The exact amount of A to B should be adjusted to obtain a final pH of 6.8 at 39°C. No further adjustment of pH is necessary. Add 1600 ml of combined A/B mixture to each jar containing the sample bags.

(b) Place digestion jars with samples and buffer solution into DairyII Incubator and activate heat and agitation switches (red lights in switches indicate power). Allow temperature of digestion jars to equilibrate for at least twenty to thirty minutes. This time could be used for collection and preparation of rumen inoculum.

Preparation of Inoculum and Incubation:

Maintain all glassware at 39°C

(a) Preheat two 2-liter thermos bottles by filling with 39°C water. Empty heated water just prior to collection of rumen inoculum. Using the appropriate collection procedure, remove at least 2000 ml of rumen inoculum and place in thermos. Include approximately two “fistfuls” of the fibrous mat from the rumen with your collection in one of the thermoses. Collection via a fistulated animal, as well as collection of inoculum (without collection of the fibrous mat) by means of an esophageal tube, is possible.

(b) Empty the rumen inoculum from the thermos into a blender. Purge the blender container with CO_2 gas and blend at a high speed for 30 seconds. The lending action serves to dislodge microbes that are attached to the mat and assure a representative microbial population for the in vitro fermentation. Filter the blended digesta through four layers of cheesecloth into a five-litre flask (pre-heated 39°C). Filter the remaining rumen fluid in the other thermos through four fresh layers of cheesecloth into the same five-liter flask. NOTE: Allow for extra cheesecloth around the edges to facilitate squeezing contents of filtered mat. The flask should be continually purged with CO_2 and continued during the transfer of the inoculum.

(c) Measure 400 ml of rumen inoculum in a graduated cylinder. Remove one digestion jar from the DaisyII Incubator and add the 400 ml of inoculum to the buffer solution and samples. Purge the digestion jar with CO_2 gas for thirty seconds and secure lid.

(d) Repeat process for all digestion jars to be used. NOTE: Do not allow CO_2 gas to bubble through the buffered inoculum, rather use the CO_2 to form a gaseous blanket over the contents of the jar.

(e) Incubate (confirm that heat and agitation switches are one) for 48 hours to determine the In Vitro True Digestibility results. The DAISYII Incubator will maintain a temperature of 39.5°C ± 0.5.

(f) At completion of incubation, remove jars and drain fluid. Rinse bags thoroughly with cold tap water until water is clear. Use a minimum of mechanical agitation.

(g) Place rinsed bags into the ANKOM200/220 Fiber Analyzer and follow the procedure for determining NDF. Record the post in vitro NDF weight as W3 for the formula below. The NDF analysis removes microbial debris and any remaining soluble fractions. NOTE: Bags can be stored in the refrigerator or freezer until NDF determinations can be performed.

Calculate:

$$\% \text{ IVIDas received} = 100 - (\{W3 - [W1 \times C1]\} \times 100/W2)$$

$$\% \text{ IVIDDM} = 100 - \frac{\{W3 - [W1 \times C1]\} \times 100}{W2 \times DM}$$

Where:

W1 = bag tare weight

W2 = sample weight

W3 = Final bag weight after In Vitro and sequential NDF determination

C1 = blank bag correction (final oven-dried weight/original blank bag weight)

C2 = ash corrected blank bag (loss of weight on ignition of blank bag/original blank bag weight)

DM = % dry matter

Method for Determining Neutral Detergent Fiber (aNDF)

ANKOM Technology – 05/03

A. Regents

(a) Neutral Detergent Solution (ND) – Add 30.0 g sodium lauryl sulphate, USP; 18.61 g Ethylenediaminetetraacetic Disodium Salt, Dihydrate; 6.81 g sodium tetraborate decahydrate; 4.6 g sodium phosphate dibasic, anhydrous; and 10.0 ml triethylene glycol, in 1 L distilled H2O (ANKOM Technology, remixed chemical solution catalog #FND20 or FND20C). Agitate and heat to facilitate solubility. Check pH range to 6.9 to 7.1.

(b) Alpha-amylase – Heat-stable bacterial alpha-amylase: activity = 17,400 Liquefon Unites/ml (catalog #FAA). One Liquefon Unit is the measure of digestion time required to produce a color change with iodine solution indicating a definite stage of dextrinization of starch substrate under specified conditions.

(c) Sodium sulfite – Na2SO3, anhydrous (catalog #FSS).

(d) Acetone – Use grade that is free from color and leaves no residue upon evaporation (catalog #FACE).

B. Safety Precautions (See MSDS provided with chemicals)

(a) Acetone is highly flammable. Use fume hood when handling acetone and avoid inhaling or contact with skin. Make sure bags are completely dry and that all the acetone has evaporated before placing in oven.

(b) Sodium lauryl sulphate will irritate the mucous membranes. A dust mask and gloves should be worn when handling this chemical.

C. Apparatus

(a) Digestion apparatus – ANKOM200/220 Fibre Analyzer

(b) Filter Bags – (catalog #F57)

(c) Impulse bag sealer – Requires high enough temperature to melt and seal polymer in filter bags. (catalog #195/1920)

(d) Desiccator – ANKOM Technology MoistureStop weigh pouch – (a large zip-log bag with desiccant packs inside – catalog #X45)

D. Procedure

(a) Prepare Filter Bags/Sample

1. Use a solvent resistant marker to label the filter bags with test and bag number.

2. Weight Filter Bag (W1) record weight and tare balance.

3. Weigh 0.5 g (± 0.05 g) of air-dried sample (W2), ground to pass through a 1 mm screen (2 mm screen when using a cyclone mill), directly into filter bag. Weigh one blank bag and include in digestion to determine blank bag correction (C1). This will account for any moisture or weight loss in the bag.

4. Seal the bags closed within 0.5 cm from the open edge using the heat sealer.

5. Spread sample uniformly inside the filter bag by shaking and lightly flicking the bag to eliminate clumping.

6. A maximum of 24 bags may be placed in the bag suspender. All nine trays are used regardless of the number of bags being processed. Place three bags per tray and then stack trays on center post with each level rotated 120 degrees. The weight is placed on top of the empty 9th tray to keep the bag suspender submerged. Insert the bag suspender with bags into the fiber analyzer vessel. NOTE: SAMPLES CONTAINING SOY PRODUCT OR > 5% FAT – Extract fat from samples by placing 24 bags with samples into a container with a top. Pour enough acetone into container to cover bags and secure top. Shake the container 10 times and allow bags to soak for 10 minutes. Repeat with fresh acetone. Pour out acetone and place bags on a wire screen to air-dry. EXCEPTION: Roasted Soy – Due to special properties of Roasted Soy a modification to the fat extraction is required. Place Roasted Soy samples into a container with a top. Pour enough acetone into container to cover bags and secure top. Shake the container 10 times and pour off acetone. Add fresh acetone and allow samples to soak for twelve hours. After soak time, drain off acetone as stated above and allow to air-dry before next step.

(b) Add 20 g (0.5 g/50 ml of ND solution) of sodium sulfite ad 4.0 ml of heat stable alpha-amylase to 2000 ml of ND solution when processing 24 sample bags. Allow sodium sulfite to dissolve in the solution. Pour solution over the bag suspender in the vessel. If processing less than 20 bags add 100 ml/bag of detergent solution and reduce sodium sulfite as indicated above. NOTE: A minimum of 1500 ml is required. Confirm that all nine levels of Bag Suspender are covered.

(c) Turn Agitate and Heat ON and confirm that Bag Suspender is agitating properly. Set timer for 75 minutes and push Start. Close and seal lid of vessel.

(d) After 75 minutes turn Agitate and Heat OFF, open the drain valve (slowly at first) and exhaust hot solution before opening lid. WARNING: The solution in vessel is under pressure. The valve should be opened first to remove pressure before lid can be opened. Ensure exhaust hose is securely positioned for safe disposal of effluent.

(e) After the solution has been exhausted, close valve and open the lid. Add approximately 2000 ml of hot (85 – 90°C) H2O and 4.0 ml of alpha-amylase to the first and second rinses. Lower lid but do not tighten. Turn Agitate ON and

leave Heat OFF. Each rinse should last 3-5 minutes. Exhaust waste and repeat rinse two more times (total of three rinses).

(f) After final rinse add “cold” tap water to assist handling and cool the vessel for the next run. Drain the water and remove bag suspender from vessel. Remove filter bags from bag suspender and gently press out excess water. Place in 250 mL beaker and cover bags with acetone. Allow bags to soak 3 minutes then remove and lightly press out excess acetone.

(g) Spread bags out and let air-dry. Complete drying in oven at 105°C (most ovens provide complete drying within 2-4 hours). WARNING: Do not place bags in the oven until acetone has completely evaporated. Remove bags from oven, place directly into MoistureStop weigh pouch and flatten to remove air. Cool to ambient temperature and weigh bags (W3).

E. Calculate Percent:

$$\text{aNDF(as-is basis)}: \frac{\{W_3 - (W_1 \times C_1\} \times 100}{W_2}$$

$$\text{aNDF (DM basis)}: \frac{\{W_3 - (W_1 \times C_1\} \times 100}{W_2 \times DM}$$

Where: W_1 =bag tare weight

W_2 = sample weight

W_3 = weight after extraction process

C_1 = blank bag correction (final oven-dried weight/original blank bag weight)

In situ materials and method:

The silages were dried at 60˚C and ground to pass a 1 mm screen using a Retzsch Grinding Mill (Retzsch GmbH, Rheinische StraBe 36, 42781 Haan, Germany).

Rumen digestibilities of 20 corn silage samples were evaluated using the nylon bag technique. DM samples were weighed at 0.25 g +/- 0.01 g and placed into 4.5 cm x 5.0 cm ANKOM Dacron bags in quadruplicate. Bags were made with N-free, white polyester monofilament fabric with 57 µ pore size. A further 6 empty bags were used in order to test for correct bag weights. All of the bags were heat sealed and placed into one of the mesh bags. A bottle weight was attached to each of the mesh bags for proper submersion beneath the raft layer within the rumen. The mesh bags were submerged into the rumen through the fistula opening of a non-pregnant dry Holstein cow. The cow was fed a diet of mixed hay and mineral premix. An extra 10 samples were chosen as “0” hour bags and were used to correct for disappearance due to solubility. These bags

were not incubated in the rumen but were soaked in distilled water, rinsed and dried.

After the removal of sample bags (24 or 48 hours), each mesh bag containing the sample bags were cold shocked by submersion into a bucket of distilled water. All individual bags were then rinsed with distilled water, until the water was predominantly clear. All bags were placed in pans and into a drying oven at approximately 60°C for 48 hours prior to weighing.

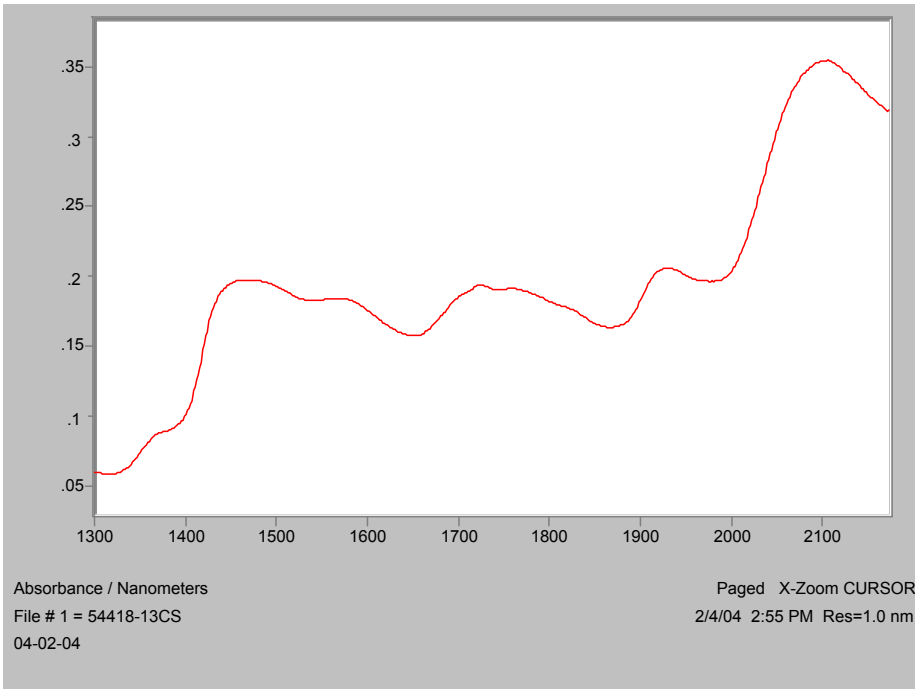
The bags were then placed in the ANKOM (200) Fiber Analyzer. The samples were exposed to NDF extraction, without sodium sulfite

RESULTS AND DISCUSSION

Samples collected from various farms were received at Agri-Food Laboratories (AFL). These samples were dried and ground (3 mm and 1 mm screens) and scanned on Unity SpectraStar 2200 NIR spectrophotometer using corn silage or mixed haylage calibrations.

The analytical data was reported i.e. protein, ADF, NDF etc., and the spectrum for each sample was stored.

Spectral analysis of corn silage

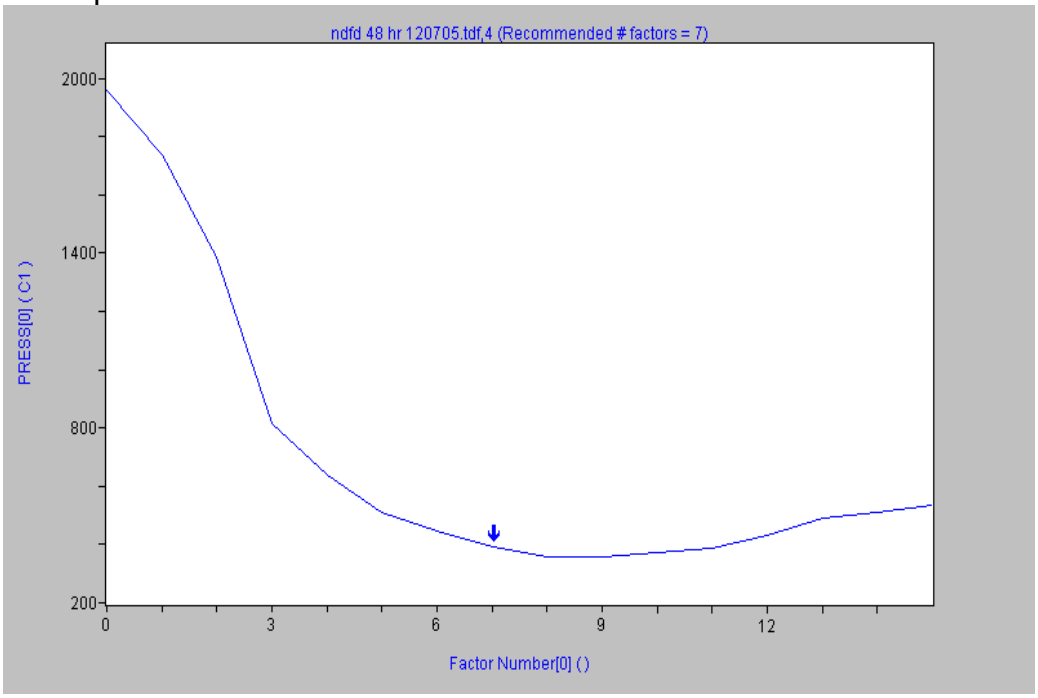


Each sample was analyzed for NDF using procedure for Ankom200 Fibre Analyzer (Ankom Technologies, Fairport, N.Y.). The NDF value determined represented the initial NDF (NDF_0). Samples were then prepared for in vitro

digestion as per "In Vitro Digestibility using Ankom's DaisyII" and "The Effects of Source and Level of Nitrogen and Changing Buffer /Rumen Fluid at 48 Hours on In Vitro Digestion of Feeds", Miner Institute, Chazy N.Y.

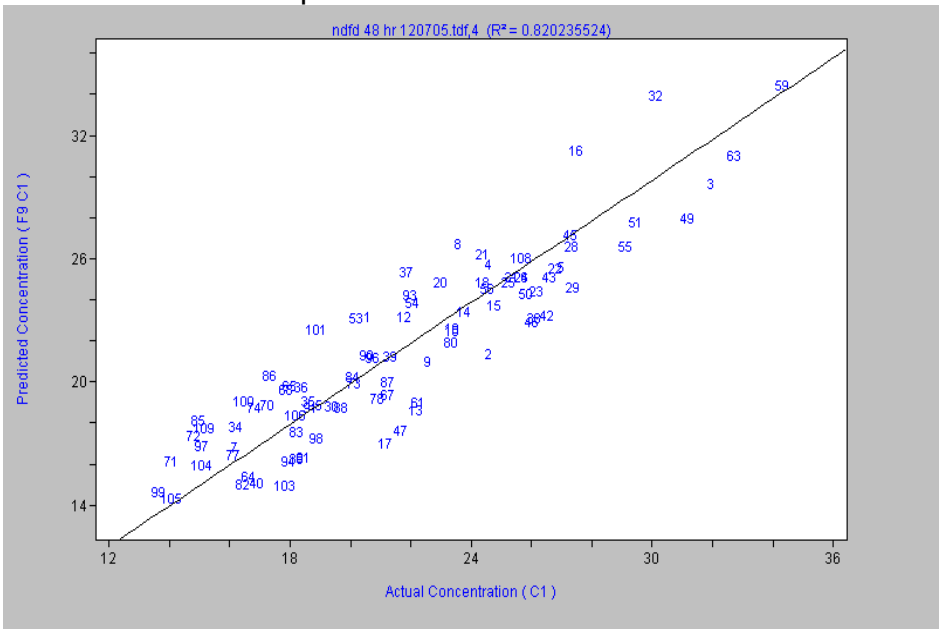
Following the 48 hour in vitro digestion, the NDF of the sample residues was determined, again using the fibre analyzer. This represented the undigested NDF (uNDF). A spreadsheet was prepared in Microsoft Excel that included sample identification (lab number), a copy of the spectra from Unity and the wet chem. 48 hour NDF.

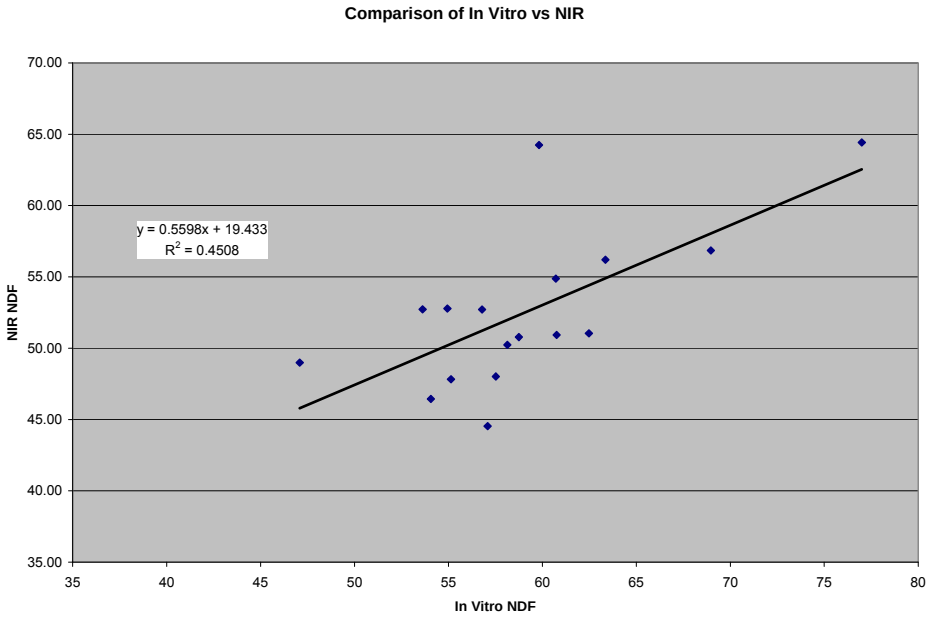
Press plot for NDFD calibration



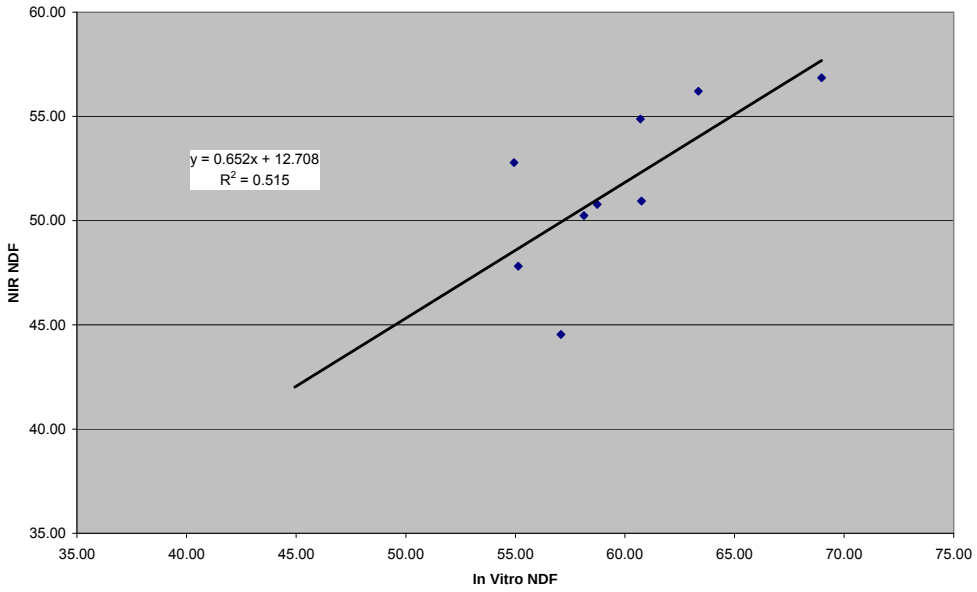
Thermo Galactic Grams AI software (Microsoft) was used to determine the calibration for NDFD. The spreadsheet was copied into the Grams software, and a series of mathematical formulas applied to create a model calibration. The calibration developed represented the uNDF. R^2's of 0.75-0.80 (predicted vs actual) were possible for the preliminary calibrations for haylage and corn silage. NDFD48 was determined according to $((NDF_0 - uNDF)/NDF_0)*100$

Plot of actual versus predicted values of NDFD in Grams AI software

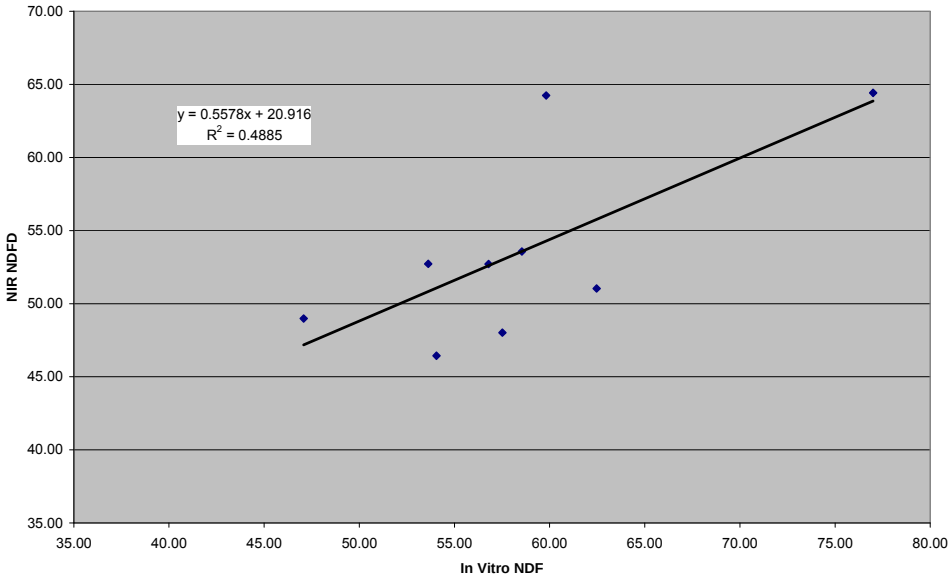




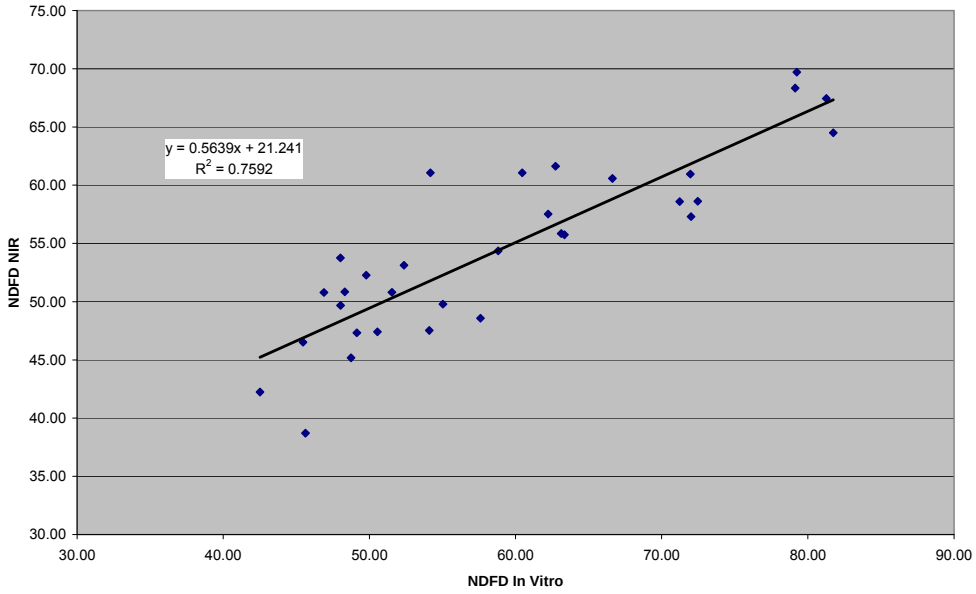
Comparison of In Vitro vs NIR for Corn Silage



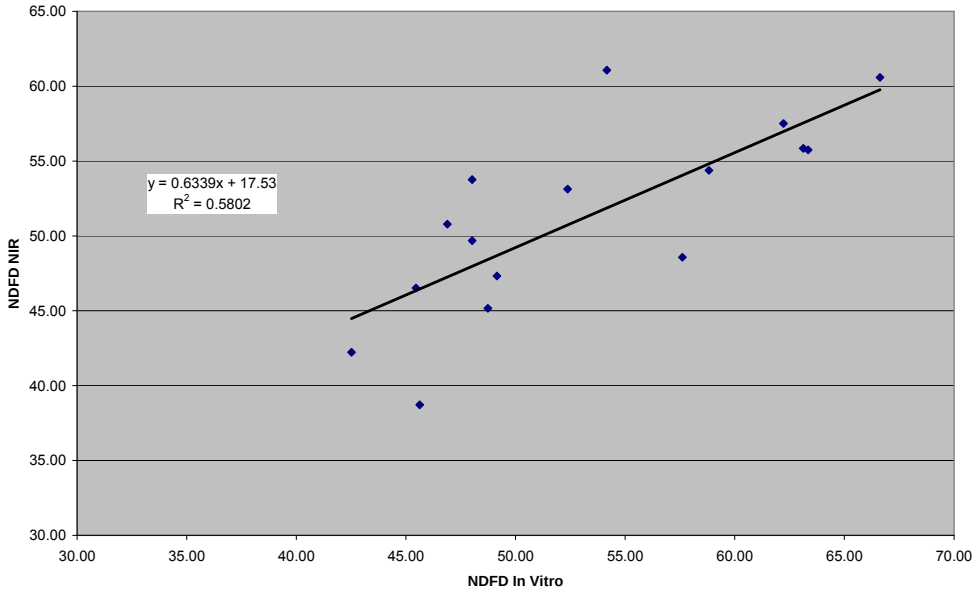
Comparison of In Vitro NDF and NIR for Haylage



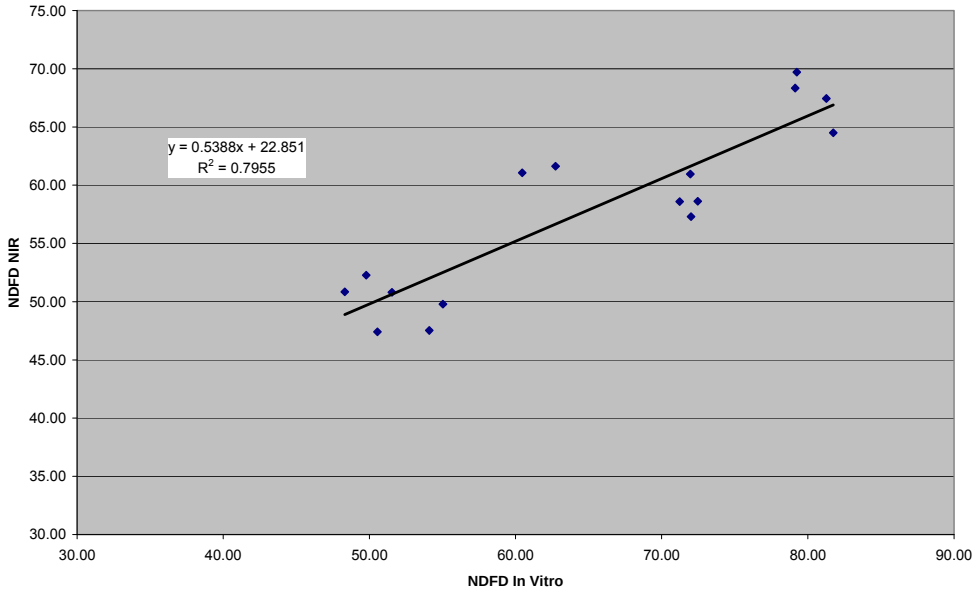
Comparison of NDFD (In Vitro) vs NDFD (NIR)



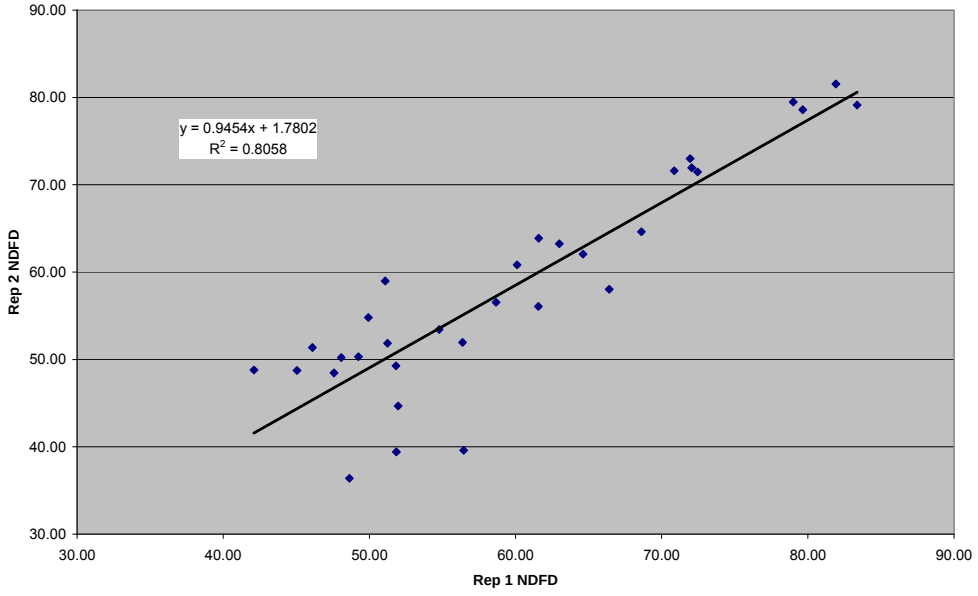
Comparison of NDFD (In Vitro) vs NDFD (NIR) for Corn Silage

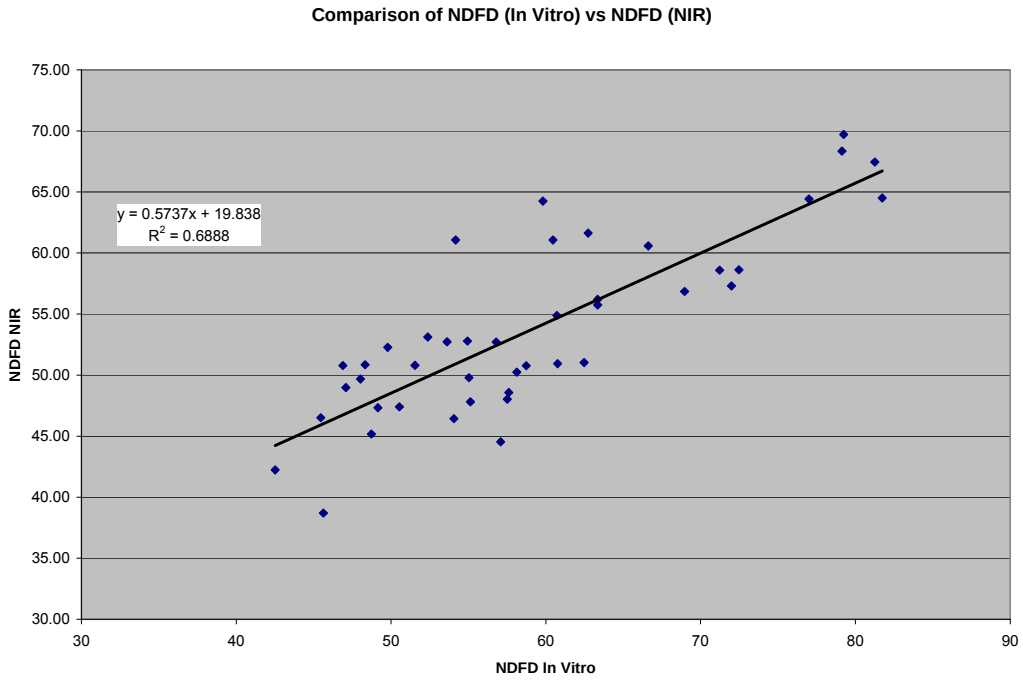


Comparison of NDFD (In Vitro) vs NDFD (NIR) for Haylgage

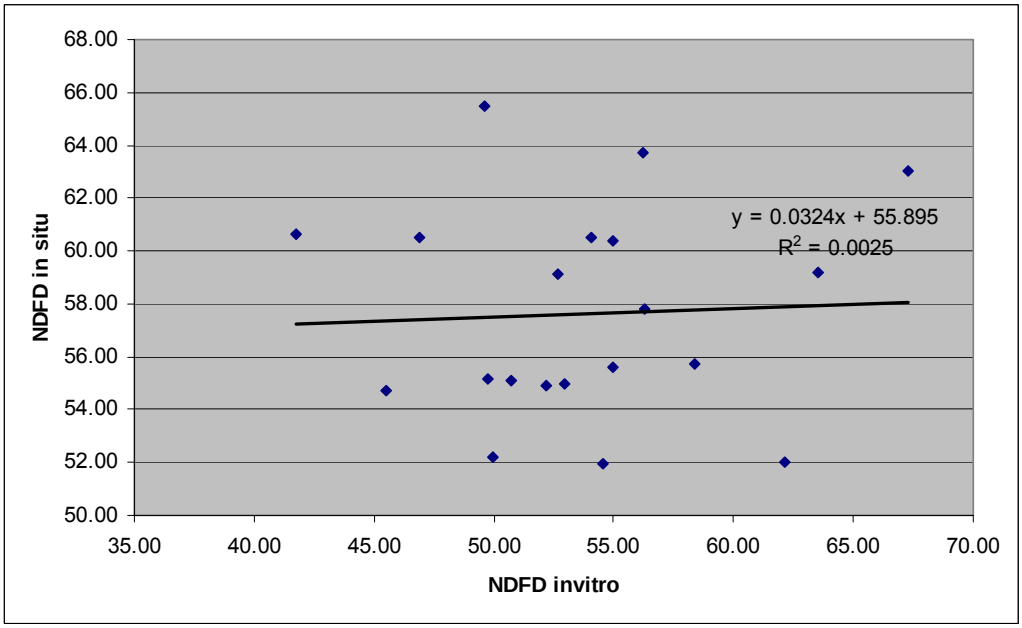


Comparison of Reps for NDFD In Vitro





Comparing NDFD *in situ* versus NDFD *in vitro*



With the comparison of *in situ* with *in vitro* DNDF there was a significant ($P < 0.05$) effect of the treatment with the in vitro method over estimating the true NDFD. The values developed where only based on 20 forage tests so more sample analysis is required to further test this comparison. But generally with other researchers this relationship is suspected.

The reports sent back to producers included *in vitro* NDF values determined by NIRS (examples following). Generally the corn silage and haylage samples varied form 45 -68 % NDFD, and 40 – 78 % for corn and haylage respectively. NDFD averages where 60 % for corn and 48 % for mixed alfalfa/hay silages.

Feed analytical reports to producers(samples)
Corn silage

Date Received: 01-Jun-2005

Date Printed: 15-Jul-2005

Lab No.: 6397001 Feed Type: corn silage

Sample: 105 - J Louwagie Corn Silage Test Type: NCPS - Forages

Test	Dry Basis	As Is	Expected Range - Dry Basis
Dry Matter %		38.20	28.61 - 43.13
Moisture		61.80	
Invitro NDF	62.09	23.72	
PROTEIN			
Protein % (N X 6.25)	7.42	2.83	6.78 - 9.16
Soluble Protein %	2.74	1.05	
SP % of CP	36.93	36.93	
ADP as % of CP	6.87	6.87	
NDP as % of CP	26.42	26.42	
UIP Bypass Est. % of CP	31.54	31.54	
FIBRES			
Acid Detergent Fibre %	24.06	9.19	19.00 - 30.00
Neutral Detergent Fibre %	39.40	15.05	40.00 - 64.00
LIG % NDF	6.29	2.40	
MINERALS			
Calcium %	0.24	0.09	0.12 - 0.40
Phosphorus %	0.17	0.06	0.18 - 0.26
Potassium %	0.76	0.29	0.68 - 1.08
Magnesium %	0.12	0.04	0.14 - 0.26
Sodium %	0.01	0.00	
ENERGY			
TDN (estimated)%	68.74	26.26	64.80 - 71.20
Net Energy (lac) MCAL/kg	1.55	0.59	1.47 - 1.62
Net Energy (gain) MCAL/kg	1.09	0.42	
Net Energy (maint) MCAL/kg	1.70	0.65	
Non Fibre Carbohydrate	44.68	17.07	
OTHER			
Fat %	2.34	0.89	
Ash %	4.44	1.70	
Starch	28.77	10.99	
WTDN	72.55	27.72	
WNEL	1.65	0.63	
WNEG	0.88	0.34	
WNEM	1.60	0.61	
Starch as % of NFC	64.39	64.39	

Alfalfa /grass silage

Date Received: 01-Jun-2005

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Lab No.: 6397002 Feed Type: mixed haylage

Sample: 106 - J Louwagie Haylage Test Type: NCPS - Forages

Test	Dry Basis	As Is	Expected Range - Dry Basis
Dry Matter %		64.60	36.10 - 62.72
Moisture		35.40	
Invitro NDF	45.17	29.18	
PROTEIN			
Protein % (N X 6.25)	20.74	13.40	12.17 - 19.43
Soluble Protein %	7.92	5.12	
SP % of CP	38.19	38.19	
ADP as % of CP	1.93	1.93	
Digestible Protein %	70.99	70.99	
NDP as % of CP	29.99	29.99	
UIP Est. AFL	24.11	24.11	
FIBRES			
Acid Detergent Fibre %	32.72	21.14	33.00 - 42.00
Neutral Detergent Fibre %	39.14	25.28	34.00 - 64.00
LIG % NDF	9.91	6.40	
MINERALS			
Calcium %	1.54	0.99	0.79 - 1.63
Phosphorus %	0.38	0.25	0.22 - 0.32
Potassium %	2.57	1.66	1.76 - 2.80
Magnesium %	0.24	0.16	0.14 - 0.31
Sodium %	0.04	0.03	
ENERGY			
TDN (estimated)%	62.87	40.61	54.40 - 62.60
Net Energy (lac) MCAL/kg	1.42	0.92	1.21 - 1.42
Net Energy (gain) MCAL/kg	0.88	0.57	
Net Energy (maint) MCAL/kg	1.47	0.95	
Non Fibre Carbohydrate	28.92	18.68	
OTHER			
Relative Feed Value	150.71	150.71	
Fat %	1.28	0.83	
Ash %	8.18	5.28	
WTDN	66.66	43.06	
WNEL	1.52	0.98	
WNEG	0.77	0.50	
WNEM	1.49	0.97	

All the diets where adjusted (data not included, 25 rations re-balanced) based on the NDFD values and rations collected. High forage NDFD values resulted in higher forage to concentrate ratio (feedlot farms) this is because the forage can meet a higher percent of the energy requirements resulting in a lowering of the grain portion of the diet. This may or may not lead to less potential of acidosis particularly in high grain finishing feedlot diets. For low NDFD values (poorer forage quality) more high-fibre by-products such as soy hulls, dried brewers grains, and corn gluten feed where added (based on price relative to grains) to increase ration digestibility.

Implications of higher NDFD values of forages on methane gas emission require further investigation. The tremendous variation seen in forage varieties from 19 different counties in Ontario is not the ideal model for suggesting methane reductions through diet formulation. Having said that we will be concentrating on one county and incorporating the soil and forage growth data to look at both emission changes and carbon sequestering capacity of each farm.

Generally good quality forage has the potential to reduce methane emission from 6- 10 % but data is very limited on whole farm emissions particularly in the beef sector.

CONCLUSIONS AND RECOMMENDATIONS

Cost effective analysis by NIRS for NDFD will be requisite for widespread producer adoption, but the improved efficiencies with the use of this management tool, will make this analysis as routine as the classical forage analysis for ADF and NDF. Nutritionists will see the advantages of more accurate assessments of forage quality and will be balancing rations incorporating an NDFD analysis as a result of this project. The development of the NIRS under Ontario forage production system was attained. However, further investigation will continue in incorporating full farm nutrient crop and livestock budgets into managing methane emissions form Ontario beef production facilities.

ACKNOWLEDGEMENTS

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SIGNIFICANCE TO ONTARIO AGRICULTURE, FOOD AND RURAL COMMUNITIES

This project is relevant to the environmental sustainability of Ontario beef and dairy farms. The project provides an efficacious approach to minimizing nutrient output and greenhouse gas emissions. The OASCC sub-committee for beef identified greenhouse gas reductions as a key component of mitigating the industry's impact on the environment in their latest report. The adoption of a new technology by Ontario beef and dairy producers that can increase environmental sustainability is deserving of OMAF's support, given the recent implementation of the Nutrient Management Act and the federal government's commitment to the Kyoto Agreement on greenhouse gases. The challenge of implementing this new technology for measuring fibre digestibility lies in proper assessment of it to Ontario conditions.

The direct benefits of this project will accrue to the Ontario beef industry and, in particular, its primary producers. The direct benefits include introduction and demonstration of advanced forage quality estimations by measuring NDFd using NIRS. This analysis will allow formulation of better beef wintering rations and a better understanding of the impact forage quality has on animal performance. Management of nutritional changes based on this information will allow more efficient diets to be formulated that will result in more efficient

production, and improvement in production performance measures such as dry matter intake, nutrient digestibility, average daily gain and feed efficiency. In the longer term, the advances in beef production efficiency will reduce GHG emissions, particularly methane, and could potentially lead to opportunities for carbon credits for the Ontario beef industry or individual producers, depending on the market structure of carbon credits. Reduced GHG emissions are a benefit to the environment and there is an economic incentive potentially, if carbon credits develop a viable market, whereby reducing GHG emissions will be valued financially by other industries in which it is less cost-effective to reduce GHG emissions

The implementation of a routine analysis for NDFD in Ontario would likely be an attractive management tool for other ruminant animal production systems including the dairy industry, as well as sheep and goat production. The Ontario dairy industry, for example, consists approximately 450, 000 head, according to Statistics Canada. The reliance on forages similar to the ones in the Ontario beef industry raises the potential for adoption of the NDFD analysis in those industries from the initiative of the proposed demonstration project. The indirect benefits of improved forage management to additional livestock sectors increases the opportunity to reduce GHG emissions, because approximately 50% more ruminant animals would be fed more efficiently, than if the results of this project were limited to the beef sector.

TECHNOLOGY TRANSFER TO DATE AND FUTURE PLANS

All participants where given an information folder explaining how NDFD can be used in their operation plus ration suggestions. A poster presentation was made at the OCA annual meeting in Toronto in 2005. A scientific and popular press article is currently being developed focusing on forage quality across the province.

COMMERCIALIZATION PROGRESS TODATE AND FUTURE PLANS

None anticipated

POPULAR PRESS ARTICLE

Project to help beef producers get more ‘bang’ for forage ‘buck’

A new research/demonstration project has been launched to help Ontario beef producers improve production efficiency and reduce greenhouse gas emissions through more accurately balanced feed rations.

“The quality of forage fed to beef cattle varies significantly and can have a major impact on production efficiency,” says project leader Dr. Vern Osborne of the

University of Guelph. “We will work directly with producers to analyze forage quality and develop recommendations for improved feed rations. Understanding the digestibility of fiber and energy helps determine the best feed for cattle.”

The two-year project is supported by the Greenhouse Gas Mitigation Program for Canadian Agriculture (GHGMP), a federal program designed to promote the awareness and adoption of agricultural practices that reduce atmospheric levels of greenhouse gas. The Canadian Cattlemen’s Association administers the delivery of the beef sector component of the program. The program has also received funding from the “New Directions Program” of OMAFRA.

“Improved ration balancing is one of several beef production management strategies with the potential to boost production efficiency,” says Pat Walker, beef sector co-ordinator for the GHGMP. “This project will help producers get a better handle on all the benefits of forage testing and accurate ration balancing, including the links to reducing greenhouse gas emissions from beef cattle operations.”

The project will introduce an innovative method for testing fibre digestibility. Analysis of Neutral Detergent Fibre digestibility (NDFD) provides a measure of digestibility for a key fibre fraction in plant cell walls. By measuring the fibre digestibility, producers will have a better understanding of how they can get a higher energy value in their forages. Results of this test help livestock producers balance feed rations and predict an animal’s dry matter intake and performance while consuming the forage.

Although existing tests are available to measure NDFD, the latest method is more affordable and practical for producers. “Currently, we can only estimate what the digestibility rate is and this leaves room for errors,” says Osborne. “Rations developed from an estimate run the risk of being skewed. But NDFD gives a much more accurate read of actual digestibility.” The project will develop neutral detergent fiber digestibility (NDFD) prediction equations for selected Ontario forages using near infra-red spectroscopy (NIRS). NIRS is a much more rapid analysis requiring no in vivo incubation

Osborne will lead a team to determine appropriate feed rations based on NDFD testing results. The team will organize 200 participants who farm in either the cow-calf or beef feedlot sectors of Ontario. Over the winter, baseline feed samples will be collected and analyzed for forage quality and NDFD measurements will be taken.

In phase two of the project, researchers will develop management strategies, ration balancing and greenhouse gas reduction estimates. Forage samples will be collected three times in the year from selected participants and tested to track forage quality and NDFD data.

“We like to say ‘garbage in garbage out’ when talking about forage quality,” says Osborne. “Feeding high quality forage and knowing it’s contribution to the diet is key to having a balanced diet for a healthier animal and a reduction in nutrients being emitted into the environment.

The adoption of an improved NDFD testing method may also have potential benefits to other ruminant animal sectors across Canada, such as the dairy, sheep and goat industries. Osborne says the opportunity to improve forage management in these other livestock sectors could further reduce greenhouse gas emissions. Approximately 50 percent more ruminant animals would be fed more efficiently than if the project results were only applied to the beef sector.