2009

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The Professional Animal Scientist 25 (2009):701–708

The Relationship Between Acid Detergent Insoluble Nitrogen and Nitrogen Digestibility in Lactating Dairy Cattle

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ABSTRACT

Five trials (19 treatments) conducted at the University of Nebraska-Lincoln (UNL) on lactating dairy cattle were analyzed to determine how the concentration of ADIN in the ration affects total tract N digestibility. Additionally, 6 published studies (13 treatments) were included to expand the data set. Results from the UNL trials showed that as the concentration of ADIN in the ration increased, the digestibility of ADIN also increased. However, the relationship was poor ($r^2 = 0.29$). To account for random effects among trials, a meta-analysis was conducted. In the UNL trials, as the ration concentration of ADIN increased, total tract N digestibility decreased; this relationship was moderate ($r^2 = 0.55$). A meta-analysis of the published studies illustrated similar results with a moderate correlation ($r^2 = 0.44$). All data were combined for a meta-analysis, and similar results illustrated a moderate relationship ($r^2 = 0.58$). There was positive relationship between ADF and the concentration of ADIN in the UNL trials; however, the relationship was poor ($r^2 = 0.19$). Additionally, a poor, negative relationship ($r^2 = 0.14$) was observed between ADF and N digestibility in the UNL trials. Milk yield (31.9 ± 3.1 kg/d) in the UNL trials was unaffected ($r^2 = 0.01$) by the concentration of ADIN in the ration. These data suggest ADIN is partially digestible, N digestibility is moderately influenced by ADIN concentration in rations, there is a poor relationship between ADF and the concentration of ADIN, and milk yield is unaffected by the concentration of ADIN.

Key words: acid detergent insoluble nitrogen, dairy cattle, meta-analysis, nitrogen digestibility

INTRODUCTION

The concentration of ADIN in feedstuffs is commonly used to determine the degree of heat damage. Specifically, this is estimated by determining the amount of insoluble N in ADF residue (Firkins et al., 1984). Several sources have reported variable ADIN levels, ranging from 0.4% of CP for corn gluten feed and cottonseed meal to 31.1% of CP for dried distillers grains with solubles (**DDGS**) for forages and concentrates in wet and dried forms (Pena et al., 1986; Clark et al., 1987; Edionwe and Owen, 1989; Weiss et al., 1989; NRC, 2001; Kleinschmit et al., 2007; Vargas-Bello-Pérez et al., 2007).

In the Cornell Net Carbohydrate and Protein System, the assumption is made that ADIN represents the portion of protein in a feedstuff that is unavailable for use by the animal because it is completely indigestible (Sniffen et al., 1992). Additionally, Van Soest (1994) noted that as the concentration of ADIN increased, total tract N digestibility decreased. This negative association has been observed in several studies (Yu and Thomas, 1976; Thomas et al., 1982; Weiss et al., 1986; Van Soest, 1994). However, these observations were made with forages, and the relationship in other feedstuffs remains unclear. Additionally, the association in forages is generally a one-to-one reduction in N digestibility as ADIN increases, indicating that ADIN is indigestible. However, limited evidence in concentrates and diets fully supports the assumption that ADIN is indigestible (Weiss et al., 1986; Weiss et al., 1989; Nakamura et al., 1994). Nakamura et al. (1994) observed that ADIN was approximately 58% digestible in nonforage fiber sources, suggesting that ADIN is digestible and that it is inaccurate to assume ADIN is indigestible. Thus, it may be useful to evaluate diets that contain corn-milling coproducts.

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Table 1. Ingredient composition of UNL[1] experimental trials 1 through 3

	Treatment[2]										
	Trial 1		Trial 2					Trial 3			
Ingredient, % DM	Control	DDGS	Control	WDGS	WCGF	15% Mix	30% Mix	Control	DDGS	Germ	HP-DDG
DDGS	—	30.1	—	—	—	—	—	—	15.0	—	—
WDGS	—	—	—	15.0	—	7.5	15.0	—	—	—	—
WCGF	—	—	—	—	15.0	7.5	15.0	—	—	—	—
Germ	—	—	—	—	—	—	—	—	—	15.0	—
HP-DDG	—	—	—	—	—	—	—	—	—	—	14.4
Corn silage	23.9	30.1	28.0	25.5	23.0	24.3	24.0	26.7	26.0	26.3	25.3
Alfalfa haylage	10.9	9.3	9.8	9.0	8.0	8.5	3.5	10.3	5.4	5.5	5.3
Alfalfa hay	10.9	9.4	9.8	9.0	8.0	8.5	3.5	5.6	5.4	5.5	5.3
Brome hay	—	—	3.5	3.0	3.0	3.0	6.0	6.7	15.2	15.3	14.8
Ground corn	16.3	12.1	17.5	13.5	14.5	14.0	9.5	20.7	13.9	9.4	15.2
Soybean meal	4.8	—	6.0	3.5	5.5	4.5	3.2	8.9	6.2	8.3	—
Soybean hulls	10.4	10.4	10.0	10.2	10.0	10.1	10.0	10.4	7.4	6.1	10.0
Cottonseed	6.6	—	6.0	5.5	5.5	5.5	4.0	3.3	—	—	6.8
Soypass[3]	5.6	1.1	6.0	4.0	4.5	4.3	3.5	4.4	2.8	5.9	—
Tallow	1.0	0.9	1.0	—	1.0	0.5	—	0.4	—	—	—
Bloodmeal	0.7	0.7	—	—	—	—	—	—	—	—	—
Urea	0.3	—	0.2	—	—	—	—	—	—	—	0.2
Vitamins and minerals	2.6	2.0	2.1	2.0	2.1	2.1	2.8	2.5	2.7	2.7	2.7

[1]University of Nebraska-Lincoln.

[2]Control = 0% DM coproducts. Trial 1: DDGS = dried distillers grains with solubles, 30% DM. Trial 2: WDGS = wet distillers grains with solubles, 15% DM; WCGF = wet corn gluten feed, 15% DM; 15% Mix = 7.5% DM WDGS plus 7.5% DM WCGF; 30% Mix = 15% DM WDGS plus 15% DM WCGF. Trial 3: DDGS = 15% DM DDGS; Germ = corn germ, 15% DM; HP-DDG = high-protein dried distillers grains, 15% DM (no solubles included).

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Limited research has been conducted on how the concentration of ADIN in rations of lactating dairy cattle affects total tract N digestibility. The objective of this research is to use a statistical meta-analysis approach to determine the relationship between the concentration of ADIN on total tract N digestibility in rations fed to ruminants. It is hypothesized that as the concentration of ADIN increases in the ration, N digestibility will decrease, and that ADIN is partially digestible.

MATERIALS AND METHODS

Animals and Dietary Treatments

Data from 5 trials, with a total of 19 dietary treatments, were collected from the University of Nebraska-Lincoln (**UNL**) Dairy Research Unit (Mead, NE) and were used to evaluate the relationship between the concentration of ADIN in the ration and total tract N digestibility. In these trials, DMI was measured and fecal output was estimated on each animal within period for each experiment. The following is a brief description of the studies.

Trial 1. Four multiparous Holstein cows were fed 1 of 2 diets (Table 1) in each of 3 periods. The 2 dietary treatments included 1) a control diet with no inclusion of coproducts, and 2) 30% DDGS.

Trial 2. Twenty primiparous and 20 multiparous Holsteins were fed 1 of 5 diets (Table 1) in each of 5 periods. The 5 dietary treatments included 1) a control diet with no inclusion of coproducts, 2) 15% wet distillers grains with solubles (**WDGS**), 3) 15% wet corn gluten feed (**WCGF**), 4) 7.5% WDGS and 7.5% WCGF, and 5) 15% WDGS and 15% WCGF (Gehman and Kononoff, 2008).

Trial 3. Four lactating Holstein heifers were fed 1 of 4 diets (Table 1) in each of 4 periods. The 4 dietary treatments included 1) a control diet with no inclusion of coproducts, 2) 15% corn germ, 3) 15% DDGS, and 4) 15% high-protein dried distillers grains (Kelzer et al., 2009).

Trial 4. Twenty-eight lactating Holsteins were fed 1 of 4 diets (Table 2) in each of 4 periods. The 4 dietary treatments included 1) 0% DM WDGS, and 31.5% corn silage, 2) 0% WDGS and 34.7% alfalfa haylage; 3) 25% WDGS and 18.3% corn silage, and 4) 25% WDGS and 15.8% alfalfa haylage.

Trial 5. Twenty lactating Holsteins were fed 1 of 4 diets (Table 2) in each of 4 periods. The 4 dietary treatments included 1) sorghum silage and 0% WCGF, 2) sorghum silage and 30%

Table 2. Ingredient composition of UNL[1] experimental trials 4 and 5

	Treatment[2]							
	Trial 4				Trial 5			
Ingredient, % DM	C-CS	C-AH	W-CS	W-AH	C-C	C-WCGF	BMR-C	BMR-WCGF
WCGF	—	—	—	—	—	29.8	—	29.8
WDGS	—	—	25.2	25.2	—	—	—	—
Control sorghum silage	—	—	—	—	27.0	16.7	—	—
BMR sorghum silage	—	—	—	—	—	—	27.0	16.7
Corn silage	31.5	17.4	18.3	7.9	19.1	16.7	19.1	16.7
Alfalfa haylage	15.8	34.7	9.2	15.8	—	—	—	—
Alfalfa hay	—	—	—	—	6.2	4.2	6.2	4.2
Brome hay	12.3	5.5	15.4	16.0	5.2	4.2	5.2	4.2
Ground corn	13.8	23.3	8.4	14.9	20.8	14.9	20.8	14.9
Soybean meal	9.7	4.6	2.1	1.3	8.6	7.3	8.6	7.3
Soybean hulls	9.0	4.4	15.6	13.8	3.2	—	3.2	—
Soypass[3]	5.7	8.2	3.5	3.1	5.3	2.9	5.3	2.9
Urea	—	—	—	—	1.0	—	1.0	—
Vitamins and minerals	2.4	2.9	2.5	2.1	3.5	3.5	3.5	3.5

[1]University of Nebraska-Lincoln.

[2]Trial 4: C-CS = 0% DM wet distillers grains with solubles (WDGS), 31.5% corn silage; C-AH = 0% WDGS, 34.7% alfalfa haylage; W-CS = 25% WDGS, 18.3% corn silage; W-AH = 25% WDGS, 15.8% alfalfa haylage. Trial 5: C-C = control sorghum silage, 0% wet corn gluten feed (WCGF); C-WCGF = control sorghum silage, 30% WCGF; BMR-C = brown mid-rib (BMR) sorghum silage, 0% WCGF; BMR-WCGF = BMR sorghum silage, 30% WCGF.

[3]LignoTech (Overland Park, KS).

WCGF, 3) brown mid-rib sorghum silage and 0% WCGF, and 4) brown mid-rib sorghum silage and 30% WCGF.

To increase the size of the data set, additional observations were added from 6 published studies that reported the concentration of ADIN in the ration and total tract N digestibility (MacGregor et al., 1983; Edionwe and Owen, 1989; Weiss et al., 1989; Dann et al., 2006, 2007; Vargas-Bello-Pérez et al., 2008). Additionally, various feedstuffs such as barley, soybean silage, alfalfa silage, corn dried distillers grains, beet pulp, and a corn milling coproduct mix were included in the rations of the published studies.

Feed and Fecal Chemical Analysis

Samples of the TMR collected at the UNL Dairy Research Unit were composited by trial and treatment within each period. A 0.5-g sample of each dietary treatment within each period from every trial was weighed in triplicate into Ankom bags (Ankom Technology, Fairport, NY) and sealed. Each TMR sample was analyzed for DM and ADF. Acid detergent fiber was analyzed using an Ankom Fiber Analyzer (Ankom Technology). Coefficient of variation was determined after ADF analysis, and samples with a CV greater than 5% were eliminated. For samples that were eliminated, new samples were prepared, and DM and ADF were analyzed again. Residues with a CV of less than 5% remaining in the Ankom bags were combined into Whirl-Pak bags (VWR International, West Chester, PA) by dietary treatment within each period. Crude protein analysis was conducted on the ADF residue for each treatment within period to determine the amount of acid detergent insoluble CP in each TMR. Crude protein was determined using the Leco Tru-Spec N Analyzer (St. Joseph, MO). Each dietary treatment within period had only one measurement of acid detergent insoluble CP because of the lack of sample remaining after ADF analysis. Acid detergent insoluble N of TMR samples was determined from the protein analysis on the ADF residue by using the equation

$$\text{ADIN (\% DM)} = \text{ADICP (\% DM)}/6.25, \qquad [1]$$

where ADIN (% DM) is the ration ADIN concentration calculated after CP analysis, and ADICP (% DM) is the acid detergent insoluble CP analyzed from ADF residue.

Fecal samples were composited by cow within each period for all trials and analyzed for ADIN by using the same procedures as the TMR samples. Fecal ADIN was determined from the protein analysis on the ADF residue by using equation [1].

ADIN Digestibility

Acid detergent insoluble N digestibility was calculated by treatment within period. Digestibility calculations for ADIN were as follows:

$$[(\text{TMR ADIN} \times \text{DMI}) - (\text{FO} \times \text{fecal ADIN})]/(\text{TMR ADIN} \times \text{DMI}), \quad [2]$$

where TMR ADIN is ADIN content of the ration, DMI is feed intake, FO is fecal output and was estimated by indigestible ADF, and fecal ADIN is ADIN content of the fecal matter. After ADIN digestibility was determined for each cow within each period, an average ADIN digestibility was calculated for each dietary treatment in each trial.

Total Tract Nitrogen Digestibility

Nitrogen digestibility was calculated by treatment within period. The digestibility calculation for N was as follows:

$$[(\text{DMI} \times \text{feed N}) - (\text{FO} \times \text{fecal N})]/(\text{DMI} \times \text{feed N}), \quad [3]$$

where DMI is feed intake, feed N is N content of the feed; FO is fecal output, and fecal N is N content in the fecal matter. After N digestibility was determined for each cow within period, an average N digestibility was calculated for each dietary treatment in each trial.

Statistical Analysis

Data from the UNL trials and the published studies were analyzed statistically by using the mixed modeling methodology of SAS (St-Pierre, 2001) to account for random effects of trials in the concentration of ADIN in the ration and total tract N digestibility. The linear model for this analysis was as follows:

$$Y_{ij} = \beta_o + s_i + \beta_1 X_{ij} + b_i X_{ij} + \varepsilon_{ij},$$

where Y_{ij} is the experiment-adjusted outcome for dependent variable, total tract N digestibility, observed at level j of the continuous variable, ADIN, in experiment i; β_o is the overall intercept across all experiments; s_i is the random effect of experiment i; β_1 is the overall regressing coefficient across all experiments; X_{ij} is the value of j of the continuous variable in experiment i; b_i is the random effect of experiment i on the regression coefficient in experiment i; and ε_{ij} is the unexplained residual error of j of the continuous variable on experiment i. The power of the relationship between 2 variables was determined using r^2 values.

RESULTS AND DISCUSSION

Acid Detergent Insoluble Nitrogen

The concentration of ration ADIN was determined for each dietary treatment in the UNL trials and ranged from 21.5 to 87.4% of N (Table 3). The concentration of ADIN in the published studies was variable as well. However, the UNL trials had a concentration of ADIN that was higher compared with the published studies. The difference in concentration of ADIN between the UNL trials and the published studies may be due to the difference in diets fed during the trials, the amount of forage included in the diets, or the method used for analyzing ADIN.

Acid Detergent Insoluble Nitrogen Digestibility

The mean ADIN digestibility from UNL trials was approximately 58.0%. The digestibility of ADIN in the UNL trials was similar to that of Nakamura et al. (1994), who observed ADIN to be approximately 58% digestible when nonforage protein sources were fed to steers. In the UNL trials, ADIN digestibility ranged from approximately 41.0 to 74.0%. Figure 1 illustrates the relationship between the concentration of ADIN in the ration and ADIN digestibility. As the concentration of ADIN increased in the ration, ADIN digestibility also increased [y = 45.6 + 0.3 (ADIN)]. However, this relationship is rather poor ($r^2 = 0.29$), indicating that other possible factors, such as animal variation, level of DMI, or level of the feedstuffs included in the TMR may affect ADIN digestibility.

Total Tract Nitrogen Digestibility

Total tract N digestibility from the UNL trials ranged from approximately 49.0 to 73.0% across treatments before the meta-analysis. The mean total tract N digestibility was approximately 63%.

The statistical meta-analysis suggested there is a negative relationship between the concentration of ADIN in the ration and study-adjusted total tract N digestibility from UNL trials (Figure 2). As the concentration of ADIN increased in the ration, total tract N digestibility decreased, with a moderate relationship ($r^2 = 0.55$). These results can be compared with the UNL trials before a meta-analysis was conducted (Figure 3). Although there was a negative relationship before the meta-analysis, the relationship was poor ($r^2 = 0.11$).

A meta-analysis was also conducted on the observations from the published studies. The relationship between the concentration of ADIN in the ration and study-adjusted total tract N digestibility from the published studies is illustrated in Figure 4. As the concentration of ADIN in the ration increased, total tract N digestibility also decreased; this relationship was moderate ($r^2 = 0.44$).

An additional meta-analysis was conducted to increase the number of plotted observations. This data set combined both the UNL trials and published studies. Figure 5 illustrates this relationship. As the ration concentration of ADIN increased, total tract N digestibility decreased, as observed in the previous meta-analyses, and this relationship was moderate ($r^2 = 0.58$).

Van Soest (1994) illustrated the relationship between the concentration of ADIN in the ration and apparent N digestibility from work conducted on cattle and sheep, as observed by Yu and Thomas (1976). Results suggested that a negative relationship existed between the concentration of

Table 3. Dry matter intake, CP, NDF, ADF, ADIN, and milk yield for each UNL[1] trial

Diet[2]	DMI, kg/d	CP, %	NDF, %	ADF, %	ADIN, % of N	Milk yield, kg/d
Trial 1						
Control	25.6	18.7	33.7	23.0	28.5	35.1
DDGS	23.6	18.9	34.7	22.6	87.4	36.9
Trial 2						
Control	22.7	19.9	37.2	22.6	32.2	33.5
WDGS	25.1	19.9	40.7	23.7	33.0	35.8
WCGF	23.2	19.8	38.4	21.5	45.0	34.9
15% Mix	23.5	19.9	40.1	23.9	35.0	35.8
30% Mix	25.5	20.7	42.5	22.8	38.6	36.1
Trial 3						
Control	22.9	17.9	37.7	22.5	40.7	26.9
DDGS	23.8	17.8	39.2	20.1	39.6	28.8
Germ	24.3	18.0	36.3	19.7	45.1	29.6
HP-DDG	22.4	17.5	41.1	24.9	60.1	28.0
Trial 4						
C-CS	22.5	17.1	38.6	25.0	47.1	29.4
C-AH	24.6	18.9	34.2	22.4	47.1	28.5
W-CS	24.6	18.1	44.1	27.9	51.7	31.7
W-AH	24.8	18.5	43.7	27.5	53.2	32.3
Trial 5						
C-C	24.7	19.9	37.2	18.2	23.3	30.6
C-WCGF	26.3	19.9	37.0	21.9	24.8	31.2
BMR-C	26.1	19.1	37.2	21.6	21.5	30.0
BMR-WCGF	26.7	19.5	36.2	17.5	25.9	30.7
Mean	24.4	18.9	38.4	22.6	41.0	31.9
SD	1.3	0.2	3.0	2.7	3.6	3.1

[1]UNL = University of Nebraska-Lincoln.

[2]Control = 0% DM coproducts. Trial 1: DDGS = dried distillers grains with solubles, 30% DM. Trial 2: WDGS = wet distillers grains with solubles, 15% DM; WCGF = wet corn gluten feed, 15% DM; 15% Mix = 7.5% DM WDGS plus 7.5% DM WCGF; 30% Mix = 15% DM WDGS plus 15% DM WCGF. Trial 3: DDGS = 15% DM DDGS; Germ = corn germ, 15% DM; HP-DDG = high-protein dried distillers grains, 15% DM (no solubles included). Trial 4: C-CS = 0% DM WDGS, high-corn silage; C-AH = 0% WDGS, high-alfalfa haylage; W-CS = 25% WDGS, high-corn silage; W-AH = 25% WDGS, high-alfalfa haylage. Trial 5: C-C = control sorghum silage, 0% WCGF; C-WCGF = control sorghum silage, 30% WCGF; BMR-C = brown mid-rib (BMR) sorghum silage, 0% WCGF; BMR-WCGF = BMR sorghum silage, 30% WCGF.

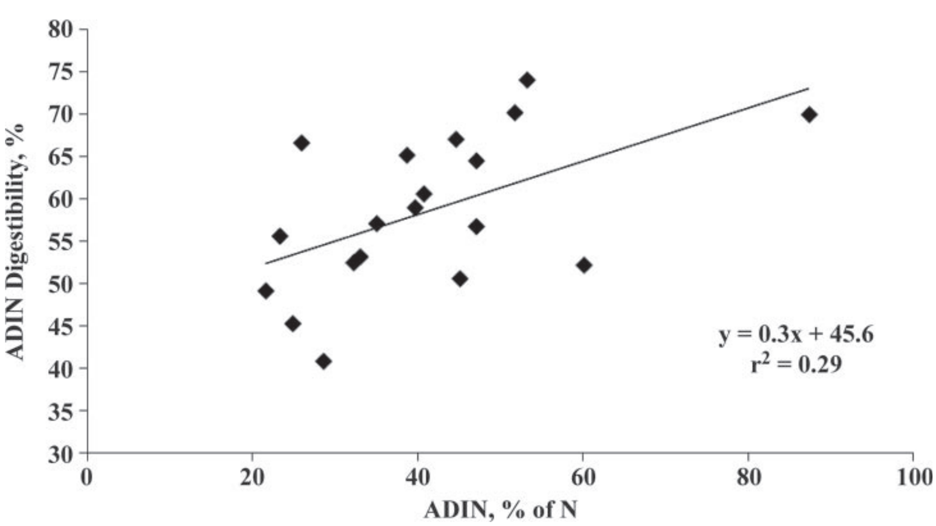

Figure 1. Relationship between total tract ADIN (% of N) and ADIN digestibility from University of Nebraska-Lincoln trials.

ADIN in the ration and apparent N digestibility. The relationship between unheated forages was moderate ($r^2 = 0.51$), whereas the relationship was stronger in heated forages ($r^2 = 0.91$). Additionally, the slope in both types of forages was close to or greater than −1.0. Acid detergent insoluble N is completely indigestible when a negative one-to-one relationship between the concentration of ADIN and N digestibility exists and the slope is close to −1.0 (Van Soest, 1994). The slope illustrated by Van Soest (1994) in unheated and heated forages was greater than the slope from the combined data (−0.01) from the UNL trials and published studies (Figure 5). Biologically, a greater slope means a smaller

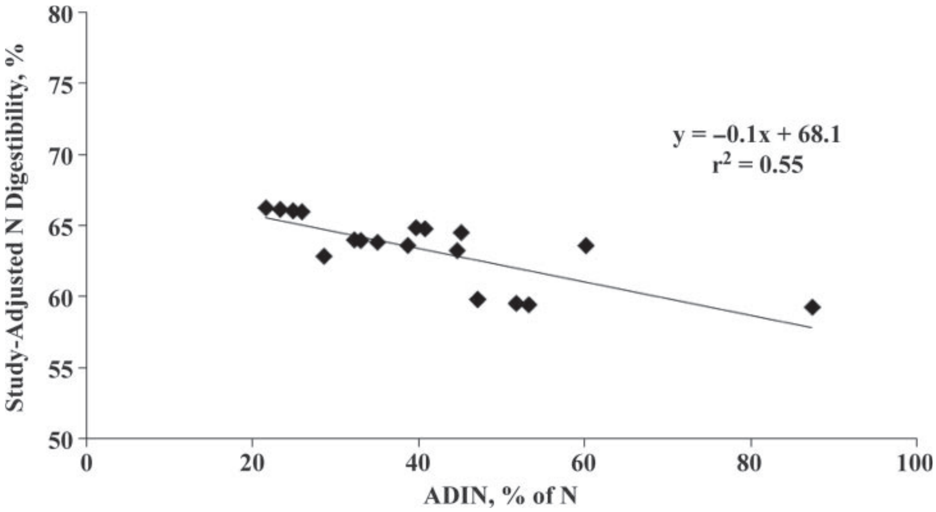

Figure 2. Relationship between total tract ADIN (% of N) and study-adjusted total tract N digestibility from University of Nebraska-Lincoln trials after meta-analysis.

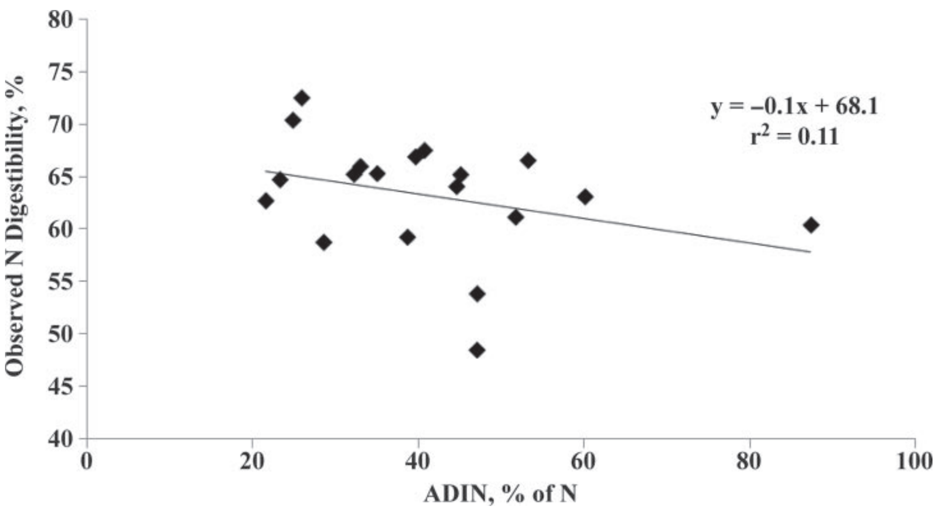

Figure 3. Relationship between total tract ADIN (% of N) and observed total tract N digestibility (before the meta-analysis) from the University of Nebraska-Lincoln trials.

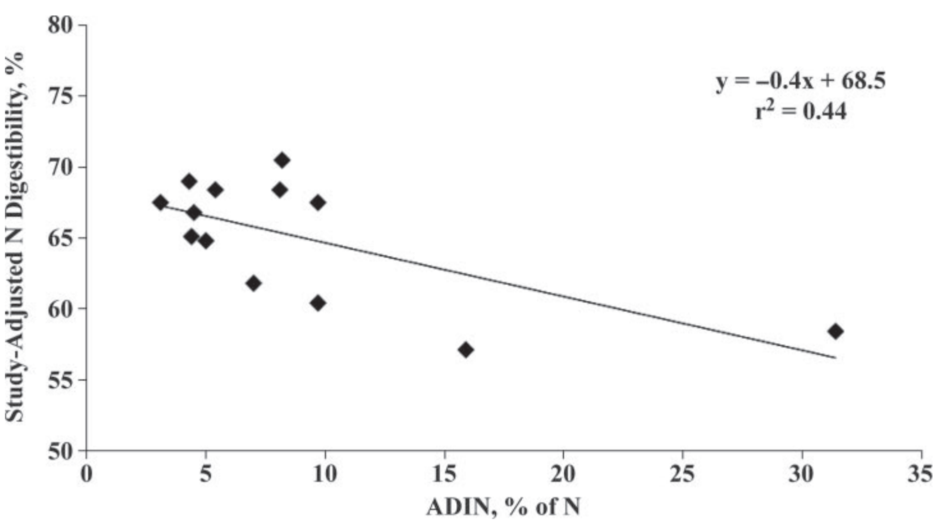

Figure 4. Relationship between total tract ADIN (% of N) and study-adjusted total tract N digestibility from published studies after the meta-analysis.

change in the concentration of ADIN in the ration will have a greater impact on total tract N digestibility. Therefore, a small increase in concentration of ADIN in the ration will decrease total tract N digestibility at a faster rate with a greater slope.

Another study conducted on sheep presented effects (Nakamura et al., 1994) similar to our findings. As the concentration of ADIN in the ration increased, true N digestibility decreased; this relationship was moderate ($r^2 = 0.66$). The slope was −0.4, indicating ADIN was digestible (Nakamura et al., 1994).

Acid Detergent Fiber

Acid detergent fiber residue is useful for measuring the amount of insoluble N in a feedstuff (Van Soest, 1994). Therefore, it may be possible that as the amount of ADF increases in feedstuffs, the concentration of ADIN increases as well. However, based on the UNL trials, this did not occur (Figure 6). As ADF increased, ADIN as a percentage of N increased as well; however, the relationship between these 2 variables was poor ($r^2 = 0.19$). This suggests that other factors may assist in determining the concentration of ADIN.

The use of ADF as a predictor of digestibility is based on statistical association, not on a theoretical basis (Van Soest, 1994). Therefore, ADF may not be used to predict digestibility accurately, such as N digestibility. The relationship between ADF and N digestibility (Figure 7) in the UNL trials was poor ($r^2 = 0.14$), indicating that ADF cannot be used to predict digestibility. Although as ADF increased, N digestibility decreased, other factors were hard to determine that might better explain N digestibility.

Milk Yield

In cases in which the intake of metabolizable protein is limiting, field nutritionists might suspect that feeding diets higher in ADIN might negatively affect protein availability

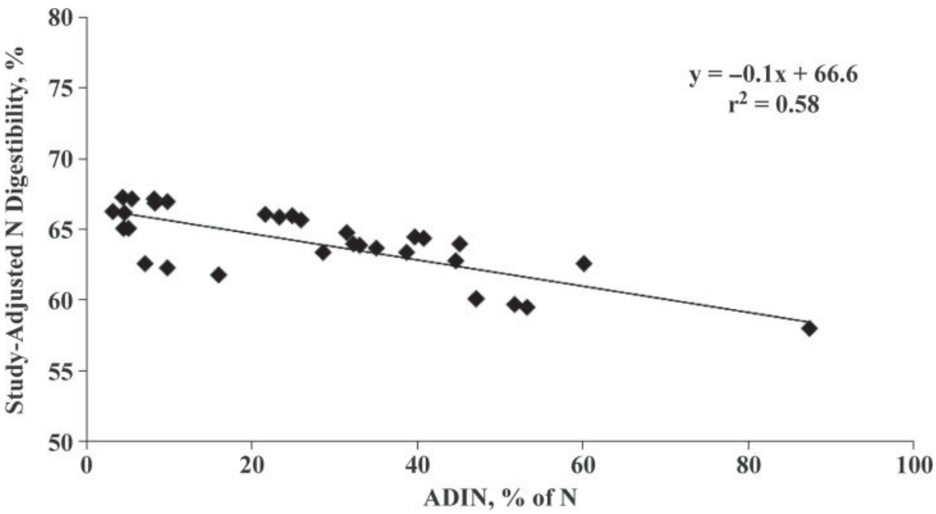

Figure 5. Relationship between total tract ADIN (% of N) and study-adjusted total tract N digestibility of combined data from University of Nebraska-Lincoln trials and published studies.

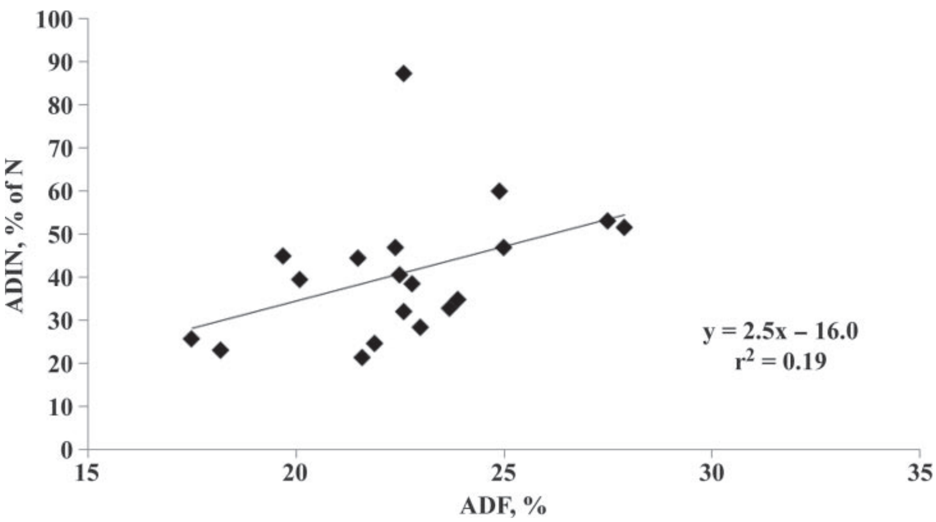

Figure 6. Relationship between ADF and total tract ADIN (% of N) from University of Nebraska-Lincoln trials.

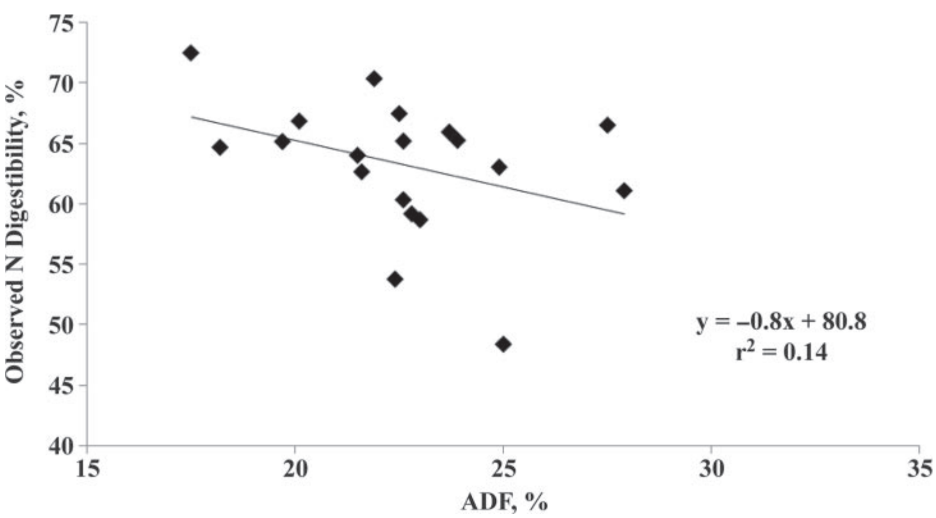

Figure 7. Relationship between ADF and observed total tract N digestibility (before a meta-analysis) from the University of Nebraska-Lincoln trials.

and, in turn, milk production. Figure 8 illustrates the lack of relationship between the concentration of ADIN and milk yield in the UNL trials, where mean milk yield was 31.9 ± 3.1kg/d. Although the slope was positive (0.02), the relationship was very poor ($r^2 = 0.01$), indicating this relationship did not exist. This observation might suggest that metabolizable protein was adequate in all diets; it is equally likely that factors such as energy balance were more important than ADIN in affecting milk yield. Weiss et al. (1989) evaluated the performance of lactating dairy cattle fed barley distillers grains. Cattle consumed either a control diet containing soybean meal, a diet containing soybean meal plus barley distillers grains (5% of DM), or a barley distillers grains diet (18% of DM). Acid detergent insoluble N was also measured (1.3, 1.6, and 2.5% of CP for the soybean meal diet, the soybean meal plus barley distillers grains diet, and the barley distillers grains diet, respectively). The ADIN increased in the diet as barley distillers grains increased, and there was no significant difference in milk yield (20.4 ± 0.8 kg/d), milk protein (3.4 ± 0.1%), or milk fat (3.7 ± 0.1%). The results in the experiment by Weiss et al. (1989) were similar to the results in the UNL trials.

IMPLICATIONS

Acid detergent insoluble N may not be a good indicator of unavailable protein. Based on this research, total tract ADIN is approximately 58% digestible. There is a moderate, negative relationship between the concentration of ADIN and total tract N digestibility. Consequently, there is not a one-to-one negative relationship between the concentration of ADIN in the ration and total tract N digestibility in TMR of lactating dairy cattle. Additionally, ADF may not accurately estimate the concentration of ADIN in rations or N digestibility. As shown in previous experiments, milk yield is not affected by the concentration of ADIN. The assumption by

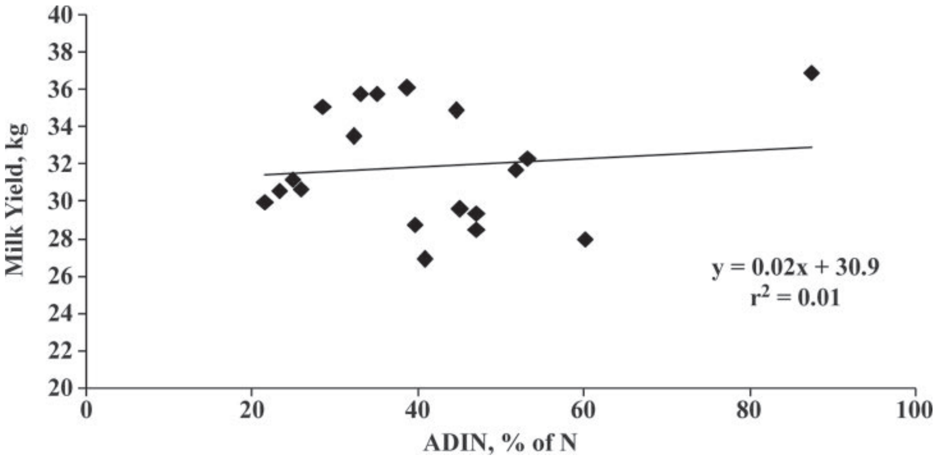

Figure 8. Relationship between total tract ADIN (% of N) and milk yield from University of Nebraska-Lincoln trials.

the Cornell Net Carbohydrate and Protein System that ADIN is unavailable may need to be reevaluated to account for the portion of protein that is received from ADIN. Although total tract ADIN concentration is only a small portion of protein, it is additional protein available for use by the animal.

ACKNOWLEDGMENTS

Appreciation is expressed to B. Janicek, A. Gehman, J. Kelzer, A. Geis, and C. Heine for use of data gathered during their experimental trials.

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