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Dairy Report

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Effect of Soyhull:Soy Lecithin:Soapstock Mixture on Reproduction in Early Lactation Dairy Cows

William Chapman
Larry Larson
Rick Grant[1]

Summary

An experiment was conducted over the first 14 weeks of lactation to determine the effect of a soybean hull, soy lecithin, and soapstock mixture on lactational and reproductive performance. Thirty-seven Holstein cows were grouped by parity and assigned randomly to one of two diets at three weeks postpartum. Diets consisted of 45% forage, 17.1% soybean hulls, and 1) no added lipid (control) or 2) soy lecithin and soapstock in a 1:1 ratio to supply 3% of dietary dry matter (DM). Lactation performance was reported in the 1997-98 Dairy Report. Soy lecithin and soapstock are economical lipid coproducts of soybean processing that effectively increased milk production and energy balance, although reproductive performance was not changed.

Introduction

As milk production has increased, postpartum reproductive problems also have increased. Reproductive failure is the second major reason for culling animals from the milking herd following mastitis. During the early postpartum period, milk production increases at a faster rate than DMI resulting in negative energy balance.

Energy balance is correlated positively with serum progesterone and IGF-I in early lactation Holstein cows. Cows with greater concentrations of plasma IGF-1 for the first two weeks postpartum are more likely to ovulate the dominant follicle. Energy balance during the early postpartum period also appears to play an important role in determining when postpartum cyclic ovarian activity is initiated. There is a high correlation between days to lowest negative energy balance and days to first ovulation. Early re-establishment of ovulatory cycles following parturition should improve reproductive performance. To improve reproductive performance, the period of negative energy balance needs to be minimized without compromising milk production.

Lipid supplementation is one method to increase the energy density of the diet while avoiding metabolic problems such as acidosis caused by high amounts of concentrates in the diet. Soy lecithin and soapstock are two lipid coproducts of the soybean oil refining process. These two lipid sources are widely available and are approximately one-half as expensive as tallow, making them economical sources of dietary lipid. However, there is limited research on these two products in diets for dairy cows.

Therefore, the following experiment was conducted to investigate the use of a mixture of soybean hulls, soy lecithin, and soapstock (SLS) as a supplemental lipid source during early lactation and to evaluate the response of DMI, milk production, energy balance, and reproductive performance.

Procedures

Thirty-seven early lactation Holstein dairy cows were grouped by parity and assigned randomly to two dietary regimens at three week postpartum: 1) control diet with no supplemental lipid, or 2) SLS added to provide 3% lipid (DM basis; Table 1). Diets were isoitrogenous (17.6% CP) with similar NDF contents. Soybean hulls, lecithin, and soapstock were mixed in a ratio of 85:7.5:7.5 (DM basis). The 1:1 ratio of lecithin and soapstock was shown previously to result in the greatest degree of ruminal lipid protection. Soybean hulls are an

(Continued on next page)

Table 1. Dietary ingredients and chemical composition of the experimental diets.

	Control	SLS[1]
	----(% of DM)----	
Ingredient		
Alfalfa silage[2]	18.0	18.0
Corn silage[3]	22.5	22.5
Alfalfa hay, chopped[4]	4.5	4.5
Corn, rolled	22.4	18.5
Soybean hulls	17.1	—
SLS	—	20.1
SoyPass®[5]	4.7	4.7
Soybean meal	8.8	9.7
Vitamin and mineral mix[6]	2.0	2.0
Composition		
DM, %	67.3	66.8
CP	17.6	17.7
ADF	27.6	27.4
NDF	41.2	40.5
Ether extract	2.9	5.7
Nonfiber carbohydrate	28.9	26.8
NE_L, Mcal/kg	1.61	1.70

[1]Soybean hulls, soy lecithin, and soapstock (85:7.5:7.5, DM basis).
[2]Alfalfa silage contained (DM basis) 45.0% DM, 20.8% CP, 38.0% ADF, and 44.6% NDF.
[3]Corn silage contained (DM basis) 35.0% DM, 8.2% CP, 32.9% ADF, and 55.3% NDF.
[4]Alfalfa hay contained (DM basis) 89.0% DM, 17.7% CP, 38.1% ADF, and 47.7% NDF.
[5]Manufactured by Lignotech USA (Rothschild, WI). A nonenzymatically browned soybean meal with 70% RUP.
[6]Supplement contained 15.2% Ca, 7.2% P, 4.1% Mg, 4.0% Na, 3000 ppm of Zn, 1750 ppm of Mn, 400 ppm of Ca, 200,000 IU/kg of vitamin A, 36,000 IU/kg of vitamin D_3, and 585 IU/kg of vitamin E.

excellent source of digestible fiber and serve as a good carrier for the lecithin and soapstock. The resulting product has good flow and handling characteristics. The control diet contained the same amount of soybean hulls, alfalfa, and corn silage as the treatment diet to allow animals equal amounts of fiber from similar sources. Both diets were fed for ad libitum intake as TMR once daily.

All cows were fed a common diet for the first three weeks of lactation as an adaptation period. At the end of the adaptation period, cows were started on treatment regimens and remained on treatment until 14 weeks postpartum. Cows were milked twice daily with milk yield being recorded electronically. Net energy balance (NEB) was calculated weekly.

The breeding program was initiated at eight weeks postpartum. A timed AI protocol was used for all cows as follows: cows received GnRH intramuscularly (Cystorelin®; Sanofi Animal Health, Inc., Overland Park, KS; 100 µg per dose) at 63+3 DIM, followed 7 days later with $PGF_{2\alpha}$ intramuscularly (Estrumate®; Miles Inc., Shawnee Mission, KS; 500 µg per dose). At 48 hours after $PGF_{2\alpha}$, cows received a second GnRH injection and were inseminated 16 to 18 hours later. Repeat services were based on detected estrus. Conception rate was defined as the percentage of inseminated cows diagnosed as pregnant. Ovulation was considered to have occurred when concentrations of progesterone were >1 ng/ml for at least two consecutive days of blood sampling. Concentrations of progesterone during the luteal phase were determined from blood samples collected between day 8 to 16 following ovulation. Ovulation was defined as the sample day prior to serum progesterone concentrations >1 ng/ml.

Blood samples were collected once at 1 to 2 weeks prepartum and twice weekly from 2 weeks postpartum to 4 weeks after first insemination for determinations of serum concentrations of progesterone and IGF-I. Reproductive measures were analyzed by the General Linear Model of SAS using Least Square Means.

Results

Lactation performance was previously reported in the 1997-98 Dairy Report. Briefly, production of 4% fat-corrected milk and DM intake were increased by the incorporation of soy lecithin and soapstock into the diet.

Reproductive performance did not differ between treatment groups although NEB was increased by feeding the lipid (Table 2). There was no parity or treatment effect on days to first ovulation, or on luteal phase serum progesterone concentrations or peak progesterone during the first ovulatory cycle or the cycle following the timed AI protocol. There was no effect of treatment on conception rate. Although there was no effect of diet on IGF-I concentration in serum (Table 2), concentration of IGF-I was correlated positively to week of first ovulation.

In summary, the combination of soybean hulls, soy lecithin, and soapstock is an economical source of lipid to increase the energy density of the diet available to the dairy industry as a coproduct of soybean processing. The previously reported positive milk production response to these soy coproducts appeared to be at the expense of any measurable benefit to reproductive performance.

Table 2. Effect of soy lecithin and soapstock on reproductive measures and IGF-I.

	Parity			
	Primiparous		Multiparous	
Item	Control	SLS[1]	Control	SLS
No. of animals	7	8	11	11
NEB,[2] Mcal/d	7.59[d]	9.10[c]	11.70[b]	15.39[a]
First ovulation cycle				
Peak progesterone, ng/ml	4.28	2.03	2.81	3.31
Luteal phase progesterone, ng/ml	2.31	1.66	2.16	2.40
Timed AI cycle				
Peak progesterone, ng/ml	3.22	3.03	2.54	3.18
Luteal phase progesterone, ng/ml	3.97	4.23	3.36	4.37
Postpartum interval to first ovulation, d	59.1	40.9	41.9	39.4
Conception rate to timed AI protocol	2/7	2/8	4/11	5/11
IGF-I, ng/ml	63.0	74.2	58.4	68.8

[1]Soybean hulls, soy lecithin and soapstock (85:7.5:7.5, DM basis).
[2]Net energy balance.
[abcd]Means within a row with different superscripts differ (P<0.05) among parity and treatment within parity.

[1]William Chapman, former graduate student; Larry Larson, Associate Professor, Animal Science, Lincoln; Rick Grant, Associate Professor and Extension Dairy Specialist, Animal Science, Lincoln.

Brown Midrib Forage Sorghum for Dairy Cows: Short-Term Responses

Gokalp Aydin
Rick Grant[1]

Summary

*Sixteen Holstein cows were assigned to one of four diets in replicated 4 × 4 Latin squares with 4-wk periods to measure dietary effect on short-term performance. Additionally, 3 fistulated cows were assigned to the same diets in a 3 ×4 Youden square with 4-wk periods to measure rumen fiber fermentation. Diets comprised 65% of either brown midrib **(BMR)** forage sorghum, standard forage sorghum, alfalfa, or corn silages and 35% concentrate. Dry matter intake **(DMI)**, milk and milk components were greater for cows fed the BMR versus the standard forage sorghum. Efficiency of 4% fat-corrected milk **(FCM)** was greatest for the corn silage diet, equivalent for the alfalfa and BMR sorghum diets, and least for the standard forage sorghum diet. Rumination and eating activities were similar for standard and BMR sorghum silages, as was rumen pH and acetate to propionate ratio. Ruminal and total tract digestibility of NDF was greater for the BMR versus the standard forage sorghum. Feeding dairy cows BMR forage sorghum silage resulted in greater DMI, fiber digestibility, and milk production versus a standard forage sorghum hybrid in this short-term study.*

Table 1. Nutrient composition of silages as percentage of DM.

Item	Normal sorghum	BMR[1] sorghum	Alfalfa	Corn
DM	30.6	31.2	45.0	39.7
CP	6.8	7.3	20.6	7.4
ADF	34.7	36.5	33.0	26.4
NDF	51.7	50.4	39.4	41.0
Lignin	9.5	7.5	6.8	4.4
Particles > 1.18 mm[2], %	71.4	71.3	62.8	70.1
pH	3.89	3.93	4.81	3.87

[1]Brown midrib.
[2]Forage particles retained on the 1.18-mm screen or greater following wet sieving as a percentage of total sample.

Introduction

Sorghum has become an increasingly important forage crop for dairy producers in the Midwestern and plains regions of the U.S. Additionally, forage sorghum can serve as an effective "rescue crop" in other regions of the U.S. when weather conditions preclude successful corn planting. In Kansas and Nebraska alone, over 300,000 acres of sorghum were harvested for silage in 1995. Forage sorghum can be planted later than corn, uses water much more efficiently, and when exposed to summer drought still produces acceptable yields.

Brown midrib forage sorghums contain less lignin than standard sorghum hybrids and the fiber is much more digestible. A previous study at Nebraska indicated that cows fed BMR versus standard forage sorghum at 65% of the dietary DM produced 18 more pounds of milk daily. To date, this has been the only reported comparison of BMR versus standard forage sorghums for lactating dairy cows.

The purpose of this study was to compare silage made from BMR sorghum with an isogenic standard sorghum silage, corn silage, and alfalfa silage for their effect on short-term (4 weeks) milk production and fiber digestibility.

Procedures

Sixteen Holstein cows (4 primiparous) were assigned randomly within parity to one of four diets in replicated 4 × 4 Latin squares with 4-wk periods. Three rumen-fistulated cows were assigned randomly to the same diets in a 3 × 4 Youden square. Alfalfa silage, corn silage, standard sorghum silage, and BMR sorghum silage were used as the dietary treatments. All diets contained 65% silage and 35% of a concentrate mixture comprised of soybean meal, dry-rolled corn, and a mineral and vitamin premix. Nutrient composition of the silages and the diets are given in Tables 1 and 2.

Cows were milked twice daily and production was recorded electronically. A daily composite of milk samples from a.m. and p.m. milkings were taken weekly and analyzed for fat, protein, and lactose. Samples of rumen fluid for pH and acetate to propionate ratio were collected during week 4 at 4-h intervals for 24 h. Fiber digestion of each silage was measured in situ using dacron bags to estimate rumen NDF digestion, and acid insoluble ash was used as an internal marker to estimate total tract NDF digestion.

Results

The BMR forage sorghum contained 21% less lignin than the standard forage sorghum, but similar NDF (Table 1). The diets were all equal in CP and rumen undegradable protein, but differed in content of lignin and NDF that

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reflected the source of the silage (Table 2).

DM matter intake among diets was not different, but when expressed as a percentage of BW, it was highest for cows fed the corn silage diet and least for cows fed the standard sorghum silage diet, with cows fed alfalfa and BMR sorghum silages being intermediate (Table 3).

Milk production and 4% FCM were 13% greater for cows fed the BMR sorghum diet than for those fed the standard sorghum diet (Table 4). Alfalfa and BMR sorghum silage diets resulted in similar milk production, but milk production was greatest for cows fed the corn silage diet. The percentage of milk fat was not different among the diets, but production of milk fat was greater for the BMR sorghum versus the standard sorghum diets, which reflected the responses observed in milk production. Milk protein percentage was similar for cows fed BMR sorghum, standard sorghum, and alfalfa silage, but was highest for cows fed the corn silage diet. Production of milk protein was greater for the BMR than for the standard sorghum silage diet. Because of differences in DMI and FCM among diets, the efficiency of FCM production was greatest for the corn silage diet, similar for the BMR and alfalfa silage diets, and lowest for the standard sorghum silage diet (Table 4). There was no effect of treatment on BW or body condition score in this short-term experiment. The diet containing standard forage sorghum was clearly inferior for milk production, DMI, and efficiency of FCM production, which agrees with earlier research at Nebraska using midlactation dairy cows.

There were no differences between standard and BMR sorghum in eating or ruminating activities (Table 5). Cows fed the corn silage diets spent the least amount of time eating and ruminating. Averaged over 24 h, ruminal pH, total volatile fatty acid concentration, and acetate to propionate ratio were not different among diets (Table 6). The mean pH was greater than 6.2 for all

Table 2. Ingredient and chemical composition of diets.

Item	Normal sorghum	BMR[1] sorghum	Alfalfa	Corn
Ingredients, % DM				
Normal sorghum silage	65.0	—	—	—
BMR sorghum silage	—	65.0	—	—
Alfalfa silage	—	—	65.0	—
Corn silage	—	—	—	65.0
Soybean meal	21.5	21.5	—	20.8
Corn, rolled	10.7	10.7	32.2	11.4
Mineral and vitamin mix[2]	2.8	2.8	2.8	2.8
Composition,[3] % of DM				
DM, %	51.2	51.0	61.0	62.0
CP	16.5	16.9	16.3	16.8
RUP[4]	5.3	5.3	5.1	5.2
ADF	27.6	25.2	20.3	21.8
NDF	39.7	40.3	29.1	34.3
Lignin	6.4	5.2	4.7	3.3

[1]Brown midrib.
[2]A mineral and vitamin supplement was added to all diets to meet or slightly exceed the nutrient requirements of NRC (1989).
[3]Dietary composition determined using analytical values for individual ingredients.
[4]Rumen undegradable protein; calculated using values reported by NRC (1989).

Table 3. Dry matter and fiber intake as influenced by forage source.

Item	Normal sorghum	BMR[1] sorghum	Alfalfa	Corn	SE
DMI					
lb/d	47.4	50.0	52.9	55.8	0.8
% of BW	3.5[c]	3.7[b]	4.0[ab]	4.2[a]	<0.1
ADF					
lb/d	13.0[a]	12.6[a]	10.6[b]	11.2[ab]	0.2
% of BW	0.9[a]	0.9[a]	0.8[b]	0.8[b]	<0.1
NDF					
lb/d	19.4[ab]	20.5[a]	15.4[c]	19.2[b]	0.4
% of BW	1.4[b]	1.5[a]	1.2[c]	1.4[b]	<0.1

[a,b,c]Means within a row with different superscripts differ ($P < 0.05$).
[1]Brown midrib.

Table 4. Lactation performance as influenced by forage source.

Item	Normal sorghum	BMR[1] sorghum	Alfalfa	Corn	SE
Milk, lb/d	47.3[c]	53.5[b]	55.4[b]	65.0[a]	1.1
Milk fat					
%	3.73	3.73	3.78	3.82	0.08
lb/d	1.74[c]	1.96[b]	2.09[b]	2.47[a]	0.06
Milk protein					
%	3.21[b]	3.23[b]	3.14[b]	3.36[a]	0.03
lb/d	1.50[c]	1.72[b]	1.74[b]	2.17[a]	0.02
Lactose					
%	4.85	4.88	4.86	4.90	0.02
lb/d	2.29[c]	2.62[b]	2.69[b]	3.17[a]	0.02
4% FCM, lb/d	45.6[c]	52.3[b]	54.0[b]	63.9[a]	1.3
FCM/DMI, lb/lb	0.94[c]	1.05[b]	1.05[b]	1.15[a]	0.03
BW, lb	1333	1316	1316	1313	7
BW change, lb/28 d	8.1	2.9	2.6	25.9	9.5
BCS[2]	3.29	3.26	3.23	3.26	0.02
BCS change, /28 d	-0.06	-0.03	-0.05	-0.01	0.05

[a,b,c]Means within a row with different superscripts differ ($P < 0.05$).
[1]Brown midrib.
[2]Body condition score (1 = thin to 5 = fat).

Table 5. Chewing activity as influenced by forage source.

Item	Normal sorghum	BMR[1] sorghum	Alfalfa	Corn	SE
Eating, min/d	277[a]	271[a]	291[a]	235[b]	7
Ruminating, min/d	459[a]	446[ab]	421[bc]	388[c]	11
Total chewing, min/d	730[a]	717[a]	712[a]	623[b]	13

[a,b,c]Means within a row with different superscripts differ ($P < 0.05$).
[1]Brown midrib.

Table 6. Ruminal pH and volatile fatty acids as influenced by forage source.[1]

Item	Normal sorghum	BMR[2] sorghum	Alfalfa	Corn	SE
Ruminal pH	6.43	6.48	6.18	6.21	0.07
Total VFA, m*M*	109.6	109.2	107.7	107.2	1.3
VFA, mol/100 mol					
Acetate (A)	62.6	60.6	62.2	62.3	0.9
Propionate (P)	30.6	29.3	28.6	30.1	1.2
n-Butyrate (B)	2.8[b]	4.1[a]	4.0[a]	3.7[a]	0.1
Isobutyrate	0.8	1.0	0.8	0.7	<0.1
n-Valerate	1.5	2.5	2.3	1.5	0.2
Isovalerate	1.4[c]	2.3[a]	1.9[b]	1.4[c]	<0.1
A:P	2.0	2.1	2.1	2.1	0.1
A+B/P	2.1	2.2	2.3	2.2	0.1

[a,b,c]Means within a row with different superscripts differ ($P < 0.05$).
[1]Data represent means over a 24-h period from samples collected every 4 h.
[2]Brown midrib.

Table 7. In situ digestion kinetics of forage NDF and total tract fiber digestibility.

Item[2]	Normal sorghum	BMR[1] sorghum	Alfalfa	Corn	SE
K_p h^{-1}	0.041	0.034	0.046	0.031	0.009
Lag, h	1.29[b]	0[b]	2.58[ab]	4.90[a]	0.77
K_d, h^{-1}	0.033[b]	0.049[ab]	0.103[a]	0.031[b]	0.013
PED, %	56.5[bc]	64.6[ab]	48.0[c]	68.6[a]	2.5
AED, %	24.1[c]	38.3[a]	29.4[bc]	29.6[b]	1.1
Total tract digestibility					
NDF, %	38.8[b]	42.8[ab]	45.6[ab]	51.8[a]	2.6
ADF, %	32.02[c]	39.1[b]	40.3[b]	48.5[a]	1.8

[a,b,c]Means within a row with different superscripts differ ($P < 0.05$).
[1]Brown midrib.
[2]K_p = Fractional rate of passage from rumen; K_d = fractional rate of digestion in the rumen; PED = potential extent of ruminal fiber digestion calculated using equations by Grant (1994); AED = apparent extent of ruminal fiber digestion = PED x $K_d/(K_d + K_p)$ x e^{-K_pL}.

diets, and all diets resulted in acetate to propionate ratios in excess of 2.0. Fractional passage rate from the rumen estimated using rare earth marker did not differ significantly among the silages (Table 7) and averaged 0.038 h^{-1}. In situ lag time and rate of silage NDF digestion were not different between standard and BMR sorghum silages (Table 7). Fractional rate of NDF digestion was highest for alfalfa and similar for standard sorghum, BMR sorghum, and corn silage. Potential extent of ruminal NDF digestion was lowest for alfalfa and highest for corn silage; it was not significantly different for standard and BMR sorghum silages. However, BMR sorghum tended to have a greater potential extent of digestion than the standard counterpart, and the apparent extent of ruminal digestion, which integrates passage and digestion, was greater for BMR than for standard sorghum silage.

Total tract digestibilities of NDF and ADF for BMR sorghum were 10 and 22% greater, respectively, than standard sorghum. Digestibilities of ADF and NDF were 20 and 14% greater, respectively, for corn silage than for alfalfa silage. All of these data indicate that even though the fiber digestion rate and ruminal VFA were not different between BMR sorghum and standard sorghum, apparent extent of fiber digestion for BMR was higher than for standard sorghum and the increased extent of total tract NDF digestion resulted in greater milk production.

This short-term trial clearly indicated that BMR forage sorghum hybrids result in greatly enhanced NDF digestibility, dry matter intake, and milk production when fed to lactating dairy cows. These hybrids are especially suitable for dairy producers in the Midwestern and plains states where corn silage is not always the most suitable crop from an agronomic perspective.

[1]Gokalp Aydin, former Graduate Student; and Rick Grant, Associate Professor and Extension Dairy Specialist, Animal Science, Lincoln.

Brown Midrib Forage Sorghum Improves Fiber Digestibility and Milk Production in Dairy Cows

Gokalp Aydin
Rick Grant[1]

Summary

Thirty Holstein dairy cows in early lactation were fed diets containing 35.3% (DM basis) standard forage sorghum silage, brown midrib ***(BMR)*** *sorghum silage, or corn silage in a 10-wk lactation trial. In vitro extent of fiber digestion was significantly higher for BMR sorghum than for standard sorghum silage. Dry matter intake* ***(DMI)*** *and body condition score were not different between cows fed BMR and standard forage sorghum, but cows fed BMR sorghum diets had greater long-term milk production than cows fed standard forage sorghum with milk production similar to cows fed corn silage. The BMR forage sorghum appears to be a viable alternative to corn silage as a source of highly digestible forage fiber and it is clearly superior to standard forage sorghum hybrids.*

Introduction

Climatic conditions in the Midwestern and plains region of the U.S., such as frequent drought and high summer temperatures, introduce considerable risk into corn production for silage, thus many producers consider raising silage-type sorghums because of high biomass yields, drought tolerance, and adaptability to late planting after winter crops. However, the DM digestibility of corn silage is typically greater than for forage sorghum. Lignin, the primary indigestible component of plant cell walls, inhibits digestion of cell wall carbohydrates in the rumen. Usually the corn plant contains less lignin than standard forage sorghum hybrids as well as a greater content of grain. Because high lignin content reduces the potential extent of fiber digestion, it may result in increased gut fill, reduced DMI, and less milk production.

Chemical and genetic approaches have been used to improve forage fiber digestibility by reducing lignification. Brown midrib forage genotypes usually contain less lignin and the chemical composition of the lignin is altered. Genetic control of the lignification process through manipulation of the BMR trait has offered the most direct approach to reducing lignin concentration and increasing digestibility of forage sorghum. In situ and in vitro NDF digestion studies have shown that BMR forages have greater extent of NDF digestion than their standard counterparts. In most lactation and feeding trials involving corn silage, BMR corn silage improved milk production, DMI, and BW gain.

Most previous studies that compared standard sorghum genotypes with corn silage have shown that milk production and DMI were consistently higher for cows fed corn silage than those fed sorghum silage. Few experiments have compared BMR sorghum to other common forages fed to lactating dairy cattle. Only one previous study, conducted at Nebraska, has compared BMR sorghum silage with corn and alfalfa silages; we observed that milk production was not significantly different for cows fed alfalfa, corn, or BMR sorghum silages when the diets contained 65% silage (DM basis).

The earlier study showed that more experiments are needed to compare BMR forage sorghum hybrids with other common forages to measure the impact on ruminal function and lactational performance. It is essential to begin development of forage systems that optimize the use of alternatives to corn silage in regions where corn is less agronomically suitable.

Therefore, the objective of this research was to compare a BMR sorghum silage with an isogenic standard sorghum silage and corn silage in a ration that also contained alfalfa silage in a 10-wk lactation study for their effect on milk production, DMI and body condition score.

Procedures

Thirty Holstein cows (15 primiparous) in early lactation were grouped by age and previous milk production and assigned randomly to one of three experimental diets in a continuous 10-wk lactation trial to measure DMI, milk production, rumination activity, and body condition score. A 2-wk covariate period was used during which all cows were fed a common diet containing alfalfa as the sole forage (50% of dietary DM).

Diets were prepared as typical lactation TMR fed to an early lactation dairy cow. All diets contained 53% forage and 47% of a concentrate mixture comprised of soybean meal, SoyPass®

(a nonenzymatically browned soybean meal to increase the escape protein content; Lignotech USA, Rothschild, WI), dry-rolled corn, and whole cottonseed (Tables 1 and 2). The sorghum and corn silages made up 67% of the forage DM in each diet with alfalfa silage comprising the remainder. Diets were formulated to be isonitrogenous (17.5% CP) and the rumen undegradable protein requirements for early lactation were calculated to be met by all diets. All diets were fed as TMR twice daily in amounts to ensure 10% feed refusals. Cows were housed in a tie-stall barn equipped with individual feed boxes and were removed twice daily for milking.

Dietary and animal measurements were forage physical form and chemical composition of forage and other dietary ingredients measured weekly, rumination activity (measured once during wk 5), DMI and milk production measured daily, milk composition measured once weekly, and BW measured weekly. Body condition score was measured weekly using a 1 to 5 scale where 1 was a thin cow and 5 was a fat cow.

Table 1. Chemical composition of experimental silages as percentage of DM.

Item	Normal sorghum	BMR[1] sorghum	Corn	Alfalfa
DM, %	36.8	34.8	35.5	47.6
CP	9.1	9.7	9.5	20.5
ADF	33.2	32.0	28.1	36.2
NDF	49.9	47.9	48.6	43.0
Lignin	7.1	6.1	5.8	7.7
Particle distribution[2]				
>3/4 inch	2.3	5.2	3.8	20.0
3/4 inch to 5/16 inch	30.1	29.2	22.3	37.0
<5/16 inch	67.6	65.6	73.9	43.0

[1]Brown midrib.
[2]Particle distribution (% of as-is silage) determined using the Penn State Forage Particle Separator.

Table 2. Ingredient and chemical composition of experimental diets.

Item	Normal sorghum	BMR[1] sorghum	Corn silage
Ingredients, % of DM			
Alfalfa silage	17.5	17.5	17.5
Normal sorghum silage	35.3	—	—
BMR sorghum silage	—	35.3	—
Corn silage	—	—	35.3
Corn, rolled	22.8	22.8	22.8
Soybean meal	6.6	6.6	6.6
Soy Pass®[2]	8.3	8.3	8.3
Whole cottonseed	6.6	6.6	6.6
Mineral and vitamin mix[3]	2.9	2.9	2.9
Chemical composition, % of DM			
DM, %	64.3	65.1	66.5
CP	17.5	17.7	17.6
RUP[4]	6.5	6.9	6.6
ADF	24.1	23.6	22.3
NDF	32.3	31.6	31.9
Lignin	4.9	4.5	4.5

[1]Brown midrib.
[2]Nonenzymatically browned soybean meal to increase rumen undegradable protein content (Lignotech USA, Rothschild, WI).
[3]Mineral and vitamin mix added to meet or slightly exceed the requirements of NRC (1989).
[4]Rumen undegradable protein; calculated using values reported by NRC (1989).

Results

Chemical composition of experimental silages is presented in Table 1. The BMR sorghum and standard sorghum had similar NDF and ADF concentrations, but lignin concentration was less for BMR than for standard sorghum silage. Standard sorghum, BMR sorghum, and corn silage had similar amounts of forage particles retained on a 3/4-inch screen.

Lactational performance data are shown in Table 3. This study is the only report of the long-term response of lactating dairy cows to diets containing BMR forage sorghum, standard forage sorghum, or corn silage. The DMI was not significantly different among diets. Milk production and 4% fat-corrected milk **(FCM)** were higher for the BMR sorghum diet than for the standard sorghum diet. Milk composition was

(Continued on next page)

Table 3. Effect of diet on lactational performance of dairy cows fed experimental diets for 10 wk.

Item	Normal sorghum	BMR[1] sorghum	Corn silage	SE
DMI				
lb/d	52.3	55.3	54.7	2.2
% of BW	4.10	4.20	4.30	0.08
Milk production, lb/d	74.5[b]	79.4[a]	76.3[ab]	1.5
Milk composition, %				
Fat	3.54	3.59	3.57	0.14
Protein	2.99	3.08	3.01	0.04
Lactose	4.97	5.04	5.04	0.05
4% FCM, lb/d	69.0[b]	74.5[a]	71.4[ab]	1.5
FCM/DMI, lb/lb	1.30[b]	1.36[a]	1.31[b]	0.05
BW, lb	1254	1294	1239	11
BW change, lb from 1 to 10 wk	24.9	22.0	33.9	1.8
BCS[2]	3.3	3.4	3.2	0.3
BCS change from 1 to 10 wk	0.04	0.09	0.03	0.04

[a,b]Means within a row with different superscripts differ ($P<0.05$).
[1]Brown midrib.
[2]Body condition score (1 = thin to 5 = fat).

unaffected by diet. Efficiency of FCM production was greater for BMR sorghum than for the standard sorghum diet. The production of FCM was similar for cows fed either the BMR sorghum or the corn silage diet. Dietary forage had no effect on body weight or body condition score.

Eating, ruminating, and total chewing times were not different among the diets (Table 4). The similar chewing activity reflects the similar NDF content of each diet and the similar particle distribution of the silages comprising these diets. These rumination results indicate that the physically effective NDF content of standard and BMR sorghum was similar, despite the lower lignin content of the BMR sorghum.

In vitro digestion kinetics showed that fractional rate of NDF digestion and lag time were not affected by silage source (Table 5). However, extent of NDF digestion was significantly greater for BMR sorghum than for standard sorghum. In addition, the 30-h in vitro digestibility of NDF was 23% greater for the BMR versus the standard sorghum silage, which would be applicable to the typical mean retention time observed for lactating dairy cows. Oba and Allen (1998) reported that higher NDF digestibility would result in higher energy intake, even if DMI was not affected. Greater milk production with BMR sorghum than standard sorghum was likely due to a greater energy availability caused by greater extent of NDF digestibility for BMR sorghum, even though the DMI was not significantly different from the standard sorghum.

Lignin is a primary factor that limits the degradability of forage cell wall carbohydrates. The BMR mutant of forage sorghum contains substantially less lignin than standard forage sorghum genotypes, and consequently has greater potential as a source of digestible fiber for lactating dairy cows. The BMR sorghum resulted in greater fiber digestion, milk production, and efficiency of FCM production versus the standard sorghum. In our longer-term trial that included a combination of alfalfa plus the test silage, the BMR sorghum resulted in milk production similar to corn silage. Our data indicates that BMR sorghum silage is superior to standard sorghum silage, and because of its agronomic characteristics, BMR sorghum has the potential to replace corn silage in diets fed to lactating dairy cows in drier regions of the U.S. such as the Midwestern and plains states. Future research will need to compare the economics of BMR sorghum versus alternative sources of forage fiber in complete dairy-forage systems.

Table 4. Effect of diet on chewing activity of lactating dairy cows.

Item	Normal sorghum	BMR[1] sorghum	Corn silage	SE
Eating				
min/d	170	183	161	14
Ruminating				
min/d	327	320	316	19
Total chewing				
min/d	497	503	477	26

[1]Brown midrib.

Table 5. In vitro digestion kinetics of NDF from experimental silages.

Item	Normal sorghum	BMR[1]	Corn	Alfalfa	SE
Lag, h	5.7^{a}	3.6^{a,b}	2.6^{b}	1.8^{b}	1.7
K_d,[2] h^{-1}	0.057	0.061	0.050	0.070	0.006
Potential extent of digestion, %	55.8^{e}	60.6^{d}	66.1^{c}	55.7^{e}	0.7
r^2	0.95	0.97	0.99	0.94	
30-h digestion, %	40.1^{d}	49.2^{c}	51.6^{c}	47.8^{c}	0.5

[a,b]Means within a row with different superscripts differ ($P < 0.10$).
[c,d,e]Means within a row with different superscripts differ ($P<0.05$).
[1]Brown midrib.
[2]Fractional rate of digestion in the rumen.

[1]Gokalp Aydin, former Graduate Student; and Rick Grant, Associate Professor and Extension Dairy Specialist, Animal Science, Lincoln.

Maximal Replacement of Dietary Concentrate and Forage with a New Wet Corn Milling Feed Product

Krishna Boddugari
Rick Grant
Rick Stock
Mike Lewis[1]

Summary

The objectives of these two experiments were to determine the maximal amount of dietary concentrate and forage that could be replaced with a new feed product based on ingredients produced by the wet corn milling industry. Experiment 1 evaluated the replacement of concentrate with the wet corn milling feed ***(CMF)****. The four diets contained 54.3% forage with CMF replacing 0, 50, 75, or 100% of the concentrate portion of the diet (DM basis). The concentrate mixture comprised soybean meal and ground corn. The NDF content of the diets ranged from 28.2% (0% replacement) to 41.6% (100% replacement). Milk production, milk fat, and milk fat production were not affected by diet. The diets containing CMF resulted in lower dry matter intake* ***(DMI)*** *than diets without the product. There was a significant linear reduction in milk protein as CMF replaced concentrate despite the predicted adequate metabolizable protein content of the diets. Efficiency of 4% fat-corrected milk* ***(FCM)*** *was higher for diets containing CMF.*

In Experiment 2, the CMF replaced 0, 15, 30, or 45% of dietary forage; the concentrate portion of all diets was entirely replaced with CMF. Dry matter intake was unaffected by diet. Milk production increased as CMF replaced forage, but milk fat percentage was simultaneously depressed. Milk protein synthesis was unaffected by diet. Overall, efficiency of 4% FCM production was unaffected by diet. Results of both experiments indicate that a new feed product based on wet corn milling ingredients has the potential to effectively replace all of the concentrate and a substantial portion of the forage in the diet for lactating dairy cows.

Introduction

In a summary of beef feedlot research conducted at the University of Nebraska, efficiency of gain was improved 5.1% when diets containing wet corn gluten feed (*Sweet Bran*®; Cargill Corn Milling, Blair, NE) were compared with dry-rolled corn diets. Feedlot performance was similar when *Sweet Bran*® was fed in the range of 20 to 50% of the ration dry matter. When fed in beef growing diets, the energy value of wet corn gluten feed (**CGF**; Minnesota Corn Processors, Columbus, NE) was greater than when fed in finishing diets. This performance response is likely due to a reduction in negative associative effects of rumen fermentable starch on fiber digestion. The energy value of wet CGF should be as high, or higher, in diets for lactating dairy cows, which rely on optimal rumen fiber digestion in the presence of substantial amounts of concentrate feeds.

Rumen acidosis is a significant concern in dairy feeding programs due to a large consumption of concentrates. Corn bran is rapidly and highly digested in the rumen. Research at the University of Nebraska showed that the in situ rate of NDF digestion for CGF was 6.8%/h. In contrast, the rate of starch digestion in the rumen ranges between 10 and 35%/h. Consequently, dilution of nonfiber carbohydrates with fiber from CGF should result in slower rates of fermentation, reduced acid load on the rumen per unit of fermentation time, and the ability to feed a highly digestible diet with minimal risk of rumen acidosis. In practical terms, energy consumption should be maximized, rumen function should be normal, and solids-corrected milk production should be optimal.

In fact, research at the University of Nebraska has shown that the effectiveness of NDF from wet CGF is approximately 74% that of alfalfa silage for maintaining 4% fat-corrected milk production. But, the effectiveness of wet corn gluten feed at stimulating rumination is only 11% that of alfalfa silage. These results suggest that the primary effect of wet CGF is on reduction of acid load in the rumen, not on stimulation of salivary buffering. Finally, by increasing the particle length of the dietary silage, the passage rate of CGF from the rumen can be reduced from 6.4 to 4.3%/h. Consequently, the extent of gluten feed NDF digestion in the rumen increases substantially. All of this information suggests that a properly formulated wet corn milling feed product **(CMF)** could be fed at much higher amounts than currently practiced in the dairy industry.

One problem with the design of some previous dairy research evaluating wet CGF has been that diets were balanced

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for crude protein, but not for metabolizable protein. Wet corn gluten feed contains twice as much crude protein as corn, but less metabolizable protein. Thus, corn control diets, using soybean meal or distillers grains to balance for crude protein, may contain similar crude protein concentrations as wet CGF diets, but these control diets also contain significantly greater amounts of metabolizable protein. If metabolizable protein is not adequate with wet CGF diets, erroneous conclusions may be made concerning the feeding value of the wet corn gluten feed. Recently, North Dakota researchers evaluated 0, 15, 30, or 45% wet corn gluten feed in isonitrogenous diets and concluded that 19% (dry basis) gluten feed was optimal for milk production. But, no attempt was made to balance the diets for metabolizable protein.

A wet corn milling feed product was developed that may improve efficiency of milk production and lower costs of production for the dairy producer. Research is needed to determine the effects of this product on ruminal and total tract nutrient digestion, ruminal pH and acid production versus buffering, nutrient intake, and milk component production particularly during early lactation when dairy cows are most susceptible to metabolic disorders related to feeding highly digestible diets.

Procedures

The research approach entailed two metabolism lactation studies to measure the effect of CMF (produced by Cargill Corn Milling, Blair, NE) on rumen fermentation and fiber digestion, plus obtain a “snapshot” of the effect on lactational performance. The optimum level(s) will be evaluated in a longer-term lactation study designed to measure intake, milk production, body condition, incidence of health problems, and economics of feeding CMF.

In Experiment 1, all diets contained approximately 27% alfalfa silage and

Table 1. Ingredient and chemical composition of diets for Experiment 1.

	Concentrate replacement (% of DM)			
Item	0	50	75	100
	(% of DM)			
Ingredients				
Alfalfa silage	27.1	27.1	27.1	27.1
Corn silage	27.1	27.1	27.1	27.1
Corn grain, ground	27.2	14.0	6.8	—
Soybean meal, 46.5% CP	15.8	7.6	4.0	—
CMF	—	22.5	33.8	45.3
Mineral and vitamin mix[1]	2.8	1.7	1.2	0.5
Chemical composition				
DM, %	58.8	56.9	56.1	55.2
CP	18.1	18.0	18.1	18.1
ADF	18.1	19.2	21.4	22.4
NDF	28.2	35.4	38.2	41.6

[1]Mix formulated to provide in total ration DM: Ca, 1.0%; P, 0.52%, Mg, 0.36%; K, 1.4%; 0.23 to 0.31% S; 120,000 IU/d of vitamin A; 24,000 IU/d of vitamin D; 790 IU/d of vitamin E.

Table 2. Effect of concentrate replacement on lactational performance during Experiment 1.

	Concentrate replacement (% of DM)				
Item	0	50	75	100	SE
DM intake, lb/d	54.3[a]	49.5[b]	50.8[ab]	47.9[b]	1.9
Milk, lb/d	66.9	67.1	67.8	64.9	1.9
Milk fat, %	3.54	3.84	3.59	3.82	0.16
Milk protein, %	3.13[a]	3.10[a]	2.84[b]	2.87[b]	0.10
Milk lactose, %	4.90	4.58	4.59	4.52	0.14
4% FCM, lb/d	62.3	65.6	63.6	62.7	1.9
FCM/DMI, lb/lb	1.15[b]	1.32[a]	1.28[ab]	1.32[a]	0.05

[ab]Means within a row with unlike superscripts differ ($P < 0.10$).

Table 3. Ingredient and chemical composition of diets for Experiment 2.

	Forage replacement (% of DM)			
Item	0	15	30	45
	(% of DM)			
Ingredients				
Alfalfa silage	27.1	23.1	18.9	15.0
Corn silage	27.1	23.1	18.9	15.0
CMF	45.2	53.4	61.6	69.6
Mineral and vitamin mix[1]	0.6	0.4	0.6	0.4
Chemical Composition				
DM, %	56.3	55.7	53.7	58.2
CP	18.3	18.9	19.3	19.9
ADF	20.7	19.7	18.6	17.6
NDF	41.2	40.9	40.8	40.7

[1]Mix contained (% of DM): 3.5% Ca; 0.46% S; 336,000 IU/kg of vitamin A; 67,000 IU/kg of vitamin D; 1346 IU/kg of vitamin E.

Table 4. Effect of forage replacement on lactational performance during Experiment 2.

	Forage replacement (% of DM)				
Item	0	15	30	45	SE
DM intake, lb/d	53.2	54.1	55.7	55.9	1.9
Milk, lb/d	64.4[b]	66.9[ab]	69.1[a]	68.4[a]	2.6
Milk fat, %	3.72[a]	3.53[ab]	3.53[ab]	3.22[b]	0.14
Milk protein, %	3.24	3.25	3.28	3.31	0.08
Milk lactose, %	4.88	4.89	4.84	4.86	0.02
4% FCM, lb/d	61.6	62.7	65.1	62.9	1.5
FCM/DMI, lb/lb	1.17	1.16	1.17	1.13	0.02

[ab]Means within a row with unlike superscripts differ ($P < 0.10$).

27% corn silage (DM basis). The remaining 46% of the diet comprised:

1. corn, soybean meal, minerals, and vitamins,
2. 50% replacement of mix 1 with CMF,
3. 75% replacement of mix 1 with CMF, and
4. 100% replacement of mix 1 with CMF

All diets met the calculated metabolizable protein requirement for a cow producing 34 kg of milk using the Cornell Net Carbohydrate and Protein Model. Also, using the Cornell Model, all diets contained at least 110% of the requirement for the essential amino acids. All diets met or exceeded the NRC (1989) requirements for minerals and vitamins. The calculated dietary NFC content ranged from 29.5% (100% replacement) to 37.1% (50% replacement). Based on our best estimates from previous research at Nebraska, the effective NDF requirement was met for all diets. Diets were fed as TMR twice daily to encourage feed intake.

Sixteen Holstein dairy cows (4 rumen fistulated), averaging 34 kg of milk per day, were assigned to these 4 diets in a replicated 4 x 4 Latin square design balanced for any possible carryover effects. Period length was 4 wk with sample and data collection occurring during the last 10 d of each period. Cows were housed in a tie-stall barn equipped with individual feed boxes for measurement of individual dry matter intake.

Daily milk production was recorded electronically, and milk composition was determined weekly on composite a.m. and p.m. milk samples.

Experiment 2 was conducted similar to Experiment 1. The diets contained the same silage mixture (1:1 alfalfa:corn silage, DM basis). The dietary treatments were:

1. CMF replacing 0% of forage,
2. CMF replacing 15% of the forage,
3. CMF replacing 30% of forage, and
4. CMF replacing 45% of forage

For all diets, CMF comprised the entire concentrate portion of the diet, except for minerals and vitamins. The same number of animals and experimental design as Experiment 1 were used in Experiment 2.

Results

The CMF product developed for these two experiments contained 65% DM, 23.1% crude protein, 40% escape protein (as a % of CP), 13.7% ADF, and 40.3% NDF.

Replacing from 0 to 100% of dietary concentrate with CMF reduced DMI, but had no effect on milk or milk fat production. Efficiency of FCM production (FCM/DMI) was increased as CMF replaced dietary concentrate. Milk protein percentage was depressed for Experiment 1, despite using the Cornell Model to formulate based on metabolizable protein and amino acids. However, these requirements were barely satisfied for the 100% replacement diet, which was also the control diet in Experiment 2. In Experiment 2, milk protein was not depressed, but cows consumed more DM and the total ration CP was slightly higher.

In Experiment 2, as CMF replaced forage, DMI was unchanged. But, milk production increased while milk fat decreased. Overall, 4% FCM production was unchanged.

We were able to successfully replace up to 70% of the dietary DM with the new CMF product. Results of both experiments indicate tremendous potential for the new wet corn milling feed product to replace both forage and concentrate in diets for lactating dairy cows.

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Corn versus Sorghum Distillers Grains for Lactating Dairy Cows

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Summary

*A dairy lactation experiment was conducted to evaluate the nutritional value of distillers grains **(DG)** from sorghum or corn fermentation, in both wet (35.4% DM) and dry (92.2% DM) form. Twelve early lactation Holstein cows (four ruminally fistulated) were used in a replicated 4 × 4 Latin square design with 4-wk periods. Corn and sorghum DG were fed at 15% of the ration dry matter **(DM)** in either wet or dry form. Diets were fed as total mixed rations that contained 50% of a 1:1 mixture of alfalfa and corn silages, 24.3% ground corn, and 9.1% soybean meal (DM basis). There was no effect of source or form of DG on DMI, ruminal pH and volatile fatty acids **(VFA)**, or in situ digestion kinetics of neutral detergent fiber **(NDF)** from DG, although there was a trend toward lower 4% fat-corrected milk **(FCM)** production with sorghum DG.*

Introduction

Distillers grains from fermentation of sorghum and corn grains are a common component of diets for lactating dairy cattle, but no direct comparison of these two DG has ever been conducted. Replacement of 40% of dry-rolled corn with wet corn DG increased ADG and feed efficiency relative to steers fed dry-rolled corn only in Nebraska studies. These experiments suggested that wet corn DG contains approximately 40% more energy for gain than dry-rolled corn. The higher energy content could be due to higher lipid content in DG compared with corn, and also a reduction in subacute ruminal acidosis due to dilution of dietary starch with NDF when DG replaces corn grain.

Recently, Nebraska researchers evaluated wet DG produced at a commercial ethanol plant from a blend of 80% sorghum and 20% corn DG. Similar ADG and feed efficiency were observed when finishing beef steers were fed diets of dry-rolled corn or when 40% of the corn was replaced by wet DG. Similar ADG and feed efficiency were observed when finishing beef steers were fed diets of dry-rolled corn or when 40% of the corn was replaced by wet DG. These data suggest that the energy content of 80% sorghum DG is similar to dry-rolled corn. Additionally, the total tract organic matter digestibility of corn DG was 5.6% greater than the 80:20 mixture of sorghum and corn DG when fed to lambs.

No analogous research concerning sorghum versus corn DG has been conducted with lactating dairy cattle. Additionally, dairy cattle routinely are fed DG in either a wet or dry form based primarily on herd size and feeding system. The lamb NDF digestibility data indicated an advantage for sorghum over corn DG when fed dry, but not when fed as wet DG. Whether this difference in NDF digestibility exists for dairy cattle has not been evaluated.

The objective of this experiment was to evaluate the effect of the same corn and sorghum DG, in both wet and dry forms, on NDF digestion and short-term lactational performance.

Procedures

Distillers grains were produced at a commercial dry milling plant (Chief Ethanol Fuels, Inc., Hastings, NE) from one fermentation batch for each source of grain. Unlike previous experiments, the DG were produced from fermentation of either 100% corn or 100% sorghum. The wet DG were stored in plastic silage bags and the dry DG were stored in metal bins prior to initiation of the cattle experiments. As the silage bags and bins were filled, representative DG samples were collected. The chemical composition of the DG products used during the dairy experiment is shown in Table 1.

Twelve Holstein cows (4 primiparous) were assigned randomly within parity to one of four diets in replicated 4 × 4 Latin squares with 4-wk periods to measure DMI and milk production and composition. Four ruminally fistulated, multiparous cows were assigned randomly to the same diets to measure ruminal and total tract NDF digestion, ruminal pH, and VFA concentrations.

Dietary treatments were: 1) dry corn

Table 1. Chemical composition of distillers grains.

Item	Corn distillers grains		Sorghum distillers grains	
	Dry	Wet	Dry	Wet
DM, %	93.0	35.5	91.4	35.3
	% of DM			
CP	28.9	30.5	32.9	31.2
ADF	25.5	25.3	28.4	28.5
NDF	42.3	42.6	41.3	45.2

Table 2. Ingredient and chemical composition of experimental diets fed to lactating dairy cows.

	Corn distillers grains		Sorghum distillers grains	
Item	Dry	Wet	Dry	Wet
Ingredient	---	--- % of DM ---	---	---
Alfalfa silage[a]	25.0	25.0	25.0	25.0
Corn silage[b]	25.0	25.0	25.0	25.0
Corn distillers grains, dry	15.0	—	—	—
Corn distillers grains, wet	—	15.0	—	—
Sorghum distillers grains, dry	—	—	15.0	—
Sorghum distillers grains, wet	—	—	—	15.0
Corn, ground	24.3	24.3	24.3	24.3
Soybean meal, 46.5% CP	9.1	9.1	9.1	9.1
Mineral and vitamin mixture[c]	1.6	1.6	1.6	1.6
Composition				
DM, %	52.6	49.1	53.9	47.2
CP	18.2	18.8	18.4	18.7
ADF	22.5	23.1	22.4	22.9
NDF	32.7	32.6	32.4	33.5

[a]Composition of alfalfa silage was (% of DM): 19.4% CP, 35.0% ADF, and 43.8% NDF.
[b]Composition of corn silage was (% of DM): 8.9% CP, 24.2% ADF, and 41.4% NDF.
[c]Mixture contained 15.2% Ca, 7.2% P, 4.1% Mg, 4% Na, 3000 ppm of Zn, 1,750 ppm of Mn, 400 ppm of Cu, 200,000 IU/kg of vitamin A, 36,000 IU/kg of vitamin D_3, and 600 IU/kg of vitamin E.

DG; 2) dry sorghum DG; 3) wet corn DG; and 4) wet sorghum DG. All diets contained 15% of the DG product and 50% of a 1:1 mixture of alfalfa and corn silages, 24.3% ground corn, 9.1% soybean meal, and 1.6% mineral and vitamin supplement (DM basis; Table 2). Diets were formulated to be isonitrogenous (18.5% CP) and fed as total mixed rations twice daily in amounts to ensure 10% refusals. Cows were housed in a tie-stall barn equipped with individual feed boxes and were removed twice daily for milking, exercise, and estrus detection for a total of 5 to 6 h daily.

Daily milk production was recorded electronically for all cows. Composite a.m. and p.m. milk samples were collected twice during wk 4 of each period and analyzed for percentage of fat, protein, and lactose. Body weight was measured weekly immediately after the a.m. milking.

Samples of ruminal fluid were collected directly beneath the ruminal digesta mat during wk 4 of each period from ruminally fistulated cows at 4-h intervals for 24 h. The pH of ruminal fluid was measured immediately using a portable pH meter, and concentrations of VFA were determined by gas-liquid chromatography.

Fractional rate of NDF digestion of each DG product was measured using the in situ bag technique in which dacron bags containing 5 g of substrate were incubated in duplicate within the rumen of each cow for 0, 6, 12, 24, 48, and 72 h.

Total tract acid detergent fiber **(ADF)** and NDF digestibilities were measured during wk 4 of each period using the ruminally fistulated cows only. Feed samples and rectal grab samples of feces were taken daily at the a.m. feeding for indirect estimation of digestibility. The total tract ADF and NDF digestibilities were determined using the acid-insoluble ash ratio technique.

Results

As analyzed, all diets contained approximately 50% DM, 18.5% CP, 22.7% ADF, and 32.8% NDF (DM basis; Table 2). The DG were added at 15% of the ration DM because a previous review of research with DG in dairy rations indicated that this amount may be nearly optimal for lactation diets based on DMI and milk production response. This amount of DG resulted in approximately 21.3 percentage units of dietary NDF from forage, or about 65% of total NDF from forage, which has resulted in increased 4% fat-corrected milk production and DMI when compared with higher forage control diets.

Table 3 summarizes the effect of DG on DMI and efficiency of milk production. Dry matter intake averaged 55.8 lb/d or 4.0% of body weight for cows on

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Table 3. Performance responses to corn and sorghum distillers grains fed to lactating dairy cows.

	Corn distillers grains		Sorghum distillers grains		
Item	Dry	Wet	Dry	Wet	SE
DMI					
lb/d	54.5	56.9	56.9	55.2	2.2
% of BW	3.9	4.0	4.1	4.0	0.2
BW, lb	1408	1421	1410	1404	35
BW change					
per period, lb	22.4	24.6	24.8	33.2	11.2
4% Fat-corrected milk, lb/d	73.3	72.6	70.3	69.0	3.9
FCM[a]/DMI, lb/lb	1.3	1.3	1.3	1.2	0.1
Milk fat					
%	3.7	3.6	3.5	3.5	0.1
lb/d	2.8	2.6	2.6	2.4	0.2
Milk protein					
%	3.4	3.3	3.2	3.2	0.1
lb/d	2.6	2.4	2.4	2.2	0.2
Milk lactose					
%	4.7	4.6	4.7	4.8	0.1
lb/d	3.5	3.5	3.7	3.5	0.2

[a]Fat-corrected milk.

all diets. Neither BW nor change in BW per 4-wk period was affected by diet. Numerically, 4% fat-corrected milk production was approximately 6% lower for the sorghum DG diets; there was a trend (P = 0.15) toward reduced fat-corrected milk production for cows fed the sorghum DG. Efficiency of 4% fat-corrected milk production was similar for all diets and averaged 1.28. Milk fat production was unaffected by diet and reflected the high ruminal pH observed for cows consuming all diets (Table 4).

Nearly all previous research with lactating dairy cows has evaluated replacement of dietary corn or soybean meal with DG, rather than comparing source or form of DG. Early research with dry DG (source not specified) indicated that DG inclusion in the ration in place of corn grain or soybean meal often increased milk fat production. More recently, Nebraska researchers compared dry corn DG with solvent-extracted soybean meal in diets for early lactation dairy cows that contained 50% of an alfalfa and corn silage mixture. In this experiment, there were no differences in DMI or milk production between the two sources of protein. In our study, all diets contained soybean meal plus DG and supplied adequate metabolizable protein for cows in early lactation.

Ruminal pH and acetate to propionate ratio indicated that DG from corn or sorghum, whether wet or dry, resulted in ruminal conditions that were optimal for cell wall fermentation (Table 4). All diets resulted in an acetate to propionate ration greater than 2.0; ratios below 2.0 have been associated with milk fat depression. Similarly, the ruminal NDF digestion rate and extent of DG were high, reflecting the high fibrolytic activity associated with ruminal pH greater than 6.2. The fractional rate, lag, and extent of NDF digestion observed for corn and sorghum DG were within the range observed previously for other nonforage sources of fiber. Apparent extent of ruminal NDF disappearance from DG (assuming a fractional passage rate from the rumen of .050 h^{-1}) ranged between 39 and 46%, with no difference among treatments (Table 5). Total tract ADF and NDF digestibility was unaffected by diet and values were typical of a highly digestible lactation ration containing fibrous coproduct feeds such as DG.

In summary, the dairy experiment demonstrated that short-term lactational performance of early lactation dairy cows was similar (P>0.10) for wet versus dry DG. Additionally, supplementing the ration with DG from either source at 15% of the DM had no deleterious effects on ruminal pH, NDF fermentation, or total tract NDF digestibility. A longer-term lactation study would clarify the significance of the trend observed in 4% fat-corrected milk production.

Table 4. Effect of corn and sorghum distillers grains on ruminal pH and volatile fatty acid concentrations.

	Corn distillers grain		Sorghum distillers grains		
Item	Dry	Wet	Dry	Wet	SE
Rumen pH	6.30	6.50	6.55	6.45	0.11
Total VFA, m*M*	96.1	98.7	96.9	96.5	0.9
Acetate (A)	53.9	54.0	54.4	54.7	0.5
Propionate (P)	24.9	24.4	25.2	25.1	0.3
Butyrate	16.3	16.4	15.5	15.4	0.4
Isobutyrate	1.5	1.4	1.2	1.2	0.1
Valerate	1.7	2.0	2.0	1.9	0.1
Isovalerate	1.7	1.8	1.6	1.7	0.1
A:P	2.20	2.23	2.18	2.15	0.04

Table 5. Digestibility of corn and sorghum distillers grains and total tract fiber digestion.

	Corn distillers grain		Sorghum distillers grains		
Item	Dry	Wet	Dry	Wet	SE
In situ NDF digestion of distillers grains					
Lag, h	.6	0	0	0	
Rate, h^{-1}	.059	.041	.042	.062	
Extent, %	87.8	86.4	85.1	81.5	
r^2	.96	.93	.93	.99	
Apparent extent of NDF disappearance[a]	46.1	39.0	38.9	45.2	
Total tract digestion, %					
ADF	62.5	59.7	58.9	57.7	5.7
NDF	64.7	59.2	66.3	62.6	6.9

[a]Calculated using the following equation assuming a fractional passage rate of distillers grains from the rumen of .050 h^{-1}: $e^{-k_pL} \times [k_d/(k_d + k_p)] \times PED$, where k_p = fractional passage rate of distillers grain particles from the rumen, k_d = fractional rate of ruminal NDF digestion, and PED = potential extent of ruminal NDF digestion.

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Longer Particle Length Alfalfa Improves Use of Wet Corn Gluten Feed by Dairy Cows

Dana Allen
Rick Grant[1]

Summary

Twelve early lactation Holstein cows (4 fistulated) were used in replicated 4 × 4 Latin squares with 4-wk periods to determine the effective neutral detergent fiber ***(NDF)*** *content of wet corn gluten feed and to measure the effect of forage particle size on ruminal mat consistency and passage rate of wet corn gluten feed. Diets were 1) 23.3% NDF (17.4 percentage units NDF from alfalfa silage), 2) diet 1 plus 11.1 additional percentage units NDF from alfalfa silage, 3) diet 1 plus 10.7 percentage units NDF from wet corn gluten feed, and 4) 8.6 percentage units NDF from alfalfa silage plus 8.9 percentage units NDF from coarsely chopped alfalfa hay with 10.7 percentage units NDF from wet corn gluten feed. The calculated effective NDF factor for wet corn gluten feed, using change in milk fat concentration per unit change in NDF, was 0.74 compared with an assumed 1.0 for alfalfa silage. Rumination activity was measured to calculate a physically effective NDF factor for wet corn gluten feed which was only 0.11 compared with 1.0 for alfalfa silage. Physically effective NDF also was determined for wet corn gluten feed by wet sieving; 22% of the particles were retained on the 3.35-mm screen or greater. Ruminal mat consistency increased and passage rate of wet corn gluten feed decreased with added hay. The inclusion of chopped alfalfa hay to a diet containing wet corn gluten feed increased ruminal mat consistency, rumination activity, and slowed passage rate resulting in greater ruminal digestion of NDF from wet corn gluten feed. Depending on the response variable, effectiveness of NDF from wet corn gluten feed varied from 0.11 to 0.74.*

Introduction

A coproduct of wet milling of corn, wet corn gluten feed (**WCGF**) is primarily a mixture of corn bran and fermented corn extractives (steep liquor). Although WCGF contains 40 to 45% NDF, it only contains 3% lignin and is a source of highly digestible fiber. As dairy operations increase in size, the ability to use wet coproduct feeds increases. When incorporating nonforage sources of fiber, such as WCGF, into rations for lactating dairy cows, there are at least two major considerations 1) the interaction between forage and nonforage fiber in terms of ruminal passage and digestion, and 2) the effective NDF content of the nonforage source of fiber.

The rumen digesta mat is a highly effective first-stage separator. Through the processes of filtration and mechanical entanglement, the mat selectively retains potentially escapable fiber particles, thereby increasing the time allowed for fermentation. Fine particles with a mean length of less than 1.0 mm were found in high concentrations over 24 h in the dorsal rumen, which also contained the greatest amount of large particles. The consistency of the ruminal mat (hard or soft packed) either promotes or retards particle passage from the reticulorumen. In the only previous study with lactating dairy cows, researchers at Nebraska observed a 16% decrease in fractional passage rate of soybean hulls from the rumen of cows fed coarsely chopped hay to increase ruminal mat consistency of an alfalfa and corn silage blend.

Nonforage sources of fiber do not stimulate rumination activity as effectively as dietary forage due to their small particle size. Therefore, it is important to consider the effective NDF content of these fiber sources. Effective NDF is defined as the fraction of NDF that maintains milk fat synthesis and provides optimal ruminal conditions for maximum fiber fermentation. Physically effective NDF (**peNDF**) specifically reflects the ability of the feed to stimulate chewing and subsequent salivation and ruminal buffering. Effectiveness factors for feeds have been estimated using three approaches 1) change in milk fat concentration, 2) change in rumination activity, and 3) sieving and particle size analysis. Ration formulation requires that accurate effective NDF values be determined for nonforage sources of fiber, but various methods of determining effective NDF have resulted in inconsistent values for the same feed. For example, Wisconsin researchers measured effective NDF of CGF, using milk fat percentage as the response variable, and found that in two separate trials the values differed by 56%.

The objectives of this research were 1) to evaluate the effect of altering forage particle size on ruminal mat consistency, rumination activity, passage rate of WCGF, and milk production, and 2) to determine the effective NDF content of WCGF relative to a high-fiber control diet based on response in milk fat concentration, rumination activity, and particle size distributions.

Procedures

Twelve Holstein dairy cows (8 multiparous including four ruminally fistulated) were used in a replicated 4 × 4 Latin square design with 4-wk periods. Fiber sources compared were alfalfa silage, alfalfa hay, and WCGF. Chemical composition and particle distribution of dietary fiber sources are shown in Table 1. The WCGF was delivered and stored in a plastic silage bag prior to the start of this experiment. There was no visual evidence of molding while feeding the product during the experiment.

Dietary treatments were 1) basal low-fiber alfalfa silage diet (**LF**) formulated to contain 23.3% NDF (17.4 percentage units of NDF from alfalfa silage), 2) high-fiber alfalfa silage diet (**HF**) formulated to contain 31.9% NDF (LF diet plus an additional 11.1 percentage units of NDF from alfalfa silage), 3) WCGF diet formulated to contain 31.6% NDF (LF diet plus 10.7 percentage units of NDF from WCGF), and 4) WCGF diet plus coarsely chopped alfalfa hay formulated to contain 32.0% NDF (8.6 percentage units of NDF from alfalfa silage plus 8.9 percentage units of NDF from alfalfa hay plus 10.7 percentage units of NDF from WCGF). Diets were formulated to be isonitrogenous (18% CP, DM basis). The calculated RUP requirements were met by adding Soy Pass® (a nonenzymatically browned soybean meal containing 70% RUP manufactured by Lignotech USA, Rothschild, WI) to the diet to achieve 5.6 to 6.3% RUP (DM basis, Table 2). With these diets, an increase in milk fat concentration or rumination activity for cows fed the LF versus the HF diet would be attributable to additional NDF from alfalfa silage. Similarly, an increase in milk fat concentration or rumination activity for cows fed the LF versus the WCGF diet would be attributable to additional NDF from WCGF. The effect of increasing dietary forage particle length on ruminal mat consistency and passage kinetics of WCGF would be determined by comparing responses to the WCGF diet with or without added chopped hay.

Experimental periods were 28 d; the last 7 d were used for sample and data collection. Diets were fed once daily in amounts to ensure 10% refusals. Body weight was measured each week immediately after a.m. milking. Daily milk production was recorded electronically for all cows. Composite a.m. and p.m.

Table 1. Chemical composition and particle distribution of alfalfa silage, alfalfa hay, and wet corn gluten feed.

	Fiber source		
Item	Alfalfa silage	Alfalfa hay	WCGF[1]
	(% of DM)		
DM, %	46.3	88.9	62.5
CP	21.2	17.6	23.4
ADF	31.6	34.7	11.7
NDF	43.4	47.3	43.9
NE_L, Mcal/kg	1.52	1.19	1.98
Particle distribution[2]			
% > 9.5 mm	27.0	44.0	1.0
3.35 mm < % < 9.5 mm	22.0	24.0	21.0
1.18 mm < % < 3.35 mm	8.0	15.0	10.0
0.3 mm < % < 1.18 mm	3.0	3.5	8.0
0.053 mm < % < 0.3 mm	3.0	1.0	6.5
% < 0.053 mm	37.0	12.5	53.5
Physically effective NDF[3], %			
> 1.18 mm	57.0	83.0	32.0
> 3.35 mm	49.0	68.0	22.0

[1]Wet corn gluten feed.
[2]Determined by wet sieving.
[3]Physically effective NDF calculated according to Mertens (1997). Neutral detergent fiber content of particles retained on 1.18-mm screen and greater was: alfalfa silage, 53.5%; alfalfa hay, 66.5%; and WCGF, 76.5%.

Table 2. Ingredient and chemical composition of dietary treatments.

	Diet[1]			
Item	LF	HF	WCGF	WCGFH
Ingredient	(% of DM)			
Alfalfa silage	40.0	65.7	39.8	19.9
Alfalfa hay	—	—	—	18.8
WCGF	—	—	24.4	24.4
Ground corn	46.3	29.2	28.6	26.9
Soybean meal	6.5	1.7	2.1	4.8
Soy Pass®[2]	3.7	—	1.7	1.7
Mineral and Vitamin mix[3]	3.5	3.5	3.5	3.5
Composition				
DM, %	66.0	56.3	62.0	70.1
NDF	23.3	31.9	31.6	32.0
Alfalfa silage (% of NDF)	17.4	28.5	17.3	8.6
Alfalfa hay (% of NDF)	—	—	—	8.9
WCGF (% of NDF)	—	—	10.7	10.7
ADF	15.8	22.4	17.3	17.5
CP	18.1	18.0	18.4	18.5
NE_L, Mcal/kg	1.78	1.67	1.78	1.73
Particle distribution[4]	(% of DM retained on screen)			
% > 9.5 mm	10.0	9.8	7.3	11.6
% > 3.35 mm	58.2	52.2	47.4	45.2
% > 1.18 mm	72.3	66.4	60.1	60.3
0.053 mm <% < 1.18 mm	9.8	12.8	14.0	14.1
% < 0.053 mm	17.9	21.1	25.9	25.6

[1]LF = low fiber, HF = high fiber, H = chopped hay, WCGF = wet corn gluten feed.
[2]Nonenzymatically browned soybean meal (Lignotech USA, Rothschild, WI).
[3]Supplement contained 7.9% Ca, 2.6% P, 1.8% Mg, 2.2% Na, 1,026 ppm of Zn, 718 ppm of Mn, 128 ppm of Cu, and 15,358, 3,072, and 94,270 IU per kilogram of Vitamin A, D, and E, respectively.
[4]Determined by wet sieving.

Table 3. Consumption of DM, NDF, and ADF by cows fed experimental diets.

Item	Diet[1]				
	LF	HF	WCGF	WCGFH	SE
DMI					
lb/d	53.2[ab]	49.3[b]	55.2[a]	57.4[a]	2.4
% of BW	4.2[ab]	3.9[b]	4.4[a]	4.5[a]	<0.1
NDF					
lb/d	12.5[c]	15.6[b]	17.6[a]	18.3[a]	0.7
% of BW	0.9[c]	1.2[b]	1.4[a]	1.4[a]	<0.1
ADF					
lb/d	8.4[c]	11.0[a]	9.7[b]	9.9[b]	0.4
% of BW	0.7[c]	0.9[a]	0.8[b]	0.8[b]	<0.1

[a,b,c]Means within row with unlike superscripts differ ($P < 0.10$).
[1]LF = low fiber, HF = high fiber, H = chopped hay, WCGF = wet corn gluten feed.

Table 4. Lactational performance of cows as influenced by experimental diets.

Item	Diet[1]				
	LF	HF	WCGF	WCGFH	SE
Milk, lb/d	68.6	64.8	72.1	74.3	4.1
Fat					
%	2.90[b]	3.25[a]	3.15[ab]	3.14[ab]	0.11
lb/d	2.00	2.13	2.16	2.33	0.18
Protein					
%	2.97[ab]	2.85[b]	2.95[ab]	3.00[a]	0.06
lb/d	2.00[ab]	1.84[b]	2.11[ab]	2.22[a]	0.13
Lactose					
%	4.87	4.86	4.89	4.88	0.07
lb/d	3.34	3.15	3.52	3.63	0.22
4% FCM, lb/d	57.2	57.6	61.4	64.8	4.1
4% FCM/DMI, lb/lb	1.07	1.17	1.11	1.13	0.06
BW, lb	1285	1261	1254	1255	13.2

[a,b]Means within a row with unlike superscripts differ ($P < 0.10$).
[1]LF = low fiber, HF = high fiber, H = chopped hay, WCGF = wet corn gluten feed.

milk samples were collected twice during wk 4 of each period and analyzed for percentage of milk fat, protein and lactose.

Forage, concentrate, and TMR samples were composited daily during the last 7 d of each collection period for chemical analysis. Particle size was determined on masticate, ruminal digesta, and fecal samples collected at approximately 4 h postfeeding on the last day of each period using wet sieving. Particle size distributions were also determined for composite TMR, forage and WCGF samples during each period. Additionally, rumens were emptied, and digesta was weighed and sampled for DM and NDF analyses to determine ruminal fill.

Total chewing, eating, and ruminating times were determined during the last wk of each collection period. Ruminal fluid samples were collected via ruminal fistula immediately beneath the ruminal mat at 4-h intervals for 24 h during the last d of each period. Ruminal pH was determined immediately using a portable pH meter. Fractional passage rate of WCGF fiber from the rumen was determined using Er as a rare earth marker. To determine fractional rate of ruminal NDF digestion of WCGF, 5-g samples of dried, unground WCGF were measured into dacron bags using the in situ bag technique.

The effect of increasing dietary particle size on ruminal mat consistency was determined using a technique adapted from Welch (1982) as described by Weidner and Grant (1992). Ruminal mat consistency was measured at 3 h postfeeding. A 454-g weight was placed in the ventral rumen 1 h prior to measurement to ensure normal mat reformation. Upon release of an exterior 1500-g weight, ascension of the 454-g weight through the ruminal contents was recorded every 10 s for 120 s. The ascension rate, in centimeters per second, was considered to be an indication of ruminal mat consistency.

Results

Cows fed the WCGF diets consumed the greatest amount of DM (Table 3). This higher DMI likely reflected the smaller particle size of the WCGF diets and the faster rate of passage for WCGF versus alfalfa silage. Averaged over all diets, NDF intake was 1.23% of BW, which is typical of cows in this stage of lactation.

Milk yield was numerically increased by 6.4% versus the LF diet for cows fed diets containing WCGF (Table 4). Cows fed the HF diet produced the least amount of milk. Production of 4% FCM was numerically greater for the WCGF diet with added chopped hay compared with other treatments. Efficiency of milk production, calculated as FCM/DMI, was highest for cows fed the HF diet (1.17) and lowest for cows fed the LF diet (1.07); however, no significance among treatments was detected.

Milk fat concentration was significantly less for cows fed the LF diet compared with cows fed the HF diet. This response can be attributed to inadequate amount and physical form of NDF needed for acetate production and maintenance of milk fat synthesis for cows fed the LF diet. The increase in milk fat percentage for cows fed the HF diet can be attributed to additional alfalfa silage and to additional NDF from WCGF in the WCGF plus hay diet. The change in milk fat concentration was used to calculate an effective NDF factor for WCGF. Milk protein concentration was different among treatments (Table 4). Cows fed the WCGF diet with added hay produced significantly greater milk protein than cows fed the HF diet, although the difference was small at 0.15 percentage units.

Dairy cattle require fiber of adequate particle size to maintain a healthy ruminal environment. Recently, rumination activity has been used as an estimate of the physical effectiveness of fiber sources

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at stimulating salivary secretion and ruminal buffering. Table 5 summarizes chewing activity as influenced by dietary treatment. Cows fed the HF diet spent significantly more time eating and ruminating per day compared with the LF diet. Addition of chopped alfalfa hay to the WCGF diet resulted in rumination activity similar to the HF diet (475 and 504 min/d, respectively). By increasing dietary particle size with replacement of 47% of the alfalfa silage with alfalfa hay, chewing activity was increased for the WCGF diet with hay versus the same diet without hay.

Table 5. Chewing activity as influenced by diet.

	Diet[1]				
Activity	LF	HF	WCGF	WCGFH	SE
Eating					
min/d	190[b]	237[a]	175[b]	192[b]	17
Ruminating					
min/d	339[b]	504[a]	356[b]	475[a]	23
Total chewing					
min/d	529[c]	740[a]	531[c]	667[b]	23

[a,b,c,d]Means within a row with unlike superscripts differ (*P* < 0.10).
[1]LF = low fiber, HF = high fiber, H = chopped hay, WCGF = wet corn gluten feed.

Table 6. Ruminal pH and VFA as influenced by diet.

	Diet[1]				
Item	LF	HF	WCGF	WCGFH	SE
pH	5.95[b]	6.36[a]	6.00[b]	6.14[b]	0.08
Total VFA, m*M*/L	104.5	102.7	103.8	104.5	0.9
VFA, mol/100 mol					
Acetate (A)	57.2	56.0	57.0	56.9	0.6
Propionate (P)	25.9	25.4	25.6	25.7	0.3
n-Butyrate	16.8	16.9	16.8	17.1	0.4
Isobutyrate	1.3	1.2	1.3	1.2	0.1
n-Valerate	1.8	1.7	1.6	1.9	0.2
Isovalerate	1.6	1.6	1.6	1.7	<0.1
A:P	2.2	2.0	2.2	2.2	<0.1

[a,b]Means within a row with unlike superscripts differ (*P* < 0.10).
[1]LF = low fiber, HF = high fiber, H = chopped hay, WCGF = wet corn gluten feed.

Table 7. Ruminal mat consistency as influenced by dietary treatment.

	Diet[1]				
Item	LF	HF	WCGF	WCGFH	SE
Distance traveled, cm					
10 s	8.3[a]	3.0[b]	7.3[a]	4.0[b]	1.2
120 s	34.0[a]	17.0[c]	31.4[a]	23.4[b]	1.4
Ascension rate, cm/sec					
10 s	0.80[a]	0.30[c]	0.70[ab]	0.40[bc]	0.10
120 s	0.28[a]	0.14[c]	0.26[a]	0.19[b]	<0.10

[a,b]Means within a row with unlike superscripts differ (*P* < 0.10).
[1]LF = low fiber, HF = high fiber, H = chopped hay, WCGF = wet corn gluten feed.

Ruminal pH was greatest for the HF diet (6.36; Table 6). Because rumination activity stimulates salivary secretion of bicarbonate and phosphate buffers, ruminal pH would be expected to be higher for diets that stimulate greater rumination. Ruminal pH was numerically higher for the WCGF plus hay diet versus the WCGF diet. Furthermore, the pH values for the LF, HF, and WCGF diets resulted in a calculated effectiveness factor for NDF from WCGF of approximately 13%. Michigan State researchers have suggested the use of ruminal pH as an accurate estimate of the physical and chemical characteristics of fiber from nonforage sources of fiber. Ruminal VFA concentrations were determined for each dietary treatment (Table 6). Increased dietary NDF for the HF and WCGF diets did not result in greater acetate to propionate ratios, which averaged 2.15 for all diets.

Specific gravity and particle size account for 88% of the variation in particle passage from the rumen. Nonforage sources of fiber often have both a high specific gravity and small particle size, resulting in decreased ruminal retention time and lowered NDF digestibility. Therefore, addition of alfalfa hay to the WCGF diet allowed a comparison of the effects of increasing dietary particle length on ruminal mat consistency, particle retention time, and ruminal NDF digestibility. At 3 h postfeeding, the WCGF diet with chopped hay had a significantly slower rate of ascension (centimeters per second) than the WCGF diet (Table 7), reflecting a more consistent, hard-packed ruminal mat. The total distance traveled in 120 s was also greater for the WCGF diet compared with the WCGF diet plus hay. Adding alfalfa hay decreased ascension rate similar to the HF diet, whereas the WCGF diet was similar to the LF diet (0.26 versus 0.28, cm/s, respectively).

Table 8 contains the rate of passage and in situ digestion data for the diets. The HF diet resulted in the greatest amount of ruminal NDF and the LF diet resulted in the least amount of NDF. We observed that passage of WCGF from the rumen was significantly decreased for the WCGF diet plus hay compared with the WCGF diet (0.042 versus 0.068/h, respectively). Apparent extent of ruminal NDF digestion was calculated and combines both NDF digestion and passage. By decreasing ruminal rate of passage, addition of alfalfa hay resulted in an increased extent of digestion for the WCGF diet versus the WCGF diet without added hay (47.4 versus 32.4%, respectively).

Three methods have been used to determine effective NDF 1) change in

Table 8. Ruminal content characteristics, passage rate of WCGF fiber, and in situ NDF digestion kinetics of WCGF.

	Diet[1]				
Item	LF	HF	WCGF	WCGFH	SE
Rumen contents					
Wet weight, lb	403.3	414.3	375.0	405.7	19.6
Dry matter, %	18.5	19.5	20.0	20.5	
Dry weight, lb	74.4	80.7	74.8	83.2	3.9
NDF, %	60.0	65.0	67.5	65.0	0.3
NDF, lb	44.7[c]	54.3[a]	49.3[bc]	53.5[ab]	1.7
Rate of passage, %/h	5.20[ab]	4.20[b]	6.40[a]	4.20[b]	0.60
Digestion kinetics					
Lag, h	5.80	4.20	5.40	3.50	1.14
k_d, %/h	5.40[ab]	6.70[a]	6.40[ab]	5.10[b]	0.50
PED[2], %	92.8	92.8	92.9	92.7	0.6
AED[3], %	32.6[b]	47.4[a]	32.4[b]	44.8[a]	2.3

[a,b,c]Means within a row with unlike superscripts differ (*P* < 0.10).
[1]LF = low fiber, HF = high fiber, H = chopped hay, WCGF = wet corn gluten feed.
[2]Potential extent of ruminal fiber digestion calculated using equations in Grant (1994).
[3]Apparent extent of ruminal fiber digestion calculated using equations in Grant (1994).

Table 9. Calculation of effective NDF and physically effective NDF based on change in milk fat concentration and rumination activity as influenced by dietary treatment.

	Fiber source	
Item	Alfalfa silage	WCGF[1]
Milk fat[2]		
Increase in milk fat %, a	0.35	0.25
Added NDF %, b	11.00	10.70
Slope, a/b	0.03	0.02
eNDF factor[3]	1.00	0.74
Chemical NDF, %	43.40	43.90
Effective NDF, %	43.40	32.90
Rumination activity[4]		
peNDF factor	1.00	0.11
Physically effective NDF, %	43.40	4.80
Ruminal pH[5]		
eNDF factor	1.00	0.13
Effective NDF, %	43.40	5.71

[1]WCGF = wet corn gluten feed.
[2]Based on data in Table 4.
[3]Effectiveness of alfalfa assumed to be 1.0.
[4]Based on data in Table 5.
[5]Based on data in Table 6.

milk fat concentration, 2) change in rumination activity, and 3) evaluation of particle size distributions. Because milk fat is dependant on fiber digestion and production of fermentation acids in the rumen, it is thought to be the most complete measure of effective NDF. In our study, an effective NDF value based on change in milk fat concentration was calculated using the slope-ratio technique as shown in Table 8. Milk fat increased in HF and WCGF diets compared with the LF diet to yield an effective NDF factor of 0.74 for WCGF if alfalfa silage is assumed to be 1.0. Therefore, WCGF contained 32.9% effective NDF based on change in milk fat percentage. Using the same technique to calculate peNDF based on change in rumination activity, the peNDF factor for WCGF was 0.11 compared with an assumed value of 1.0 for alfalfa silage. An effective NDF factor based on change in ruminal pH (Table 6) of 0.13 was similar to the peNDF value for rumination activity. The large range in values may reflect the chemical and physical attributes of WCGF as a highly digestible fiber which is capable of diluting dietary NFC and slowing rate of fermentation acids production, yet is only 11% as effective as alfalfa silage at maintaining rumination activity due to its small particle size.

Mertens (1997) proposed using the laboratory technique of particle sieving. In our study, particle distributions were determined for each fiber source. Particles retained on the 1.18-mm screen and greater were 57, 83, and 32% for alfalfa silage, alfalfa hay and WCGF, respectively. These larger particles require rumination and reduction in size for passage from the reticulorumen to occur. Particles retained on the 3.35-mm screen and greater are more applicable to larger ruminants. Therefore, the peNDF factor for WCGF would be 0.22 compared with alfalfa silage at 0.49. This suggests that the alfalfa silage used in our experiment was not 100% effective, emphasizing the need to standardize effective NDF values based on one fiber source.

Interactions between forage and nonforage sources of fiber are not clearly understood. Coarsely chopped hay decreased passage rate of WCGF, increased rumination activity, and increased ruminal extent of NDF digestion compared with the WCGF diet without hay. Effective NDF values can vary substantially, depending on the response variable chosen to calculate the effectiveness factor. To be conservative, a smaller peNDF value should be used to avoid a situation in which ruminal acidosis could occur. More research is needed to confirm if in fact some nonforage sources of fiber, such as WCGF, have effectiveness factors greater than 50%. Quantitating the impact of dietary forage on utilization of nonforage sources of fiber will allow us to define accurately the peNDF requirement of lactating dairy cows.

[1]Dana Allen, former Graduate Student; Rick Grant, Associate Professor and Extension Dairy Specialist, Animal Science, Lincoln.

Genetics Research

Jeffrey F. Keown[1]

Summary

Often, producers ask what type of research is being conducted in the genetics area. This is a legitimate question, so I am listing in abstract form six areas that my students have researched this past year. The next six articles are written in a more formal mode, but I think you will have an understanding of the scope of the research involved. In the dairy genetics area are students from the United States, Saudi Arabia, India, South Korea, Japan, Mexico and Brazil. Most of our research is conducted using producers' records from the Dairy Records Processing Center in Raleigh, North Carolina.

New Age-month Correction Factors for Milk Production of Holstein Cattle in Mexico

M. Valencia-Posadas[1]

Correction factors (CF) for milk production used nationally in Mexico were estimated 23 years ago using a sire model with few records and assuming a value of heritability. Since those CF were adopted, many changes of management practices have occurred. New CF are needed to reduce possible biases in genetic evaluations. The objectives of this study were to estimate age-month CF for milk production by region and to compare currently used CF and those obtained in this study. Records were provided from the Mexican Holstein Association. Only 305d milk yields were considered. Records were classified by three regions. Numbers of records, including all lactations, were 12,062, 42,059, and 17,990 for the North (N), Central (C) and South (S) regions, respectively. The base group included cows calving in January between 70-73 months of age. Variance components and age-month solutions were obtained by REML using an animal model. Averages of milk production and heritability estimates were 8,446, 7,841, and 7,176 kg and 0.26, 0.24, and 0.18 for N, C, and S regions, respectively. Deviations of solutions from base groups were smoothed through polynomial regression and then used to obtain the CF. Differences (DIF) between new CF for each region and current national CF were obtained. Analysis of variance was used to test equality between them. Correlations between CF also were estimated. Correlations between current CF and the new CF by region were only 0.89 to 0.92. The new CF was different because group of age and month effects were significant for DIF. The new CF could be less biased than current CF because an animal model was used with the most recent records and with specific CF for each region.

Heterogeneity of Variance and Interaction of Genotype by Environment for Milk Production in Holstein Cattle in Mexico

M. Valencia-Posadas[1]

For the establishment of selection programs for dairy cattle in Mexico it is important to determine if heterogeneity of variance exists for milk production and to investigate genotype x environment interaction (GxE) among regions. The objectives of this study were 1) to estimate variance components (VC) by region and periods of time, 2) to estimate VC after classifying herd-years by standard deviation level (SDL), and 3) to investigate GxE between regions. Records were provided from the Mexican Holstein Association. Only mature equivalent 305d milk yields were considered. Records were classified by three regions (North, Central, and South), three periods of time (1973-1983, 1984-1990, and 1991-1997) and herd-years divided in three SDL (high, medium, and low). Separate analyses were made for first and all lactations. The VC were obtained by REML using an animal model. To study GxE, genetic correlations (rg) were obtained through daughters of sires distributed among regions. The likelihood ratio test was used to test if rg between two regions was different from one. Evidence for heterogeneity of variance, principally additive genetic variance, was found among regions and periods of time with analyses of first and all lactations. Heritability estimates were 0.18 to 0.31 for all lactations and 0.21 to 0.31 for first lactations. Even though genetic and phenotypic variances were different for records classified by SDL, heritabilities were similar (0.23, 0.21, and 0.24, for high, medium, and low SDL, respectively). The rg between the North and South regions was statistically different from one (0.38), indicating the presence of GxE. Important differences in ranking of sires by regions were found in all analyses.

Genetic Parameters for Longevity Traits for Holstein Cattle in Mexico

M. Valencia-Posadas[1]

The Mexican Holstein Association (MHA) has not until now utilized records to estimate genetic parameters or EBV for longevity traits. Different variables and methods of analyses have been used to study longevity and to estimate genetic parameters in dairy cattle. The objective of this study was to estimate heritabilities (h2) and genetic correlations (rg) between lifetime and stayability traits and milk production of first lactation. Records of Holstein cattle were provided from MHA. Only mature equivalent 305d milk yields were considered. Most recent year of birth was 1988. Cows were assumed to have been culled or died after last recorded lactation. Total number of cows was 46,026. Lifetime traits were: number of lactations initiated (NLI), total milk production over all lactations (TMP), and length of productive life (LPL). Stayability traits were: stayability to 36, 48, 60, and 72 months of age (S36, S48, S60, and S72, respectively). Milk production for first lactation (MP1) was used to obtain rg with lifetime and stayability traits. Variance components were estimated utilizing REML for animal models. Averages for NLI, TMP, LPL, and MP1 were 2.63, 18,530 kg, 1,812 days, and 6913 kg, respectively. Percentage of live cows at 36, 48, 60, and 72 months of age was 95, 66, 42, and 25%, respectively. Heritability estimates for lifetime traits were 0.11 to 0.14, for MP1 was 0.30 and for stayability traits were 0.05 to 0.09. All rg between lifetime and S48, S60, and S72 were greater than 0.85. The NLI, TMP, and LPL are essentially the same trait because estimates of rg between them were about 0.94. The MP1 and S48 can be used as early indicators of longevity (i.e., for TMP and LPL) because of high estimates of rg. The traits analyzed in this study could be used in selection programs for Holstein cattle in Mexico.

Variance Due to Cytoplasmic Line and Sire by Herd Interaction Effects for Milk Yield Considering REML Bias

P. R. N. Rorato[1]

A total of 138,869 lactation milk yields (305 d, 2x, ME) from first three parities of 68,063 New York Holstein cows were used to estimate variance components due to additive direct genetic, cow permanent environmental (cow within sire for sire model), sire by herd interaction, and cytoplasmic line effects. The original data (OD) were assigned to ten random samples which were each analyzed using an animal model (AM) and a sire model (SM). From each sample of OD, twenty other samples with levels assigned randomly to cytoplasmic and interaction effects (data with randomly simulated levels - SL) were analyzed, of which ten were analyzed with an AM and ten with a SM. The models also included fixed effects of herd-year-seasons. Average fractions of phenotypic variance and average standard errors were respectively for AM and SM: for additive direct genetic effects, .300 (.029) and .228 (.040) for (OD) and .325 (.025) and .262 (.039) for (SL); for cow permanent environmental effects, .242 (.024) and .444 (.014) for (OD) and .235 (.025) and .492 (.016) for (SL); for sire by herd interaction effects, .015 (.008) and .018 (.007) for (OD) and .003 (.007) and .004 (.009) for (SL); and for cytoplasmic line effects, .011 (.007) and .043 (.008) for (OD) and .003 (.006) and .003 (.007) for (SL). The differences between estimates of variance components for OD and SL suggest that estimates of fractions of total variance due to sire by herd interaction and cytoplasmic effects estimated with REML may be biased upward by .003 to .004.

Parameter Estimates for Direct and Maternal Genetic Effects for Yearling, Eighteen-month, and Slaughter Weights of Korean Native Cattle

Ji-Woong Lee[1]

Data collected by the National Livestock Research Institute in Rural Development Administration of Korea were used to estimate genetic parameters for yearling weight (YWT, n=5,848), 18 month weight (WT18, n=4,585), and slaughter weight at about 22 months (SWT, n=2,279) for Korean Native Cattle. Nine animal models were used to obtain REML estimates of genetic parameters. Model 1 (DP-2) included direct genetic, maternal, and residual environmental random effects. Model 2 (DQ-2) included direct genetic, sirexregionxyear-season (SRYS) interaction, and residual environmental random effects. Model 3 (DPQ-2) was based on Model 2 (DQ-2) but included both the interaction and maternal effects. Model 4 (DMP-2) was based on Model 1 (DP-2) but the maternal effect was partitioned to include maternal genetic and permanent environmental effects. Model 5 (DMPQ-2) was based on Model 3 (DPQ-2) and included maternal genetic and permanent environmental as well as the sire interaction effects. Those five models included two fixed factors: regionxyear-season and age of damxsex effects. Models 6 (DP-3), 7 (DQ-3), 8 (DPQ-3) and 9 (DMPQ-3) were based on Models 1, 2, 3, and 5, respectively but included as a third fixed factor whether or not identification of the sire was known. A single-trait animal model was initially used to obtain starting values for multiple-trait analyses. Estimates of heritability with Model 9 (DMPQ-3) for YWT, with Model 6 (DP-3) for WT18, and with Model 8 (DPQ-3) for SWT when analyzed with single-trait analyses were .14, .11, and .17, respectively and nearly the same with bivariate analyses. Estimate of maternal heritability for YWT from single trait analysis was .04 with estimates for the other traits near zero but for bivariate analyses the estimate for YWT was .01. With single trait analysis, estimate of the direct-maternal genetic correlation for YWT was strongly negative (-.81). Estimates of direct genetic correlations between YWT and WT18, YWT and SWT, and WT18 and SWT were large: .99, 1.00, and .97, respectively. Estimates of environmental correlations varied from .60 to .81; the largest was between WT18 and SWT. Inclusion of a fixed factor for whether sire identification was missing or not missing in the model reduced estimate of direct heritability for slaughter weight. These results suggest that SRYS interaction is important for yearling weight and may be needed in a model for slaughter weight and that maternal effects may be of slight importance for yearling weight but of no importance for WT18 and SWT. Models for national cattle evaluations for Korean Native Cattle for YWT should be considered that include maternal genetic and permanent environmental as well as SRYS interaction effects, but those effects don't seem to be needed for models for WT18 and SWT.

(Continued on next page)

Use of Records of Bovine Somatotropin Treated Cows in Genetic Evaluation

Shogo Tsuruta[1]

Records from the North Carolina State Dairy Records Processing Center were used to estimate effects of bovine somatotropin (bST) treatment and (co)variance components and to predict breeding values on milk production traits. The data comprised 5,245 test-day (TD) records of bST treated cows and 126,223 TD records of untreated cows in first lactation for milk, fat, and protein yields. Fixed effects of bST by days in milk (DIM) interaction and (co)variance components of random effects (animal, permanent environment, random regressions, and residual) were estimated from TD animal models with herd-year (HY) effects on herd-test-date (HTD) effects using the REMLF90 program. To assess the potential for bias in genetic evaluations when some and not all cows are treated with bST, breeding values predicted by the animal models with and without effects of bST treatment were compared for cows and sires. Random regressions for additive genetic and permanent environmental effects were included in the models. In the model with HY effects, responses to bST treatment for milk yield increased with DIM, suggesting interaction between effects of bST and DIM. However, in the model with HTD effects, the interaction between effects of bST and DIM was small. Percentages of increase due to bST treatment were ranging from 5 to 8% for TD milk, fat, and protein yields. Correlations between breeding values predicted from the models with and without effects of bST treatment were greater than .99. These results suggest that bias in genetic evaluation due to ignoring bST treatment may be small or that responses to bST and breeding values may be highly correlated.

[1]Jeffrey F. Keown, Professor and Extension Dairy Specialist, Lincoln; M. Valencia-Posadas, former graduate student; P. R. N. Rorato, former graduate student; Ji-Woong Lee, Post-doctoral; Shogo Tsuruta, former graduate student.

Dairy Technician Certification

Jeffrey F. Keown[1]

Summary

This article gives an overall outline of the Dairy Certification Program that the University of Nebraska-Lincoln Dairy Extension staff has started with the Beatrice Campus of Southeast Community College. It is hoped that through this one-year program of class study and an internship, students will be prepared to assume mid-level management positions in Midwest dairy operations.

Purpose

The purpose of the Dairy Technician Certification is to train individuals to work on the large number of expanding dairy farms in Nebraska. We anticipate a need for 300 to 400 new dairy employees over the next five years to fill new positions in the expanding dairy industry.

Administration

The program will be jointly administered by Southeast Community College-Beatrice (SCC) and the Cooperative Extension Service of the University of Nebraska-Lincoln (UNL). A group of ten individuals consisting of dairy producers and dairy industry representatives has been formed to supervise and work with the Dairy Certification. This group will help assure that the graduates of the certification program are trained to become mid-level management personnel.

Responsibilities of Cooperating Groups

Southeast Community College-Beatrice Campus will offer its students courses that will give them the basic scientific background to work on more specialized modules which will be prepared by the Cooperative Extension Service at the University of Nebraska-Lincoln. The Cooperative Extension Service will also arrange for a two-month internship for students to gain hands-on dairy experience. UNL will also work with SCC to add dairy emphasis to existing course offerings.

Basic Courses Offered by SCC-Beatrice Campus

The following courses are an essential component of Dairy Technician Certification.

Course #	Course Title	Credit Hours
AGR 131	Crop and Food Science	4
AGR 141	Livestock Management and Selection	4
AGR 171	Ag Spreadsheets	2
AGR 205	Farm Records	3
AGR 221	Nutrition	4
AGR 223	Feeds	2
AGR 231	Animal Breeding	5
AGR 241	Range & Forage Management	4
AGR 245	Animal Health	4
AGR 281	Agribusiness Coop Internship	7
AGR 285	Seminar II	2
	Total Credits	**41**

Upon completion of the 41 credits listed under the Basic Courses offered by SCC-Beatrice Campus, the student will participate in a two-month intern program. The program will be administered by University of Nebraska Extension and will involve working on a dairy farm to learn the basic operations of a dairy farm.

Dairy Modules

The dairy portion of the courses listed will be offered via computer modules from UNL. These four modules will cover the areas of Dairy Rations, Dairy Genetics and Sire Evaluation, Forage Quality, and Dairy Herd Health. These modules will be incorporated into the various courses listed under Basic Courses.

Specific hands-on modules not offered via the computer:

P.C. Dart — dairy record keeping

Milkers School — learn how to properly milk cows and maintain equipment

You may access the various dairy modules on the Internet at

http://deal.unl.edu/dairy/

Please feel free to send your comments to me at:

ANSC407@UNLVM.UNL.EDU

This program began Fall 1999 with SCC. If you have any questions, please give me a call at (402) 472-6453.

[1]Jeffrey F. Keown, Professor and Extension Dairy Specialist, Lincoln.

Land Requirements for Managing Manure Nutrients On Dairy Operations

Rick Koelsch[1]

Summary

Manure nutrient excretion by cattle and the resulting land requirements for managing those nutrients are affected by feed bunk decisions. Increasing a ration's crude protein level from 17.1 to 19.5% may increase the land requirements of a 100-cow dairy by 25 acres. Increasing phosphorus levels from 0.43 to 0.52% may increase land requirements for a 100-cow dairy by more than 50 acres. This article will summarize the impact of feeding program options on land requirements and introduce tools for evaluating these issues for individual farms.

Introduction

Is sufficient land available for managing the nutrients in manure? This question is being asked by the Nebraska Department of Environmental Quality (NDEQ) as it reviews permit applications for livestock facilities. Any producer with livestock in confined facilities should also consider this issue. This question is fundamental to sound environmental management of manure.

Current NDEQ permit procedures for livestock facilities require producers to document the land base available for manure application. If the owned or managed application ground is inadequate for agronomic application of manure based upon **nitrogen** (N), the producer must identify sufficient land through signed agreements with neighboring crop producers.

Phosphorus (P) based management of manure requires significantly greater land base than N-based management. Currently, land requirements are not regulated based upon P. NDEQ requires that a producer submit soil tests for soil P levels, minimum of one composite per 40 acres. For fields where soil P levels exceed "agronomic levels", a management plan for minimizing runoff from these sites may be required. No upper limits for soil P level have been established to deny future manure application on a site. However, growing pressure exists for greater regulation of phosphorus buildup in soil.

Many factors affect manure nutrient excretion and eventual land base for agronomic nutrient application. Decisions at the feedbunk will play a critical role. The purpose of this article is to examine the impact of feed bunk decisions on land needs for manure application.

Feeding for High Milk Production Levels

As milk production potential of dairy cattle has increased, so has the nutrient requirements of those cattle and the nutrients they excrete (Table 1). Historically, a rule of thumb of one acre per cow has been used to define manure application site requirements for dairy cattle.

With higher milk production levels, such rules of thumb are inadequate for manure handling systems designed to conserve nutrients (manure storage and immediate incorporation of manure). For herds producing between 70 and 100 pounds of milk per cow per day, a 100-cow herd will require between 140

Table 1. Change in land application area needs with change in milk production level.[1]

Milk Production (lbs./day)	Manure Nurtient Excretion (lbs. of nutrient/yr.)		Available Nutrients after Losses (lbs. of nutrient/yr.)		Land Requirements if Manure is Applied at an:	
	N	P_2O_5	N	P_2O_5	N Rate	P Rate
System That Conserves Nutrients (manure storage and incorporation during application) [2]						
100	34,800	14,200	28,100	14,200	170	240
70	28,900	13,000	23,400	13,000	140	220
50	24,300	11,900	19,600	11,900	120	200
Nutrient Disposal System (anaerobic lagoon and pivot irrigation) [3]						
100	34,800	14,200	6,500	5,000	41	84
70	28,900	13,000	5,400	4,500	32	76
50	24,300	11,900	4,600	4,200	28	70

[1]Assumptions:
- Feed nutrient concentrations based upon NRC recommendations. Crude protein levels of 17.5, 16.4, 15.3, and 12.0% were assumed for cows producing 100, 70, 50, and dry cows respectively. Phosphorus concentration of 0.5% was assumed for all groups. It was assumed that
- 100-cow herd included 83 lactating cows and 17 dry cows.
- Nutrient use in crop production assumed a six-year rotation of corn (170 bushels/acre), corn silage (22 tons acre), and alfalfa (5 ton/acre).

[2]Assumes 80% of the nitrogen and 100% of the phosphorus is conserved.

[3]Assumes 20% of the nitrogen and 35% of the phosphorus is conserved in the wastewater to be pumped annually. The remaining P will accumulate in sludge and require an additional 400 and 500 acres if removed every 10 years and applied at three times agonomic phosphorus rates.

and 170 acres to manage the nitrogen in manure, depending on crop rotation and yield. To manage the nitrogen in manure and satisfy NDEQ, one should plan on at least 1.5 acres per cow. With a greater focus on environmental problems associated with excess soil phosphorus levels, access to at least 2.25 acres per cow may be necessary.

A smaller land base is required to manage the nutrients in a system designed to "dispose" of nutrients (anaerobic lagoon and land application with center pivot (see Table 1). A significant portion of the nitrogen volatilizes into the air while P settles with solids and accumulates in the bottom of the lagoon. Between 0.3 and 0.8 acres per cow would be required for this type of manure management system, depending upon the milk production level and choice of N- vs. P-based manure management.

Recognize that the "lost" phosphorus continues to accumulate in the lagoon. At the time that this sludge must be removed, a very large land base may be required to avoid excessive application of phosphorus in the sludge.

Systems that "dispose" of nutrients are under increasing scrutiny. The volatilized ammonia eventually returns to earth, often adding to nitrogen loading of surface waters. Lagoons also experience greater total seepage — due primarily to their larger size — than manure storage. These factors contribute to surface water problems, especially in coastal areas, and can create greater risk to ground water. The state of North Carolina has banned the construction of anaerobic lagoons. It is important to recognize the uncertain future for anaerobic lagoons.

Impact of Feed Nutrient Concentrations

Protein not utilized for milk production or animal maintenance/growth needs will be excreted as urea or organic nitrogen in the manure. Typically, 70% of the nitrogen fed to animals as protein will be excreted in a diet balanced according to National Research Council guidelines. Feeding protein in excess of these levels adds to the nitrogen in the manure.

Two dairy rations with different protein levels are illustrated in Table 2. The high alfalfa diet (19.5% crude protein) results in about 20% more nitrogen in the manure as compared to a diet with supplemental by-pass protein (17.1% crude protein). Twenty percent more land is needed for manure management for the higher protein diet. For a 100-cow herd, an additional 6 to 25 acres is needed for managing the nitrogen in manure for the two systems detailed in Table 2.

Commonly observed ranges for phosphorus levels in dairy rations can have an even greater impact on land requirements. A ration containing 0.52%

(Continued on next page)

Table 2. Changes in land application area needs for 100-cow dairy as a result of difference in diet protein level.

Crude Protein Dietary Options	Manure N Excretion (lbs. N/yr.)	Available N after Losses (lbs. N/yr.)	Land Requirement for Managing N
System That Conserves Nutrients (Manure Storage and Incorporation During Application) [1]			
High Alfalfa Diet/No Added Escape Protein (19.5% CP)	35,400	28,600	162
Diet Supplemented with Escape Protein (17.1% CP)	30,000	24,200	137
Nutrient Disposal System (anaerobic lagoon and pivot irrigation) [1]			
High Alfalfa Diet/No Added Escape Protein (19.5% CP)	35,400	6,600	39
Diet Supplemented with Escape Protein (17.1% CP)	29,900	5,600	33

[1]See Assumptions used for Table 1 except for crude protein levels.

phosphorus will result in 30% more land needed for managing manure phosphorus than a 0.43% dietary phosphorus level (Table 3). Both phosphorus levels should meet the needs of a dairy cow producing 75 pounds of milk per day. For a 100-cow herd with a manure management system designed to conserve nutrients, an additional 50 or more acres is needed for managing the extra phosphorus.

Table 3. Changes in land application area needs as a result of differences in diet P level.

Phosphorus Dietary Options	manure P Excretion (lb. P_2O_5/yr.)	Available P after Losses (lb. P_2O_5/yr.)	Land Requirement for Managing P
System That Conserves Nutrients (Manure Storage and Incorporation During Application) [1]			
Nebraska Industry Average (0.52% P)	13,400	13,400	225
UNL Recommendation (0.43% P)	10,200	10,200	171
Nutrient Disposal System (anaerobic lagoon and pivot irrigation) [1]			
Nebraska Industry Average (0.52% P)	13,400	4,700	79[2]
UNL Recommendation (0.43% P)	10,200	3,600	60[2]

[1]See Assumptions used for Table 1 except for crude protein levels.
[2]Additional land will be needed for managing the phosphorus accumulating in the sludge. That land requirement is approximated in Table 1 footnote.

Estimating Land Requirements

The previous estimates of land application area needs may vary for individual farms for a variety of reasons. To develop a better understanding of land needs for an individual situation, a "Manure Nutrient Inventory" spreadsheet has been developed to assist Nebraska livestock producers. The spreadsheet can be accessed from a home computer with Microsoft Excel (version 5.0 or later) and Internet access. The spreadsheet and a set of instructions are available at: **http://www.ianr.unl.edu/manure/**

Many Cooperative Extension and NRCS offices also have access to this tool and would likely be able to assist in reviewing an individual situation.

The purpose of the Manure Nutrient Inventory Spreadsheet is to estimate the excretion of nutrients by livestock and poultry, the quantity of nutrients remaining after losses, and the land needs for utilizing those nutrients at agronomic rates (see Table 4 for sample printout). A producer can evaluate the impact of the following inputs on the required land base:

- Herd size,
- Feeding program,
- Method of storage and/or treatment of manure,
- Method of land application, and
- Crop selection, rotation, and yield.

The nutrient balance component of the spreadsheet is a unique approach to estimating manure nutrient excretion. Typically, book value estimates are used for manure nutrient production. The weakness of this approach is that it assumes all dairy cows are fed the same ration and perform the same. The nutrient balance approach requires information on the feeding program (feed consumption and feed protein, phosphorus, and potassium concentration) and animal products produced (milk production for lactating cows and weight gain for heifers). Manure nutrient excretion is assumed to be the difference between feed nutrient consumption and nutrients retained in animal products (Figure 1). Either book value or nutrient balance methods can be used in the spreadsheet.

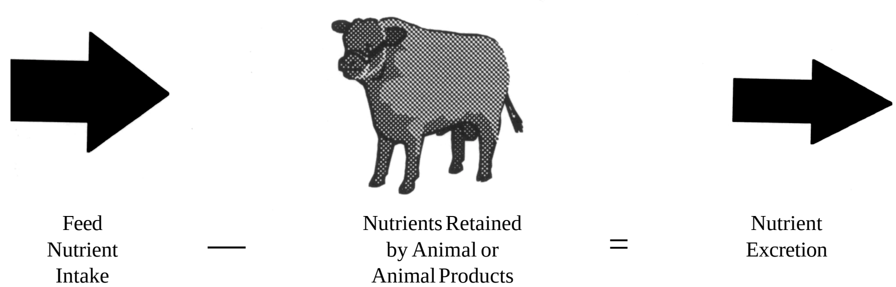

Figure 1.

Conclusions

Nutrients in manure represent a critical environmental threat if managed improperly. Dairy producers should have access to at least 1.5 acres of land per cow to manage manure in a nutrient conservative manure management system (0.4 acres per cow for a nutrient disposal manure management system). The actual quantity of land is affected by many decisions including feed bunk decision. Commonly observed ranges for ration crude protein and phosphorus levels resulted in a 20 to 30% change in the land requirements for managing the nutrients in manure. This amounted to 25 to 50 acres of additional land needs for a 100-cow dairy herd. However, because these estimates require information specific to individual dairies, producers are encouraged to use the "Manure Nutrient Inventory" spreadsheet or similar tools to evaluate those site-specific parameters.

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[1]Rick Koelsch, Associate Professor and Extension Livestock Environmental Engineer, Animal Science and Biological Systems Engineering, Lincoln.

Table 4. Summary of nutrient excretion, nutrient remaining after storage and field losses, and land requirements for agronomic application.

Producer's Name:	John Doe	Address:	Box 100	Phone:	402-499-9999
Farm Name:	Shady Acres	Address:	Route 1	Fax:	402-499-9998
		Town, State, Zip:	Anytown, NE 60000	e-mail:	jdoe@share.com

Herd/Flock Summary:

Species and	Group ID	Average Capacity	Average Weight	Portion of Year Facility Is Occupied	Method for Estimating Nutrient Excretion
Dairy	Hi Group	200	1400		Nutrient Balance
Dairy	Low Group	200	1400		Nutrient Balance
Dairy	Dry Cows	60	1450		Nutrient Balance

Nutrient Excretion by Livestock Summary

1. Earthen Storage	164,286	lbs. N/yr.	69,393	lbs. P_2O_5/yr.	77,422	lbs. K_2O/yr.
2.		lbs. N/yr.		lbs. P_2O_5/yr.		lbs. K_2/yr.
3.		lbs. N/yr.		lbs. P_2O_5/yr.		lbs. K_2/yr.
4.		lbs. N/yr.		lbs. P_2O_5/yr.		lbs. K_2/yr.

Nutrients Remaining After Storage Losses

1. Earthen Storage	139,643	lbs. N/yr.	69,393	lbs. P_2O_5/yr.	77,422	lbs. K_2O/yr.
2.		lbs. N/yr.		lbs. P_2O_5/yr.		lbs. K_2/yr.
3.		lbs. N/yr.		lbs. P_2O_5/yr.		lbs. K_2/yr.
4.		lbs. N/yr.		lbs. P_2O_5/yr.		lbs. K_2/yr.
TOTAL	139,643	lbs. N/yr.	69,393	lbs. P_2O_5/yr.	77,422	
lbs.K_2O/yr.						

Nutrients Remaining After Field Application Losses (ammonia losses only)

1. Earthen Storage	132,661	lbs. N/yr.	69,393	lbs. P_2O_5/yr.	77,422	lbs. K_2O/yr.
2.		lbs. N/yr.		lbs. P_2O_5/yr.		lbs. K_2/yr.
3.		lbs. N/yr.		lbs. P_2O_5/yr.		lbs. K_2/yr.
4.		lbs. N/yr.		lbs. P_2O_5/yr.		lbs. K_2/yr.
TOTAL	132,661	lbs. N/yr.	69,393	lbs. P_2O_5/yr.	77,422	
lbs.K_2O/yr.						

Manure Nutrient Application Rate Assuming That Manure is Distributed Evenly Over Existing Land Base

1. Earthen Storage 800 ac.	165	lbs. N/yr.	87	lbs. P_2O_5/yr.	97	lbs. K_2O/yr.
2.		lbs. N/yr.		lbs. P_2O_5/yr.		lbs. K_2/yr.
3.		lbs. N/yr.		lbs. P_2O_5/yr.		lbs. K_2/yr.
4.		lbs. N/yr.		lbs. P_2O_5/yr.		lbs. K_2/yr.

Crop Land Requirements if Manure Nutrients are Distributed According to Crop Nutrient Removal Rates.

Land Base Identified	Available	Nitrogen Utilized	Remaining	Available	P_2O_5 Utilized	Remaining	Available	K_2O Utilized	Remaining
1,460 ac	132,661 lb.	132,661 lb	0 lb.	69,393 lb	46,626 lb	22,767 lb.	77,422 lb.	77,422 lb.	0 lb.
		650 acres to utilize N			1,460 acres to utilize P			650 acres to utilize K	

Crop Land Requirements for Accumulated Phosphorus in Settled Solids of an Anaerobic Lagoon

Land Base Identified	Available	P_2O_5 Utilized	Remaining
600 ac	0 lb.	0 lb.	0 lb.

The Accuracy of Test Strategies to Classify Herds by Johne's Disease Status

David R. Smith[1]

Summary

*To prevent movement from farm to farm of **Mycobacterium paratuberculosis**, the agent of Johne's disease, dairymen must be able to accurately determine the infection status of their own herds and the herds that are sources of replacement cattle. The accuracy of two herd-testing strategies were graphically modeled using assumptions about the performance of Johne's disease diagnostic tests on healthy adult cattle, the expected percentage of herds harboring cattle infected with **M. paratuberculosis**, and the percentage of cattle infected within those herds. The model predicts that it is possible to correctly classify 99% of herds by **M. paratuberculosis** infection status if 125 cattle in the herd are tested by ELISA for antibodies directed against M. paratuberculosis, and if positive serology test results are confirmed with fecal culture. Dairy farmers following this herd-testing strategy can determine the Johne's disease status of their herds with confidence, and cattle sold from dairies classified as negative may have additional value as replacements with low risk of infection.*

Introduction

The ability to accurately classify a herd by *Mycobacterium paratuberculosis* infection status is an important diagnostic challenge for veterinarians. Dairy farmers cannot fully address Johne's disease control and prevention until they can reliably know the infection status of their herds as well as the herds from which they purchase replacements. Producers can address pathogen containment within their own operations once they reliably know *M. paratuberculosis* infected cattle exist within their herds. Producers that know they are unlikely to have infected cattle can begin to address biosecurity strategies to prevent introduction of the agent through purchased bulls and replacements. Also, the cattle from herds that are reliably classified as unlikely to contain *M. paratuberculosis* may have added value when marketed as replacements.

Proposals to classify herds by *M. paratuberculosis* infection status makes some producers and their veterinarians nervous. Herds classified as *M. paratuberculosis* infected may suffer a loss of market and increased liability concerns. Misclassification of herd infection status also has serious implications for both buyers and sellers. Buyers of replacement cattle want assurance that herds classified as uninfected are classified correctly. Sellers of replacement cattle want assurance that their herds will not be classified as infected unless they truly are. Veterinarians working with these herds should have confidence that the herd-testing strategies they recommend will accurately determine a herd's infection status.

The probability of correctly classifying a truly infected herd is termed herd-level sensitivity. Herd-level specificity is the probability of correctly classifying a truly non-infected herd. When a herd's infection status is determined by testing individuals within the herd, then the herd-level sensitivity and specificity can be calculated from the sensitivity and specificity of the test for individuals, the expected prevalence of infected individuals within infected herds, the number of herdmates tested, and the number of reactors (positive tests) that will classify a herd as infected (Martin et al. 1992).

Statistics such as predictive value, efficiency and apparent prevalence can be used to interpret the diagnostic value of a herd-level classification of infection based on tests of individuals. These statistics can be calculated if herd-level sensitivity and specificity and the expected prevalence of infected herds are known. The predictive value of a positive herd classification is the probability that there truly are infected animals in herds classified as infected (Martin et al.1992; Martin, 1977). Similarly, the predictive value of a negative herd classification is the probability that there are truly no *M. paratuberculosis* infected animals in a herd classified as not infected (Martin et al.1992; Martin, 1977).

The proportion of herds classified correctly is termed efficiency (Trajstman, 1979). The efficiency of a herd-testing strategy is a function of the sensitivity and specificity at the herd level, and the prevalence of infected herds. The proportion of herds that test positive with a herd-testing strategy, the apparent prevalence, is also a function of the same factors (Martin et al. 1992; Martin, 1977).

The objective of this study was to use these statistics to determine an optimal diagnostic strategy to classify a herd correctly by *M. paratuberculosis* infection status.

Procedure

A spreadsheet software program was used to calculate herd-level sensitivity, specificity, predictive value, efficiency, and apparent prevalence with varying numbers of animals tested within a herd.

Two herd-testing strategies were evaluated over a range of herd sample sizes:

1) ELISA screening — Testing serum collected from a random sample of the herd for the presence of antibodies directed against *M. paratuberculosis* by enzyme-linked-immunosorbent-assay (ELISA). All cattle with positive ELISA results would be considered reactors.
2) Serial testing — ELISA screening, followed by culturing the

feces of ELISA-positive cattle to confirm positive ELISA test results. Only cattle testing positive to both ELISA and fecal culture testing would be considered reactors.

The prevalence of infected herds was assumed to be 22% and the prevalence of infected individuals within infected herds was assumed to be 15% (3.4% overall prevalence of infected individuals divided by 22 percent prevalence of herds with infected individuals) based on the results of a recent national survey (NAHMS, 1997). One reactor was used to classify a herd as infected.

The herd screening protocol was based on the expected performance of a commercially available antibody-capture ELISA (HerdChek M.pt., IDEXX Laboratories, Westbrooke, MN 04092) because the test is already being used by many veterinary diagnostic laboratories; it is relatively inexpensive; and a short time is required to obtain results. The ELISA for individual adult cattle without clinical signs of Johne's disease was estimated to be 45% sensitive and 99% specific, and the serial testing strategy 25% sensitive and 99.99% specific, based on expert opinion (National Johne's Disease Working Group, 1998). The sensitivity of the test for individuals is lower with serial testing because some truly infected cattle, positive by ELISA, will not be culture positive (more false negative test results than ELISA screening alone). Serial testing is more specific (fewer false positive test results than ELISA screening alone) because a positive ELISA result must be confirmed by fecal culture.

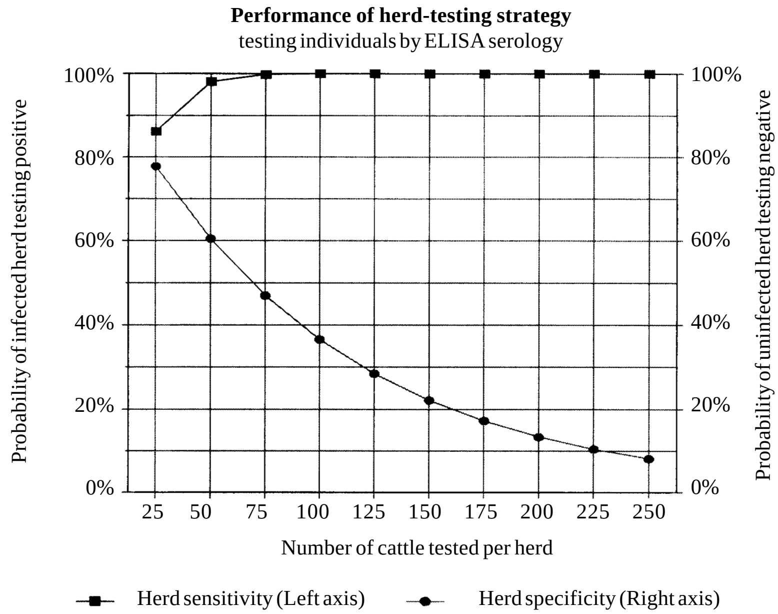

Figure 1. The probability that an infected herd will be correctly classified (herd sensitivity) and the probability that an uninfected herd will be correctly classified (herd specificity) by *M. paratuberculosis* infection status when various numbers of cattle in the herd are tested using ELISA serology alone. Calculations assume that the sensitivity and specificity of the test for individual cattle is 45 percent and 99 percent respectively, and that in infected herds 15 percent of the cattle will be infected.

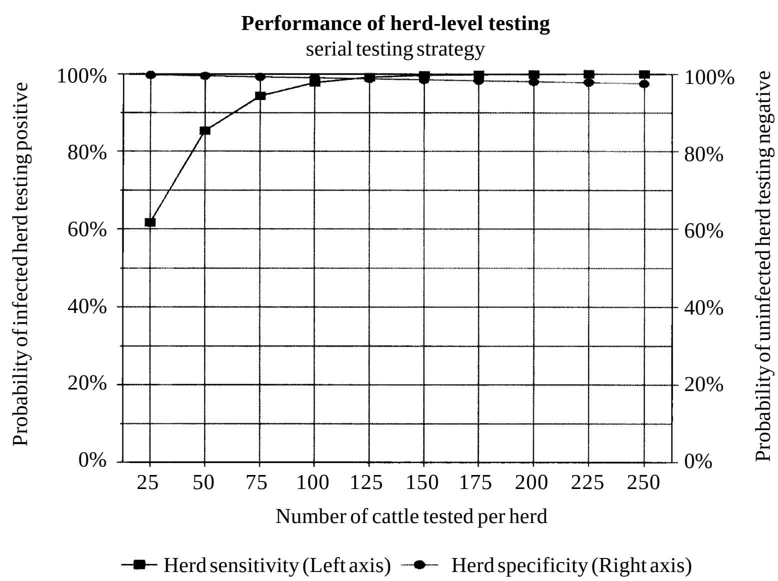

Figure 2. The probability that an infected herd will be correctly classified (herd sensitivity) and the probability that an uninfected herd will be correctly classified (herd specificity) by *M. paratuberculosis* infection status when various numbers of cattle in the herd are tested by serology in series with fecal culture. Calculations assume that the sensitivity and specificity of testing for individual cattle when ELISA serology is conducted in series with fecal culture is 25 percent and 99.99 percent respectively, and that in infected herds 15 percent of the cattle will be infected.

Results

With both testing strategies the calculated herd-level sensitivity increased and herd-level specificity decreased as the number of cattle tested per herd increased (Figures 1 and 2). The sensitivity of a herd-level classification increases with larger sample sizes because there are more opportunities to find the one positive test result that will classify the herd as infected. The specificity of a herd-level classification decreases as more cattle in a herd are tested because of the increasing opportunity to find a false positive test result.

Compared to serial testing, ELISA screening was predicted to have higher herd-level sensitivity at smaller sample sizes and lower herd-level specificity at

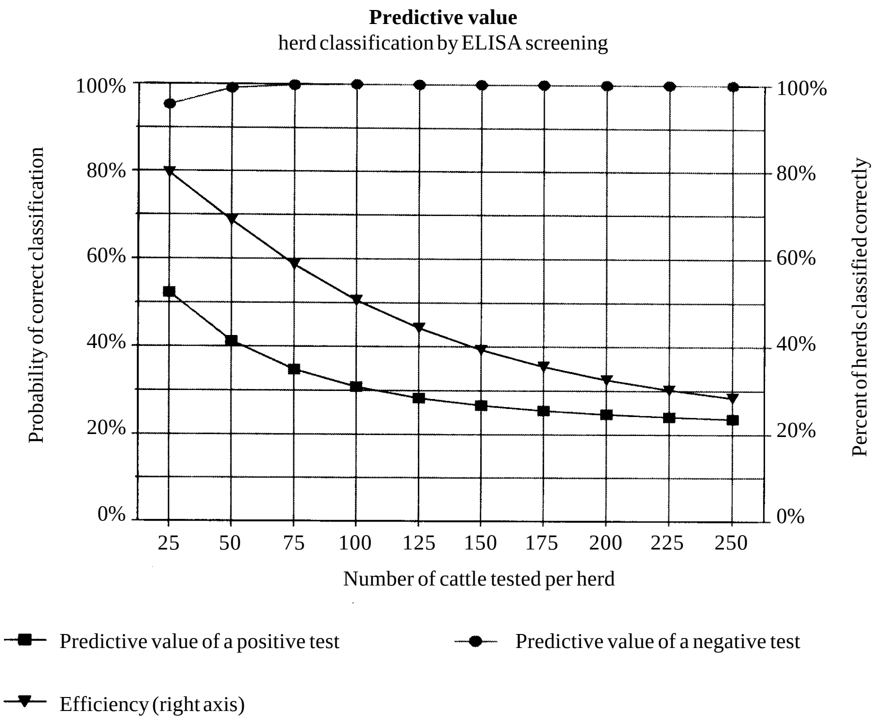

Figure 3. The probability that a herd classified as *M. paratuberculosis* infected truly has infected cattle in the herd, the probability that a herd classified as uninfected truly is uninfected, and the percentage of herd classified correctly (efficiency) for a given number of herd members tested by serology alone, assuming the true prevalence of infected herds is 22 percent.

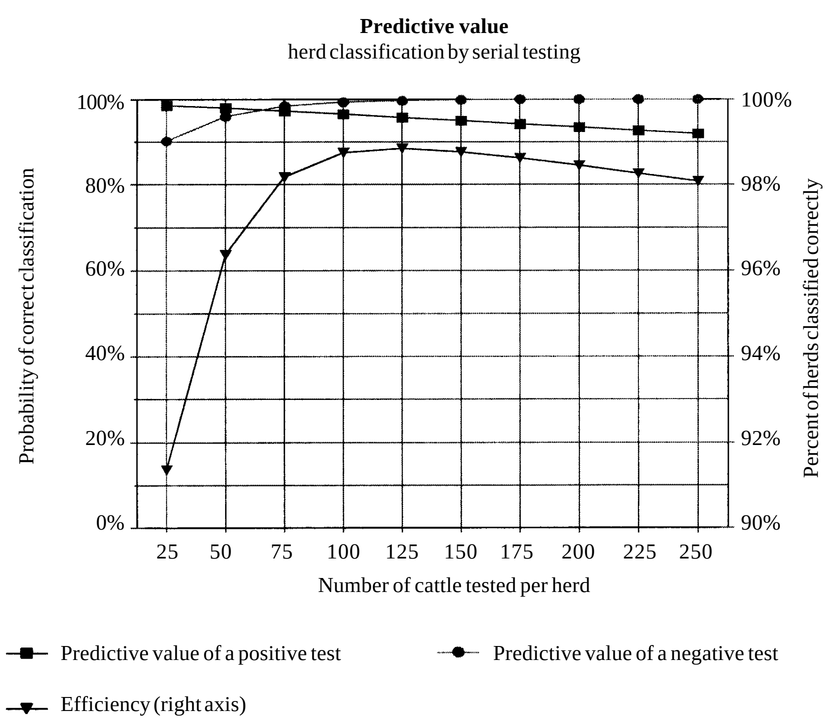

Figure 4. The probability that a herd classified as *M. paratuberculosis* infected truly has infected cattle in the herd, the probability that a herd classified as uninfected truly is uninfected, and the percentage of herd classified correctly (efficiency) for a given number of herd members tested in series by ELISA serology then fecal culture, assuming the true prevalence of infected herds is 22 percent.

all herd sample sizes. The graphical models illustrate that as sample size increases, increasing numbers of herds will be incorrectly classified as infected when screening herds by ELISA serology alone.

The predictive value of a negative herd classification was similar for both strategies regardless of herd sample size (Figures 3 and 4). The predictive value of a positive herd classification decreased with both test strategies as the number of cattle tested increased but was lower for ELISA screening at all sample sizes.

Serial testing was predicted to correctly classify a greater percentage of herds (greater efficiency) than ELISA screening over the range of sample sizes. The efficiency of ELISA screening decreased as the number of cattle tested per herd increased because uninfected herds were predicted to be incorrectly classified as infected. The efficiency of serial testing was maximized at a sample size of 125 cattle. Efficiency of serial testing was predicted to be less at sample sizes below 125 because of false negative classifications and less at sample sizes above 125 because of increasing false positive classifications. The model predicted that if 125 cattle were tested per herd, then 99% of herds would be classified correctly by serial testing compared to less than 45% by ELISA screening.

As the number of cattle tested per herd increased, the apparent prevalence of herds classified as infected was predicted to increase (Figures 5 and 6). Because of false-positive herd classifications, ELISA screening was predicted to overestimate the prevalence of infected herds over the entire range of sample sizes. Serial testing was predicted to underestimate the prevalence of infected herds at low sample sizes, but more closely approximate the assumed true prevalence as sample sizes increased.

Except for finite sample size corrections not calculated, herd-level sensitivity and specificity are not related to herd size (Martin et al. 1992). Therefore, the number of cattle to test in a herd does not depend on the size of the herd in order to optimize herd-level predictive value and efficiency.

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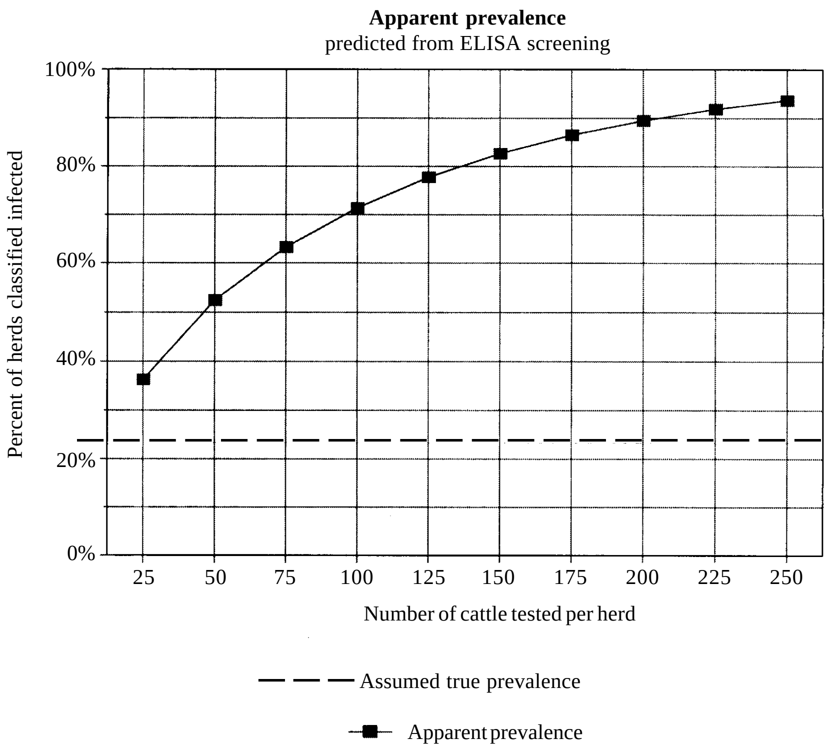

Figure 5. The percentage of herds predicted to be classified as infected with *M. paratuberculosis* (apparent prevalence) when various numbers of cattle in the herd are tested by serology alone. The percentage of herds classified as infected by this sampling scheme is predicted to greatly exceed the assumed true prevalence.

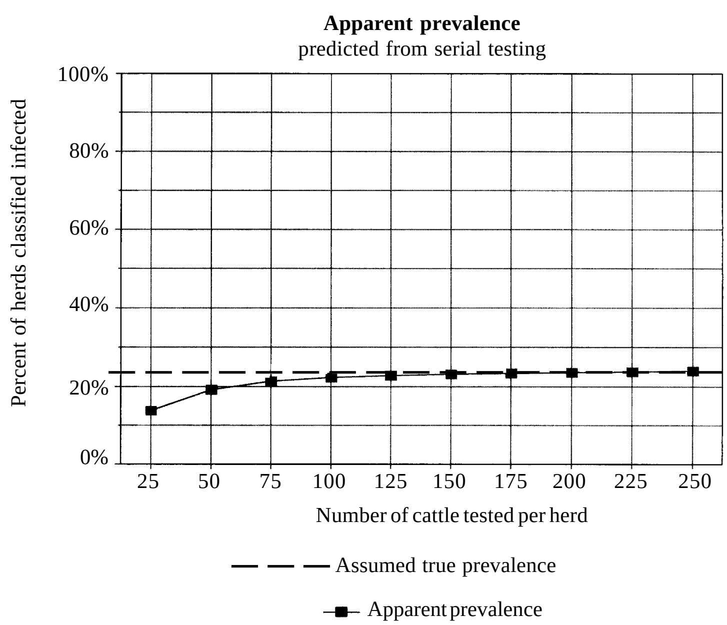

Figure 6. The percentage of herds predicted to be classified as infected with *M. paratuberculosis* (apparent prevalence) when various numbers of cattle in the herd are tested by serology in series with fecal culture. The percentage of herds classified as infected by this sampling scheme is predicted to closely approximate the assumed true prevalence over a wide range of sample sizes.

The statistics used to evaluate the diagnostic herd-testing strategies are based on an assumption that the cattle to be tested were randomly selected from the adult herd, and the inferences regarding the herd's infection status refer to this population of adult cattle. It may be possible in relatively closed herds, to infer that younger cattle also share the same infection status as adult cattle in the tested population; however, due to the long incubation period of *M. paratuberculosis,* this may not be true in herds that have introduced cattle in recent years.

If the assumptions used to model the statistics are correct, and if 125 adult cattle were tested per herd, then we would predict that 77 percent of herds would have at least one animal test positive by ELISA serology. Fecal culture would confirm the presence of *M. paratuberculosis* in 22 percent of the herds and overall only 1 percent of herds would be classified incorrectly. Serial testing should provide a level of accuracy in classifying the Johne's disease status of herds that should give veterinarians and dairy farmers confidence that Johne's disease herd-testing programs can be successful and that sources of replacement animals at low risk for carrying the agent of Johne's disease can be identified.

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Dairy Research Herd Report

Erin Marotz[1]

The University Dairy Unit's appearance was changed dramatically in 1998 with the demolition of the former ordinance plant buildings. Demolition started in July and was completed by year's end — finally no more old ugly buildings to look at. With the demolition came new challenges and new opportunities. Some of the buildings were still being used by the dairy for everything from storage to cattle housing and thus replacements had to be found. These buildings also served as boundary fences for many of our pastures; therefore, new fences will have to be built. So, 1999 will find us building new facilities and new pasture fences. The good news is that these buildings and fences will be the type that we want and in the location that best suits the dairy's needs.

We are currently milking 120 cows with a rolling herd average (RHA) of 22,065 pounds of milk, 822 pounds of fat, and 715 pounds of protein. Our current SCC is 200 to 220,000. Cows are housed in two groups according to stage of lactation and milk production. Both groups are housed in free-stall buildings with outside feeding facilities. The lactating cows are fed a total mixed ration twice daily in a fence line bunk with refusals monitored daily and weigh backs fed to heifers. Currently the ration consists of corn silage, alfalfa silage, wet corn gluten feed, and a protein, mineral, and vitamin mix. We also have a 40 cow tie-stall barn that houses all the cows on nutrition experiments. With new facilities we may group our first lactation cows separately. All of our replacements are grown at the unit, and all are sired and bred using AI. Our average age at first calving is 25 months and our average age of the milking herd is 38 months with 50% being first-lactation animals.

In 1999, we are planning the construction of a new free-stall barn to accommodate the loss of some animal housing due to building demolition. We are constructing a hoop-style barn to house approximately 55-60 cows. The barn will improve cow comfort by enabling the cows to eat inside the barn. This should be beneficial both in the summer and winter months. It will have 10-feet high side walls to allow for adequate ventilation and will be approximately 40 x 130 feet in dimensions. It will be equipped with sand-bedded free stalls that should maximize cow comfort. We are also planning to upgrade the equipment in the milking parlor. The parlor is a double-5 herringbone equipped with computerized meters and automatic detachers. We will replace the old meters with new, more reliable and advanced meters and automatic detachers. This was September 1999. Other future improvements that we hope to make are a new feed mixer that will allow us to incorporate long-stem alfalfa into the ration, and updating of equipment with which to perform the daily chores.

Along with dairy research, another important service the dairy unit provides is education and public awareness. This is becoming more important as the average citizen is becoming farther removed from agriculture. In 1998, we had approximately 2,000 visitors to the dairy. The majority of them were grade school children who were here to learn more about agriculture. A common educational tour for these children is to visit the dairy unit and learn about baby calf care, the milking procedure, and some housing and nutrition. These kids also tour other units such as the sheep, crops and horticulture units to learn more about agriculture. We also provide some education for the dairy and animal science classes at UNL. International visitors frequent the dairy with people coming from Japan, South America, and the Middle East. Linking programs with Cooperative Extension has increased. We hosted the PAK 10 Judging Contest in 1998 and 1999; this is a combination workshop and judging contest. In 1999, we hosted the Nebraska Holstein Association's Spring Fling Fancy Heifer Sale in conjunction with the PAK 10 event. This day was a huge success with over 150 people in attendance and 75 people participating in the judging clinic.

The Dairy Unit employs seven people to accomplish the many tasks to allow for optimum research. Erin Marotz serves as the manager, and is responsible for overall management and research coordination. Erin has been the unit manager for six years. The outside crew consists of three people. Darren Strizek serves the Nutrition Research Barn and is responsible for replacement management. Darren also assists in pasture management as most of the pastures are intensively grazed. Darren has been with the University for 10 years. Scott Ellinger's position is that of feeder and waste removal. His responsibilities include feeding the milking herd, dry cows and bred heifers, along with daily manure removal. Scott has been with us for three years. Gene Anderson serves in the swing position, performing the daily operations of both outside positions when Darren and Scott have the day off. Gene also has the responsibility of light mechanic duty and maintenance; he has served in his capacity for two years. Performing the milking operations are three milkers. One person does the milking per shift. Serving as the day milker is Kent Sweet. Kent's duties also include parlor maintenance and assisting the outside crew as needed. Kent has served as a milker for six years. Milking the night shift, which starts at 5 p.m., is Robin Drake-Woods. Her duties include milking, Heatwatch patch application, parlor sanitation, and nutrition barn cleaning. She has been with us for six months. Ken Cejka's time is split between the day and night shifts. He does milking as well as the other responsibilities of both shifts. Ken has been a part of the Dairy Unit for six years. Many of the employees are cross-trained and perform a multitude of tasks at the Dairy Unit.

We are located at the Agriculture Research and Development Center south of Mead. Our phone number is (402) 624-8068 and someone is here every day of the year. If you would like to schedule a visit, please give us a call or simply stop by; I will do what I can to accommodate you. If you have any questions about the research or management practices in use, do not hesitate to call. If you have a larger group that would like to tour the Dairy or the ARDC in general, contact the ARDC at (402) 624-8022 and schedule a tour; last year about 20,000 people did.

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