Effects of Varying Rates of Tallgrass Prairie Hay and Wet Corn Gluten Feed on Productivity of Dairy Cows

D.J. Rezac, K.N. Grigsby[1], and B.J. Bradford

Summary
Productivity of lactating dairy cows was assessed when fed diets containing wet corn gluten feed (**WCGF**; Sweet Bran, Cargill Inc.) as the primary energy substrate and prairie hay as the primary source of physically effective neutral detergent fiber (**peNDF**) compared with a control diet. Treatment diets were: 1) a control diet with 18% alfalfa, 18% corn silage, 33% WCGF, and 15% forage NDF (**CON**); 2) a diet with 20% tallgrass prairie hay, 46% WCGF, and 13% forage NDF (**TPH20**); and 3) a diet with 14% tallgrass prairie hay, 56% WCGF, and 9% forage NDF (**TPH14**). Midway through period 2, the TPH14 treatment diet was discontinued because of numerous cases of diarrhea. Dry matter intake was not altered by treatment. Milk yields were 80.0, 76.3, and 78.5 lb/day for CON, TPH20 and TPH14, respectively; milk yield was greater for CON than TPH20. Milk fat percentage was least for TPH14 with means of 3.47, 3.40, and 2.82% for CON, TPH20, and TPH14, respectively. Fat yield was greater for CON compared with TPH14, but was not different from TPH20. Milk urea nitrogen (MUN) was greatest for TPH20 and least for CON with TPH14 being intermediate, consistent with differences in dietary protein. Efficiencies, expressed as energy corrected milk divided by dry matter intake, were 1.45, 1.40, and 1.30 for CON, TPH20, and TPH14, respectively, and did not differ among diets. These data indicate that TPH14 did not provide adequate peNDF to support normal rumen function in midlactation dairy cows; however, TPH20 offered a feasible diet for use in dairies where high-NDF grass hay and WCGF are available.

Key words: milk yield, tall grass prairie hay, wet corn gluten feed

Introduction
Poor milk prices or small profit margins lead dairy producers to search for opportunities to reduce input costs. Often the first area of interest is feed cost, because this often represents the largest variable cost for dairy operations. Novel diet formulation methods using atypical feedstuffs or uncommon inclusion rates may be a way to decrease ration costs. In addition, in circumstances in which supplies of typical feedstuffs may not be sufficient for a production year, a ration that includes alternative feed ingredients may be useful when those ingredients are readily available and do not severely compromise performance.

Wet corn gluten feed (**WCGF**), a coproduct of the wet-milling process, is a high-fiber, low-lignin feedstuff that has been shown to be a viable optional component in lactating dairy cattle rations. Although the fiber in WCGF is highly digestible, the effective neutral detergent fiber (NDF) percentage can be variable depending on the method used to estimate it. Estimations of the effective NDF (**eNDF**) percentage in WCGF have ranged from 32.9% to just 5.7% based on change in milk fat concentration and ruminal pH, respectively, whereas physically effective NDF (**peNDF**) has been estimated to be 4.8%, based solely on rumination activity. Regardless of the variance of these figures, peNDF must be supplied by other fiber sources to prevent ruminal acidosis and milk fat depression. WCGF, because of the nature of its origin, is quite low in rapidly fermentable carbohydrates such as starch compared with other high-energy feedstuffs,

[1] Cargill, Inc., Blair, NE.

so the risk of ruminal acidosis is decreased. Taking this into account, a diet with high inclusion rates of WCGF may be formulated with lower peNDF.

Tallgrass prairie hay (**TPH**), a mixture of many grass species native to the central plains region, is a relatively inexpensive forage fiber source that is typically fed to beef cattle or far-off dry dairy cows with a low energy requirement. On average, TPH consists of about 67.4% NDF, 15.2% acetyl bromide lignin, and 3.9% crude protein, and thus, depending on processing, TPH may be used as a good source of peNDF in a ration. The nature of TPH and WCGF may complement each other in lactating dairy cow rations. No published research, however, has shown the effects of such a diet compared with a ration containing common ingredients such as alfalfa hay and corn silage. Our objectives were to compare diets containing varying amounts of TPH and WCGF with a control ration and observe effects on productivity of lactating dairy cows.

Experimental Procedures

Twenty-one primiparous and 27 multiparous lactating Holstein cows (167 ± 47 days in milk, 1.8 ± 0.97 lactations, mean ± SD) were selected from the Kansas State University Dairy Teaching and Research Center herd and assigned randomly to 1 of 6 free-stall pens. Pens were assigned to a treatment sequence in a replicated 3×3 Latin square design that was balanced for carryover effect of treatment. Treatment periods were 21 days, with 17 days of diet adaptation and 4 days of sampling. Feeding of treatment diets began in September and continued through November 2009. Cows were fed daily a fresh total mixed ration (TMR) blended in a TMR wagon at 9:30 a.m. and milked 3 times daily at 6:00 a.m., 1:00 p.m., and 8:00 p.m.

Three treatment diets consisted of: 1) a control (CON) diet containing 18% of dry matter alfalfa hay and 18% of dry matter corn silage; 2) a diet containing 20% of dry matter TPH (TPH20); and 3) a diet containing 14% of dry matter TPH (TPH14; Table 1). Rations were formulated to contain similar protein and energy concentrations with varying amounts and sources of forage NDF; however, chemical analysis showed that protein concentration was not constant among rations.

Midway through period 2, feeding of TPH14 was discontinued because of diarrhea in more than 25% of cows fed that diet. The 2 pens on TPH14 then were switched to the CON ration for the remainder of period 2 and pens allocated to TPH14 in period 3 were assigned to either TPH20 or CON.

Feed offered and refusals for each pen were recorded on the final 4 days of each treatment period except in the case of inclement weather. The TMR samples also were gathered on these days, composited by period, and analyzed by particle size using a 4-compartment Penn State Particle Separator. Samples of corn silage, alfalfa hay, TPH, WCGF, cottonseed, and grain mixes also were gathered for laboratory analysis. Milk samples were collected for each cow at every milking during the last 4 days of each sample period and analyzed for milk fat, protein, lactose, somatic cells, and urea nitrogen at the Heart of America Dairy Herd Improvement Association laboratory (Manhattan, KS). Body weight was measured on day 21 of each period immediately following the milking at 1:00 p.m. Data were analyzed using JMP (version 6.0, SAS Institute, Cary, NC) including the fixed effect of treatment diet, the random effect of period, and the random effect of pen. The random effects of cow nested within pen and period by pen interaction also were included in the model when analyzing milk traits.

Economic Analysis. Prices of alfalfa hay, corn silage, dry rolled corn, soybean meal, and whole cotton seed were obtained from the Penn State Feed Price list (June 15, 2010). Price of WCGF was obtained from the University of Missouri By-Product Feed Price Listing (June 19, 2010) with freight costs added for transportation from the point of origin to the Kansas State University Dairy Teaching and Research Center in Manhattan, KS. Vitamin and mineral mix cost was fixed across both treatments at $0.38/lb of dry matter. Ration costs were multiplied by the dry matter intakes for each respective treatment to produce actual cost per cow per day. The milk price of $0.14/lb was multiplied by the milk yields for each respective treatment to produce income per cow per day.

Results and Discussion

Diet Composition and Particle Size. Diets were formulated to be isocaloric and isonitrogenous; however, crude protein levels fluctuated among diets because of differences in nitrogen concentration of the respective grain mixes (Table 2). Milk urea nitrogen (MUN) was greater ($P < 0.004$) for cows that consumed TPH20 and least for CON, 17.0 and 13.9 mg/dL, respectively. Not surprisingly, these differences coincided with the differences in dietary crude protein, but minimum target values for MUN of 10 mg/dL were met, suggesting that protein limitation of milk synthesis or components was not a factor (Table 3).

Physically effective NDF values were 15.8, 11.9, and 11.6% of diet dry matter for CON, TPH20, and TPH14, respectively, and were greater ($P < 0.05$) for CON compared with TPH20 (Table 1). As described in the methods, TPH14 was discontinued midway through period 2 because of numerous cases of diarrhea and gastrointestinal tract abnormalities, which is a common result of a lack of adequate peNDF in the diet. In contrast, peNDF values for TPH20 and TPH14 were not different, suggesting that perhaps the method used to calculate peNDF for the diets was not adequate for rations of this nature.

Particles > 19.0 mm (% of dry matter) were 18.8%, 14.7%, and 9.1% for CON, TPH20, and TPH14 diets (Table 4), respectively, but did not differ from one another. Percentages of particles retained on the middle screen was greatest for CON and least for TPH20 ($P < 0.05$, 27.2 vs. 16.0%). Percentage of particles retained on the lower sieve was greatest ($P < 0.05$) for TPH20 and least for CON.

Dry Matter Intake and Performance. Dry matter intakes did not differ among treatment diets (Table 5). Dry matter intake is controlled by a complex set of factors that possess the ability to outweigh each another depending on the nature of the diet being consumed. Dry matter intake of diets with greater amounts of peNDF as a result of a greater amount of large feed particles, as was the case for CON, are more likely to be limited by physical regulation mechanisms. In contrast, in the case of TPH20 and TPH14 where peNDF was lower, a significant increase in dry matter intake was not detected.

Milk yield (Table 5) was greatest for CON and least for TPH20 ($P < 0.05$) with TPH14 remaining intermediate. Efficiency was not different among any treatments. Milk fat yield and percentage (Table 2) were greatest for CON and least for TPH14 ($P < 0.05$); however, TPH20 was not different from CON. Ability of the diets with high inclusion rates of WCGF, but with low forage NDF and peNDF concentrations, to maintain acceptable milk fat production may likely be attributed to the lower starch content of WCGF that may limit the occurrence of ruminal acidosis, which leads to milk fat depression.

Although use of milk fat to measure the effectiveness of the fiber in rations encompasses a far greater set of variables within the ration, it cannot be used to decide whether a dietary change should be made, but only whether changes already made were acceptable. For our diets, peNDF, calculated as the proportion of particles on the top 2 screens multiplied by the total dietary NDF, was not a good predictor of eNDF because just a 3% difference in peNDF between TPH20 and TPH14 resulted in a large difference in milk fat production and overall cow health. In an attempt to account for this difference, we alternately calculated peNDF by multiplying the proportion of particles on the top 2 sieves by the forage NDF concentration rather than by total dietary NDF. Although not different from one another, physically effective forage NDF was 21% greater for TPH20, suggesting that perhaps in diets with large amounts of a non-forage fiber source, this method may better represent true physical effectiveness.

MUN was greatest for TPH20 and least for CON ($P < 0.05$), which agreed with differences in dietary crude protein content. Milk protein yield and percentage were not different among treatment diets, suggesting that the differences in dietary crude protein did not limit milk protein synthesis (Table 3). Despite differences in particle size between TPH20 and CON, few effects on milk components occurred, which suggests that particle size was sufficient to promote a healthy rumen environment.

Economic Analysis. Because WCGF and TPH are relatively low-cost feedstuffs, an economic analysis was conducted to determine if the decreased cost of TPH20 would result in an increased income over feed cost (IOFC, Table 6). Because TPH14 did not prove to be a viable option for ration formulation it was not included in the analysis. Cost per lb of dry matter and feed cost per cow per day were smaller for TPH20 than CON ($0.081 vs. $0.086 and $4.41 vs. $4.72). In contrast, IOFC was $0.21 per cow per day greater for CON because of greater milk yield. Table 6 shows the potential income differential of feeding TPH20 versus CON. According to Table 7, feeding TPH20 would not be more profitable than CON until the feed cost margin per cow per day between TPH20 and CON reached at least $0.35. The potential income differential of feeding TPH20 is greatest when milk prices are low and feed cost margins between the diets are high.

Proximity to a source for WCGF can drastically influence its price because of transportation costs. Therefore, farms closer to the point of origin may realize less expensive ration costs. Even though feeding TPH20 is not always profitable because of decreased milk yield, fluctuating commodity prices, milk price, and proximity to point of origin of WCGF may make it profitable for some producers to feed a ration similar to TPH20.

Although TPH14 apparently did not supply adequate peNDF or forage NDF to the diet, TPH20 offered a feasible option for lactating dairy cows and resulted in component yield and efficiency similar to that of CON. Use of a diet similar to TPH20 may sometimes be economically feasible in a location where WCGF and TPH are readily available. In addition, in an emergency situation in which supplies of other feedstuffs are limited or exhausted, TPH20 could serve as an auxiliary option for dairy producers.

Table 1. Ingredient and nutrient composition of experimental diets

	Treatment diets[1]		
Item	CON	TPH20	TPH14
Ingredient, % of dry matter (DM)			
Corn silage	17.6	-	-
Alfalfa hay	17.7	-	-
Prairie hay	-	19.2	13.8
WCGF[2]	33.0	46.1	56.0
Cottonseed	7.3	7.5	7.5
Corn grain	16.6	17.5	15.6
Soybean meal (48%)	1.0	2.6	-
SoyBest[3]	4.1	4.2	4.2
Limestone	1.2	1.6	1.7
Magnesium oxide	0.1	0.1	0.1
Sodium bicarbonate	0.8	0.8	0.8
Trace mineral salt	0.5	0.1	0.1
Salt	0.03	-	-
Micronutrient premix[4]	0.13	0.13	0.13
Nutrient, % of DM			
DM, % (as fed)	62.7	60.7	61.5
Crude protein	16.5	18.0	18.6
NE_L (Mcal/kg)	1.7	1.6	1.7
Neutral detergent fiber (NDF)	34.5	38.3	37.0
Forage NDF	15.3	12.9	9.3
Ether extract	3.6	4.1	3.7
Starch	20.8	13.9	12.1
Ash	10.9	8.9	9.5
Physically effective NDF[5]			
$peNDF^{8.0}$	15.8 ± 1.0^{a}	11.9 ± 1.0^{b}	11.6 ± 2.7^{ab}
$peFNDF^{8.0}$	7.0 ± 0.4^{a}	4.0 ± 0.4^{b}	3.1 ± 1.0^{b}

[a,b] Means within a row having different superscripts differ ($P < 0.05$).

[1] CON = control, TPH20 = tallgrass prairie hay 20%, TPH14 = tallgrass prairie hay 14%.

[2] Wet corn gluten feed (Sweet Bran, Cargill, Inc., Blair, NE).

[3] SoyBest, West Point, NE.

[4] Micronutrient premix consisted of 30.2% Se premix (0.06%), 34.9% 4-Plex (Zinpro Corp., Eden Prairie, MN), 23.3% Vitamin E (44 IU/g), 9.3% Vitamin A (30,000 IU/g), 2.32% Vitamin D (20,000 IU/g).

[5] $peNDF^{8.0}$ was calculated as the proportion of particles retained on the top 2 sieves of a Penn State particle separator multiplied by the total dietary NDF concentration.

Table 2. Composition of corn silage, alfalfa hay, wet corn gluten feed (WCGF), and tallgrass prairie hay

	Ingredient			
Nutrient[1]	Corn silage	Alfalfa hay	WCGF	Tallgrass prairie hay
Dry matter	36.9	89.5	58.5	88.5
Neutral detergent fiber	43.2	43.6	37.5	67.5
Crude protein	8.0	18.3	22.9	6.6
Ether extract	2.9	1.1	2.6	1.7
Ash	5.2	11.4	5.8	7.3

[1] All nutrients except dry matter are expressed as a percentage of diet dry matter.

Table 3. Effect of treatments on milk component yield and concentration

	Treatment[1]			
Item	CON	TPH20	TPH14	*P*-value
Milk fat, lb/day	2.71 ± 0.07[a]	2.56 ± 0.07[ab]	2.25 ± 0.13[b]	0.009
Milk fat, %	3.47 ± 0.13[a]	3.40 ± 0.13[a]	2.82 ± 0.19[b]	0.005
Milk protein, lb/day	2.64 ± 0.06	2.54 ± 0.06	2.71 ± 0.15	0.66
Milk protein, %	3.35 ± 0.05	3.37 ± 0.05	3.37 ± 0.10	0.88
Milk lactose, lb/day	3.81 ± 0.11	3.70 ± 0.11	3.79 ± 0.15	0.24
Milk lactose, %	4.82 ± 0.04	4.85 ± 0.05	4.87 ± 0.11	0.74
Somatic cell count, 1,000 cells/mL	260 ± 76	198 ± 76	190 ± 140	0.62
Milk urea nitrogen, mg/dL	13.9 ± 0.89[b]	17.0 ± 0.89[a]	16.5 ± 1.12[ab]	0.004

[a,b] Means within a row having different superscripts differ ($P < 0.05$).
[1] CON = control; TPH20 = tallgrass prairie hay 20%; TPH14 = tallgrass prairie hay 14%.

Table 4. Particle size separation (% of dry matter)

	Treatment diets[1]			
% dry matter retained on sieves	CON	TPH20	TPH14	SEM
19.0 mm	18.8	14.7	9.1	6.3
8.0 mm	27.2[a]	16.0[b]	21.7[ab]	4.7
1.18 mm	43.1[b]	61.6[a]	55.4[ab]	7.8
Pan	10.9	7.7	9.2	5.3

[a,b] Means within a row having different superscripts differ ($P < 0.05$).
[1] CON = control; TPH20 = tallgrass prairie hay 20%; TPH14 = tallgrass prairie hay 14%.

Table 5. Effect of treatments on dry matter intake (DMI) and performance

	Treatment diets[1]			
Item	CON	TPH20	TPH14	*P*-value
No. of observations	53	53	15	
DMI, lb/day	54.8 ± 1.9	54.6 ± 1.9	59.6 ± 2.8	0.24
Milk, lb/day	80.0 ± 2.2^{a}	76.3 ± 2.2^{b}	78.5 ± 2.9^{ab}	0.02
Energy-corrected milk (ECM), lb/day	80.0 ± 1.6^{a}	76.5 ± 1.6^{b}	73.4 ± 2.9^{b}	0.03
ECM/DMI	1.45 ± 0.04	1.40 ± 0.04	1.30 ± 0.09	0.31
Body weight change, lb/21 days	15.9 ± 8.4	29.5 ± 8.4	13.2 ± 11.0	0.71

^{a,b} Means within a row having different superscripts differ ($P < 0.05$).

Table 6. Economic analysis of CON and TPH20

	Diet[1]	
Item	CON	TPH20
$/lb of dry matter	$0.086	$0.081
Feed cost per cow per day	$4.72	$4.41
Income per cow per day	$11.12	$10.60
IOFC[2]	$6.40	$6.19

[1] CON= control; TPH20=tallgrass prairie hay 20%.
[2] Income over feed cost.

Table 7. Potential income differential of feeding TPH20 across different milk prices and feed costs per cow per day

Milk price,	Potential difference in feed cost per cow per day between CON and TPH20								
$/lb	$0.20	$0.25	$0.30	$0.35	$0.40	$0.45	$0.50	$0.55	$0.60
$0.09	-$0.14	-$0.09	-$0.04	**$0.01**	**$0.06**	**$0.11**	**$0.16**	**$0.21**	**$0.26**
$0.10	-$0.17	-$0.12	-$0.07	-$0.02	**$0.03**	**$0.08**	**$0.13**	**$0.18**	**$0.23**
$0.11	-$0.21	-$0.16	-$0.11	-$0.06	-$0.01	**$0.04**	**$0.09**	**$0.14**	**$0.19**
$0.12	-$0.24	-$0.19	-$0.14	-$0.09	-$0.04	**$0.01**	**$0.06**	**$0.11**	**$0.16**
$0.13	-$0.28	-$0.23	-$0.18	-$0.13	-$0.08	-$0.03	**$0.02**	**$0.07**	**$0.12**
$0.14	-$0.31	-$0.26	-$0.21	-$0.16	-$0.11	-$0.06	-$0.01	**$0.04**	**$0.09**
$0.15	-$0.34	-$0.29	-$0.24	-$0.19	-$0.14	-$0.09	-$0.04	**$0.01**	**$0.06**
$0.16	-$0.38	-$0.33	-$0.28	-$0.23	-$0.18	-$0.13	-$0.08	-$0.03	**$0.02**
$0.17	-$0.41	-$0.36	-$0.31	-$0.26	-$0.21	-$0.16	-$0.11	-$0.06	-$0.01
$0.18	-$0.45	-$0.40	-$0.35	-$0.30	-$0.25	-$0.20	-$0.15	-$0.10	-$0.05
$0.19	-$0.48	-$0.43	-$0.38	-$0.33	-$0.28	-$0.23	-$0.18	-$0.13	-$0.08