Effects of Variable Sources of Distillers Dried Grains Plus Solubles on Milk Yield and Composition[1]

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ABSTRACT

This study compared diets supplemented with distillers dried grains plus solubles originating from whiskey distilling with those from fuel alcohol production or soybean meal. Forty-eight cows in mid and early lactation were offered a different dietary treatment in each of three 28-d periods. Dietary design included three supplements at 14 or 18% CP of dietary DM, with or without blood meal. Additionally, a third, darker, fuel ethanol source was added at 14 and 18% CP without blood meal during period 3 to incorporate greater variation in quality of distillers grains. No detectable differences occurred in DMI or in any variables because of blood meal. Milk yield was higher when cows were fed diets at 18% rather than at 14% CP. Cows fed the two lighter distillers grains diets yielded .8 kg/d more milk than cows fed soybean meal diets, and cows fed whiskey distillers grains yielded 1.3 kg/d more SCM than cows fed diets with darkest distillers grains. Milk protein percentage was depressed when the darkest distillers grains were fed. Distillers dried grains plus solubles can provide an excellent substitute for soybean meal and corn in dairy cow diets.

(**Key words**: distillers dried grains, dietary protein, lactation)

Abbreviation key: **BM** = blood meal, **DDGS** = distillers dried grains plus solubles, **MY** = milk yield, **SBM** = soybean meal.

INTRODUCTION

By-product protein sources often are more economical than commonly fed soybean meal (**SBM**) or other oilseed meals and also may supply more RUP, which is needed when dietary protein requirements of lactating cows are greater than can be supplied by protein from rumen microbes. Theoretically, optimization of dietary RUP permits minimization of RDP, thus sparing total dietary CP (11) and fecal and urine N if RUP supplements are digestible and if they complement AA of microbes. Additionally, by-products fed to livestock offer an alternative to waste disposal for producers of the primary products from which the by-products were derived.

Distillers dried grains plus solubles (**DDGS**) long have been recognized as a protein supplement for lactating cows [e.g., (2, 9)]. The DDGS became much more available after establishment of large distilling plants to produce fuel alcohol (8) and potentially represent a significant RUP supplement. However, relative effects on milk yield (**MY**) and milk composition of RUP supplements compared with those of SBM have been variable [review, (20)]. Results from DDGS also were inconsistent (3, 6, 9, 13, 14, 19) but indicated that poor performance may have been due to heat-damaged grains (19). Therefore, the objectives of this experiment were 1) to evaluate differences in RUP contents of commercial DDGS sources differing in color and, thus, expected differences in heat damage during processing and 2) to determine relative MY responses of lactating cows fed diets supplemented with DDGS (and associated changes in dietary RUP) compared with that of cows fed diets supplemented with SBM or comparable RUP from SBM and blood meal (**BM**).

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MATERIALS AND METHODS

In Situ Experiment

The extent and rate of degradation of DM and protein in the rumen were estimated in situ for BM, SBM, and three sources of DDGS using a dacron bag technique described by Emanuele and Staples (4). The supplements were oven-dried at 55°C for 72 h and ground through a Wiley mill (2-mm screen; Arthur H. Thomas Co., Philadelphia, PA). Degradation was measured by removal of bags containing the supplements from the rumen of a fistulated cow at 0, 2, 4, 8, 14, 24, 48, and 72 h during two experimental periods. The cow was fed a 50% corn silage diet (DM basis), which included SBM and DDGS from whiskey distilling. Period 1 evaluated four supplements, SBM, BM, and two DDGS sources. The second period included a third DDGS source (a second source from a fuel ethanol production plant), which was introduced to the feeding trial after completion of the first in situ experiment. The four supplements examined in period 1 were replicated sufficient times at various hours during period 2 to permit pooling of data from the two periods to estimate degradability of all supplements independent of period effects. All bags were analyzed for DM and N remaining after removal of bags from the rumen. The model for kinetics of CP digestion was that given by Mertens and Ely (10):

$$R = B_0 e^{-k(t - L)} + C$$

when $t > L$ and $R = B_0 + C$ when $0 < t < L$, where R = CP residue at time after incubation t, B_0 = fraction degradable at measurable rate (at time $t < L$, $B_0 = R - C$), $k = k_d$ = digestion rate constant, L = discrete lag time, and C = undigested fraction at 72 h of in situ incubation. Rate of CP digestion and lag time were calculated using the nonlinear iterative procedure of Marquardt in SAS (16) with the data set of least squares means of in situ measurements at various hours obtained from the least squares and maximum likelihood computer program of Harvey (7) to adjust hour means for period effects and to account for unequal numbers of observations at various hours.

Degradability of CP was calculated using the equation of Ørskov and McDonald (12) as follows:

$$D = A + (B_0 \times k_d)/(k_d + k_r)$$

where D = CP degradability, A = soluble fraction that is quickly degradable, B_0 and k_d as defined, and k_r = fractional passage rate from the rumen [assumed to be .05/h based on Erdman et al. (5)]. The RUP was estimated as 100 − D (expressed as a percentage).

Feeding Trial

Forty-eight multiparous cows in mid and early lactation, averaging 133 DIM at start of experiment, were utilized to evaluate DDGS and two fuel-ethanol DDGS sources as supplements in a TMR. Cows were fed different TMR in each of three 28-d periods. Twelve diets, based on SBM (control), DDGS of whiskey origin (DDGS-1), or DDGS from fuel-ethanol production (DDGS-2), were formulated during the first two periods, and 14 diets were used during period 3 (Table 1). For each primary supplement (SBM, DDGS-1, and DDGS-2), four diets were formulated that contained 14 and 18% dietary CP with or without inclusion of BM. The BM was added as a control source of RUP. Amounts of DDGS sources included were 13% of DM in 14% CP diets and 26% of DM in 18% CP diets. Two diets (14 and 18% CP, without BM), based on a second, darker DDGS source from fuel-ethanol production (DDGS-3), were added during period 3 to test a wider range of supplement quality in the DDGS sources evaluated. A total of 12 concentrate mixtures were prepared for periods 1 and 2, and 14 concentrates for period 3, in the proportions of the concentrate components in the diets (Table 1), excluding whole cottonseed, which was added daily with concentrate and silage to prepare respective TMR. The diet assignments to cows were according to a partially balanced incomplete block design that was similar to those used previously [e.g., (15, 17)]. Final diet assignments (Table 2) reflected a change from the original plan for period 3 because of the introduction of DDGS-3. More cows were fed diets 13 and 14 (8 cows per diet) than the original 12 diets during period 3 to obtain as much information as

TABLE 1. Composition of the TMR (DM basis) and coefficients for contrasts of dietary treatments.[1]

	SBM				DDGS-1				DDGS-2				DDGS-3	
	No BM		BM		No BM		BM		No BM		BM		No BM	
Composition and contrasts	14%	18%	14%	18%	14%	18%	14%	18%	14%	18%	14%	18%	14%	18%
Ingredients														
Corn silage	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
Corn meal	30.1	21.3	30.8	22.7	22.5	5.9	23.8	8.8	22.5	5.9	23.8	8.8	22.5	5.9
Whole cottonseed	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Distillers dried grains plus solubles					13.0	26.0	13.0	26.0	13.0	26.0	13.0	26.0	13.0	26.0
BM			1.0	2.0			1.0	2.0			1.0	2.0		
SBM (49% CP)	8.8	17.6	7.1	14.2	3.4	7.0	.9	1.8	3.4	7.0	.9	1.8	3.4	7.0
Mineral supplements[2]	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
Calculated composition[3]														
CP, %	13.7	17.5	13.8	17.7	13.7	17.6	13.9	17.9	14.2	18.7	14.4	19.0	13.8	17.8
RUP, % of CP	32.0	29.7	36.2	35.3	37.4	37.1	41.0	42.7	37.5	37.3	40.9	42.5	37.2	36.7
RUP, % of dietary DM	4.4	5.0	5.0	6.2	5.1	6.5	5.7	7.6	5.3	7.0	5.9	8.1	5.1	6.5
ADF, %	18.2	18.4	18.1	18.3	19.9	22.0	19.8	21.8	19.9	22.0	19.8	21.8	19.9	22.0
NDF, %	32.4	32.4	32.4	32.2	37.0	41.6	37.0	41.5	37.0	41.6	37.0	41.5	37.0	41.6
Ether extract, %	4.5	4.2	4.5	4.3	5.2	6.1	5.5	6.2	5.4	6.1	5.5	6.2	5.4	6.1
Ca, %	.64	.66	.64	.66	.64	.67	.64	.66	.64	.67	.64	.66	.64	.67
P, %	.44	.47	.43	.46	.47	.54	.46	.52	.47	.54	.46	.52	.47	.54
Mg, %	.29	.31	.29	.30	.30	.31	.29	.31	.30	.31	.29	.31	.30	.31
K, %	1.03	1.20	.99	1.13	.93	1.01	.88	.91	.93	1.01	.88	.91	.93	1.01
Na, %	.39	.41	.39	.41	.44	.50	.44	.50	.44	.50	.44	.50	.44	.50
Cl, %	.33	.33	.33	.33	.34	.36	.35	.37	.34	.36	.35	.37	.34	.36
Orthogonal contrasts														
CP (14 vs. 18%)	−1	1	−1	1	−1	1	−1	1	−1	1	−1	1	−1	1
BM (0 vs. +)	−1	−1	1	1	−1	−1	1	1	−1	−1	1	1	0	0
SBM vs. DDGS-1 + 2	−2	−2	−2	−2	1	1	1	1	1	1	1	1	0	0
DDGS-1 vs. DDGS-2	0	0	0	0	−1	−1	−1	−1	1	1	1	1	0	0
CP × BM	1	−1	−1	1	1	−1	−1	1	1	−1	−1	1	0	0
CP × SBM vs. DDGS-1 + 2	2	−2	2	−2	−1	1	−1	1	−1	1	−1	1	0	0
BM × SBM vs. DDGS-1 + 2	2	2	−2	−2	−1	−1	1	1	−1	−1	1	1	0	0
Nonorthogonal contrasts														
DDGS-1 vs. DDGS-3	0	0	0	0	−1	−1	0	0	0	0	0	0	1	1
DDGS-2 vs. DDGS-3	0	0	0	0	0	0	0	0	−1	−1	0	0	1	1

[1]SBM = Soybean meal, BM = blood meal, and DDGS = distillers dried grains plus solubles. The percentages of CP in SBM, BM, DDGS-1, DDGS-2, and DDGS-3 were 53.2, 94.0, 28.3, 32.5, and 29.1, respectively.

[2]Mineral supplementation was the same in all diets (.4% NaCl, .6% $NaHCO_3$, .8% $CaCO_3$, .2% MgO, .7% dicalcium phosphate, and .4% $KHCO_3$).

[3]Calculated from analyzed ingredient values.

possible regarding DDGS-3 and still permit least squares estimates of all diet effects to be obtained.

Cows were housed in a free-stall barn with 24 cows on each side of a central alley equipped with Calan gates (American Calan Inc., Northwood, NH), which allowed for monitoring of individual feed intake. Orts were recorded between 0730 and 0830 h daily, which permitted cows to eat for approximately 30 min after their return from the morning milking. Rations were fed daily as TMR between 0900 and 1200 h. The amount offered to each cow was changed as needed to obtain orts but to limit orts to <7% of the amount offered. Corn silage and whole cottonseed were mixed in correct proportions in a farm-scale mixer wagon; the appropriate amount of this mixture for a particular TMR was transferred to a mixer cart (Data Ranger®; American Calan Inc.), concentrate mixture was added, and the TMR was mixed and delivered to individual cows (up to 4 cows fed per mix). The trial was conducted in a relatively cool season from March 1992 to late May 1992, thereby permitting once daily feeding without heating of the feed in the feed bunks.

All cows were milked three times per day at approximately 0700, 1500, and 2300 h. The MY was recorded by calibrated electronic milk meters at each milking. Periods were 28 d; the first 14 d were used to adjust cows to the diet, and the final 14 d were used for data collection on DMI and MY. On the last day of each period, milk was sampled during each of the three milkings, and each of the three samples taken for each cow was analyzed for SCC and percentages of fat and protein at the Southeastern DHI Laboratory (McDonough, GA). On the day before the start of period 1 and the last day of each period, cows were weighed after the morning milking before returning to the barn to eat.

The DM percentage of the corn silage was determined twice weekly throughout the feeding trial to permit adjustment for changes in the wet weight of corn silage in the TMR, if needed, such that silage contributed a constant 50% of dietary DM. The silage, whole cottonseed, and the concentrate mixtures were sampled during wk 2 and 4 of each feeding period, and a combined sample for the three periods of these ingredients was sent to the Northeastern DHI Laboratory (Ithaca, NY) for analyses of NDF, ADF, ether extract, Ca, P, Mg, K, Na, Fe, Zn, Cu, Mn, and Mo. The N contents for all concentrate mixes, the whole cottonseed,

TABLE 2. Diet sequence assignments for cows for the three periods.

		Diets fed during period		
Cow	Sequence	1	2	3
1670	1	3	2	13
8907	2	7	2	1
1292	3	8	3	2
1319	4	10	5	14
1377	5	4	11	13
8925	6	12	7	14
1414	7	8	3	2
1418	8	9	4	13
1689	9	9	6	1
8937	10	6	1	14
1572	11	7	2	1
1581	12	3	10	13
1591	13	2	9	14
5147	14	10	9	12
1722	15	12	11	2
1116	16	5	12	11
1713	17	4	1	8
5027	18	11	4	5
1622	19	5	6	7
2096	20	5	2	9
5248	21	2	9	8
7962	22	8	5	12
5014	23	1	8	7
8994[1]	24	8	7	10
1746	25	10	5	4
5137	26	11	10	1
1678	27	6	3	10
5005	28	6	5	4
8918	29	9	8	11
8942	30	10	7	2
5060	31	11	8	3
5065	32	11	6	5
5077	33	5	12	13
1568	34	2	11	6
5104	35	12	9	14
5082	36	4	11	10
5150	37	9	4	3
1113	38	1	12	3
5136	39	2	1	4
1547	40	7	6	9
5081	41	7	4	14
1717	42	4	3	6
1705	43	1	10	13
1614	44	3	12	14
8966	45	6	1	13
5145	46	12	7	14
8936	47	1	8	13
5086	48	3	10	9

[1]Cow data not used in production trial analyses.

TABLE 3. Least squares ANOVA for milk yield.[1]

Source	df	SS	MS	F	P
Cow	46	1797.06	39.07	16.39	.001
Period	2	128.16	64.08	26.88	.001
Treatment	13	66.66	5.13	2.15	.020
Error[2]	79	188.33	2.38		
Contrast[3]					
CP	1		34.02	14.27	.001
BM	1		.94	.40	.531
SBM vs. DDGS-1 + 2	1		12.25	5.14	.026
DDGS-1 vs. DDGS-2	1		1.44	.60	.440
CP × BM	1		6.11	2.56	.113
CP × SBM vs. DDGS-1 + 2	1		1.12	.47	.494
BM × SBM vs. DDGS-1 + 2	1		.49	.21	.651
DDGS-1 vs. DDGS-3[4]	1		2.78	1.16	.284
DDGS-2 vs. DDGS-3[4]	1		3.62	1.52	.221

[1]SAS (16). Type III SS. Error mean square and probabilities were identical to output from Harvey (7).

[2]The coefficient of variation for this experiment with mean milk yield of 27.5 kg/d was $[(2.38)^{.5}/27.5] \times 100 = 5.6\%$.

[3]SBM = Soybean meal, BM = blood meal, and DDGS = distillers dried grains plus solubles.

[4]Nonorthogonal contrasts.

and the corn silage were determined in the University of Florida Dairy Science Department laboratory for each feeding period using the macro-Kjeldahl method (1).

Data were analyzed by method of least squares ANOVA using the computer program of Harvey (7) and general linear models procedures of SAS (16). The first model included cows, periods, and diets. Preselected contrasts to test for significance of effects of dietary treatments are shown in Table 1. A second model was employed that partitioned cow variation into that associated with high and low yielding groups to examine whether dietary treatments interacted with level of MY. Cows were assigned to group based on least squares means for MY for the cow over the total experiment. The resulting model included yield group, cows within group, period, diet, and group × diet interactions. Group × diet interactions were not significant ($P > .10$) for MY, SCM, or percentages of milk fat or milk protein; therefore, data reported are from the first model. An example output of this mathematical model with the chosen statistical contrasts is in Table 3. Additionally, this model was utilized with DMI as a continuous independent variable.

It would have been preferable for the experimental design to have distributed the DDGS-3 dietary treatments equally with other dietary treatments across all three periods or perhaps to have used it in place of DDGS-2. However, by the time the results from the in situ tests became available and it became evident that there might be little difference in quality of DDGS-1 and DDGS-2, the feeding trial already had been initiated. Thus, a decision was made to add another treatment while an opportunity still existed to compare performance of cows consuming it with performance of cows consuming other DDGS supplements. The DDGS-3 treatments were distributed in period 3 so that the mathematical model solved for least squares means of all 14 dietary treatments adjusted for other effects included in the model and unequal numbers of observations per treatment. The coefficient of variation for milk yield in this incomplete block design was 5.6% (Table 3), which is similar to that usually achieved with complete block (Latin square) designs, e.g. [6.3% in the experiment of Clark and Armentano (3)].

RESULTS AND DISCUSSION

In Situ Experiment

Table 4 summarizes the RDP analyses of the five protein supplements used in the feed-

TABLE 4. Summary of protein fractions determined in the in situ experiment for the protein supplements[1] tested.

Source	Protein fraction[2]			L[3]	k_d[4]	RUP[5]
	Soluble	Slowly degraded	Undigested			
BM	13.8	16.2	70.0	4.69	.012	83.1
SBM	26.4	72.2	1.4	.05	.094	26.5
DDGS-1	28.3	58.4	13.3	0	.038	46.5
DDGS-2	26.1	63.1	10.8	0	.042	45.1
DDGS-3	31.2	68.3	.4	2.11	.029	43.7

[1]BM = Blood meal, SBM = soybean meal, and DDGS = distillers dried grains plus solubles.

[2]Expressed as a percentage of the original N. Undigested is in situ residue after 72 h; slowly degraded fraction = total − soluble minus undigested.

[3]Lag time in hours.

[4]Digestion rate constant of the slowly degraded protein (per hour).

[5]Ruminally undegradable protein as a percentage of original N, estimated as 1 − degradability (D), where D = soluble fraction + (slowly degraded fraction × k_d)/(k_d + k_r). Fractional passage rate from the rumen (k_r) was assumed to be .05/h.

ing trial. The SBM protein was degraded somewhat more extensively than previously reported [26.5 vs. 35% RUP in NRC (11)] but similarly to previous determinations in Florida (17). Although estimated RUP were not appreciably different, DDGS-3, which was somewhat darker, was less degradable than DDGS-1 or DDGS-2, based on the degradation rate and the indication of a 2-h lag time before degradation was initiated. Similarly, ADIN measures (from samples sent to Northeastern DHI) showed that DDGS-3 contained 21% of CP in this less available form compared with 13% for DDGS-1 and 17% for DDGS-2. However, the small undigested residue for DDGS-3 is inconsistent with higher ADIN content if it is assumed that ADIN is unavailable.

Feeding Trial

DMI. Neither supplementary protein sources nor dietary CP affected DMI ($P > .10$) when averaged across other main effects. However, interactions existed between CP concentration and SBM versus DDGS diets (DDGS-1 plus DDGS-2; $P = .036$; Table 5). This interaction was due to slightly higher DMI from diets at 14% CP than 18% CP based on SBM, but DMI were higher with 18% than with 14% CP with DDGS. Owen and Larson (13) found some reduction in DMI with 35.8% DDGS compared with 18.8% and no overall difference compared with SBM. Van Horn et al. (19) obtained slightly less DMI from diets containing DDGS.

MY. Diets containing 18% CP resulted in mean MY of 28.0 kg/d compared with 27.0 kg/d from 14% diets ($P < .001$). This effect was consistent across all supplements. Owen and Larson (13) found that cows fed DDGS diets with higher protein concentrations (17.7 vs. 14.6% CP) and, thus, more DDGS (35.8 vs. 18.8%), yielded less milk, suggesting an upper limit to recommended dietary concentrations of DDGS. Owen and Larson (13) observed no differences between MY of cows fed SBM diets or when both treatments were fed at 14.7% CP. In the present study, MY were higher with 26% DDGS (18% CP diets) than with 13% DDGS (14% CP diets) with or without added BM. Mean MY from cows fed diets containing DDGS-1 and DDGS-2 were significantly higher than those for cows fed SBM ($P = .026$), and MY from cows fed DDGS-3 was about the same as for similar SBM controls. Probable reasons for improved MY from dietary supplementation with high quality DDGS relative to SBM are increased RUP and greater NE_L than usually estimated (11). Van Horn et al. (19) obtained less milk from fuel-ethanol DDGS diets (15.9 to 41.6% DDGS) than from SBM control diets that contained 50% corn silage, as in the present experiment. Van Horn et al. (19) suggested that the DDGS had been overheated because 32.9% of CP was in ADIN, thereby providing a poor source of

protein and energy. Palmquist and Conrad (14) also observed a depression in MY for Holsteins receiving DDGS diets compared with MY of Holsteins receiving SBM diets. However, Jerseys had higher MY when fed DDGS.

In this experiment, BM had no effect on MY, even with SBM or in the high yielding group, suggesting that dietary RUP was not limiting.

Statistical analysis also was performed using DMI as a continuous independent variable to adjust analyzed response variables to the mean DMI. Although probabilities changed slightly, no change in the contrasts that were significant with the first model occurred in this model.

Percentage of Milk Fat. The main effects of treatments did not affect the percentage of milk fat. The interaction of BM versus SBM × DDGS (DDGS-1 + DDGS-2) was expressed (P = .029) as BM affecting higher milk fat percentages with SBM (3.55 vs. 3.36%), but,

TABLE 5. Least squares means for DMI, lactation variables, and BWC.[1]

Diets[2]	n	DMI	MY	Milk fat	Milk protein	SCM	BWC
		(kg/d)		(%)		(kg/d)	
Diets without BM							
SBM, 14% CP	12	24.2	26.5	3.25	3.13	25.5	.47
SBM, 18% CP	12	23.5	27.0	3.47	3.25	26.0	.28
DDGS-1, 14% CP	11	24.1	27.4	3.61	3.05	27.2	.46
DDGS-1, 18% CP	11	24.3	28.0	3.68	3.25	28.5	.16
DDGS-2, 14% CP	11	23.6	27.5	3.60	3.12	27.7	.24
DDGS-2, 18% CP	10	23.8	28.0	3.32	3.07	27.1	.65
DDGS-3, 14% CP	8	23.6	26.4	3.39	2.95	25.5	.17
DDGS-3, 18% CP	8	24.4	27.4	3.59	3.08	27.6	.54
Diets with BM							
SBM, 14% CP	10	24.0	26.7	3.51	3.15	26.6	.03
SBM, 18% CP	10	23.5	27.7	3.51	3.10	27.6	.00
DDGS-1, 14% CP	9	23.9	26.0	3.45	3.21	25.7	.27
DDGS-1, 18% CP	9	24.9	29.2	3.35	3.28	28.6	.71
DDGS-2, 14% CP	10	23.9	27.8	3.30	3.18	26.9	.35
DDGS-2, 18% CP	10	24.5	28.4	3.35	3.18	27.6	.60
Means for diets							
14% CP	71	23.9	27.0	3.44	3.14	26.6	.30
18% CP	70	24.1	28.0	3.47	3.19	27.7	.40
SBM	44	23.8	27.0	3.44	3.16	26.7	.20
DDGS-1	40	24.3	27.6	3.52	3.20	27.5	.40
DDGS-2	41	23.9	27.9	3.39	3.14	27.3	.46
DDGS-3	16	24.0	26.9	3.49	3.02	26.6	.36
No BM	67	23.9	27.4	3.49	3.15	27.1	.38
BM	58	24.1	27.6	3.41	3.18	27.2	.33
Error MS (79 df)		1.38	2.38	.10	.01	3.23	.07
Significant contrasts[3]							
CP (14 vs. 18%)			<.001		.003	<.001	
BM (0 vs. +)							
SBM vs. DDGS-1 + 2			.026			.060	.055
DDGS-1 vs. DDGS-2					.027		
CP × BM					.074		
CP × SBM vs. DDGS-1 + 2		.036					
BM × SBM vs. DDGS-1 + 2				.029	.003		.079
DDGS-1 vs. DDGS-3					.007		

[1]MY = Milk yield, SCM = 3.5% SCM = 12.82 × fat yield + 7.13 × protein yield + .323 × MY [derived from Tyrrell and Reid (18)], and BWC = BW change.

[2]BM = Blood meal, SBM = soybean meal (control), and DDGS = distillers dried grains plus solubles.

[3]P = Probability stated; $P > .10$ not shown.

when BM was included with DDGS, milk fat percentages were reduced (3.36 vs. 3.51%). An explanation for this interaction is not apparent. In some experiments (3, 14), DDGS increased milk fat percentage.

Percentage of Milk Protein. Percentage of milk protein (Table 5) was higher when 18% CP diets were fed versus 14% CP diets (P = .003), with DDGS-1 versus DDGS-2 (P = .027), and with DDGS-1 versus DDGS-3 (P = .007). Van Horn et al. (19) observed a depression in milk protein percentage for cows fed DDGS from ethanol production relative to those fed SBM. This effect was attributed to unavailable dietary protein and lower energy intake, as indicated by the high ADIN content of DDGS (32.9% of DDGS N) and reduced OM digestibility. In this experiment, the depression of milk protein percentage when DDGS-3 was fed was the most conspicuous quantitative indicator that DDGS-3 was of poorer quality than the other DDGS sources. Palmquist and Conrad (14) also observed depression in milk protein percentage for cows receiving DDGS diets than for those fed SBM diets but attributed the depression to an unbalanced supply of AA, particularly Lys, in the DDGS diets. Owen and Larson (13), however, found no difference between protein percentages in milk from cows fed DDGS or SBM when both diets were formulated to have 14.5% CP. Owen and Larson (13) observed a depression in percentage of milk protein with high protein DDGS diets (18% CP; DDGS at 35.8% total dietary DM) compared with the lower protein concentration (14.5% CP). An interaction between BM and CP percentage was significant (P = .074); BM addition increased milk protein percentage in 14% CP diets (from 3.10 to 3.19%) but had little effect in 18% CP diets (3.18 vs. 3.19%). Perhaps the 14% CP BM had an effect because it provided additional RUP. The positive effect of BM at the low CP percentage appeared to be independent of effects of SBM or DDGS.

SCM. As with MY, dietary CP percentage affected SCM yield. Cows fed 18% CP diets yielded 1.1 kg/d more SCM than those fed 14% CP (P < .001). Mean SCM yields from cows fed DDGS-1 and DDGS-2 diets were .7 kg/d higher than for cows fed SBM (P = .060). Also, cows fed DDGS-1 tended to yield more SCM than cows fed DDGS-3 (P = .115).

CONCLUSIONS

As dietary CP concentration was increased from 14 to 18%, MY and SCM increased about 1.0 kg/d and milk protein percentages also increased. The effect on milk protein percentage was more pronounced in diets without added BM. Added BM had no effect on MY.

Results from this study indicated that DDGS can provide an excellent substitute for SBM and corn in dairy cow diets. Cows fed higher quality DDGS sources (DDGS-1 and DDGS-2) yielded slightly more MY and SCM (about .75 kg/d) than did SBM-supplemented cows and yielded milk with higher protein percentage than with DDGS-3. Thus, variation in quality of DDGS products exists and should be considered when DDGS is fed to dairy cows. Quality differences in the three sources fed in this experiment were indicated by 1) color of feed, which ranged from light (DDGS-1 with DDGS-2 only slightly darker) to a medium dark (DDGS-3); 2) differences in ADIN, which suggested that 13% of the CP was relatively unavailable in the DDGS-1, 17% in DDGS-2, and 21% in DDGS-3; and 3) in situ degradation rate for DDGS-3, which was somewhat slower than for the other two sources. Depressed milk protein percentages may be an early indicator of poor quality (or heat damage). If ADIN were used as an indicator, 21% of DDGS CP in ADIN (the amount in DDGS-3) would be marginally excessive; higher ADIN would be expected to be associated with much poorer performance; e.g., DDGS with 32.9% of CP in ADIN gave larger depression in milk protein percentage and great depression in MY (19).

With high quality DDGS, this experiment indicated that up to 26% of total dietary DM could come from DDGS without detriment; data from Owen and Larson (13) suggested that 35% was too much, perhaps because of insufficient dietary Lys when excessive amounts of protein from corn sources are utilized. With alfalfa-based diets, however, Grings et al. (6) fed up to 31.6% of dietary DM from DDGS and obtained increased MY.

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