Dietary Variety Via Sweetening and Voluntary Feed Intake of Lactating Dairy Cows

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ABSTRACT

The effects of choice of diets on feed intake were studied using 12 lactating Holstein cows. A switchback design was used that had three periods and two sequential blocks. Diets were 1) a control total mixed ration (TMR), which consisted of alfalfa haylage, corn silage, and a concentrate mixture based on ground corn and soybean meal (25:25:50 on a dry matter basis) and 2) a sweetened TMR in which a brown sugar food product constituted 1.5% of the dietary dry matter. Treatments consisted of the control TMR fed on both sides of divided feed bunks, the sweetened TMR fed on both sides of divided feed bunks, or both TMR fed on alternating (daily) sides of divided feed bunks in tie stalls. Periods were 2 wk in duration, and cows averaged 67 and 53 d of lactation at the start of blocks 1 and 2, respectively. The dry matter intake, body weight, milk yield, and percentages of milk fat, protein, and solids not fat were similar when either TMR was fed alone. A choice of control TMR or sweetened TMR did not affect any of these variables. The dry matter intake, body weight, milk yield, and milk protein percentage were affected by block; however, these effects were probably caused by differences between the blocks in environment and stage of lactation. The results of this experiment might have been affected by the composition of the control TMR, its similarity to the sweetened TMR, availability of both diets simultaneously when a choice was offered, and use of a TMR instead of separate feeds or simpler mixtures.
(**Key words**: variety, feed intake, lactation, diet)

INTRODUCTION

Offering a choice of feeds (often described as a cafeteria regimen) can elicit hyperphagy in poultry, rats, and humans (12, 13, 14), although the response may depend on the degree of similarity of the feeds and whether the feeds are provided simultaneously or successively. The successive presentation of feeds did not affect intake or rate of BW gain of pigs growing from 25 to 90 kg (2); however, an initial short-term increase in feed consumption was noted.

Sheep consumed a mixture of feeds varying in energy density (1) and grazed a mixture of grass and clover (9) when both were available simultaneously. Reid and Jung (11) reported that hay intakes of sheep were higher under such circumstances. Beef cattle that were fed a single forage for a 3-wk period showed at least a short-term (3-d) increase in acceptance of an alternative forage after being offered a choice (10). Huber et al. (4) reported that 5-mo-old Holstein heifers consumed more DM when they were offered a choice of corn and grass silages than when offered either feed alone; however, a choice was offered only during the third of three 28-d periods, which confounds interpretation of dietary variety with period.

Lactating dairy cows are often fed different feeds, or mixtures of feeds, or a TMR at various times throughout the day, but are rarely offered simultaneous choices. More DMI in early lactation could improve milk yield or energy balance; therefore, it is important to know whether something as simple as providing a choice of diets might increase DMI. Our objective was to determine whether a sweetened TMR or a choice of control TMR and sweetened TMR affected DMI, milk yield, or milk composition.

MATERIALS AND METHODS

A switchback experiment was conducted with three 2-wk periods and two sequential blocks of 6 Holstein cows that were 42 to 85 d into the second or later lactation. This design allowed all possible orders of three treatments (ABA, ACA, BAB, BCB, CAC, and CBC, where A, B, and C represent treatments) to be evaluated in each block. One diet was a control TMR, which consisted of alfalfa haylage, corn silage, and a concentrate mixture based on ground corn and soybean meal (Table 1; 25:25:50 on a DM basis). The second diet was a sweetened TMR in which a mixture

Received May 3, 1996.
Accepted November 12, 1996.

of soybean meal and brown sugar food product [a by-product from sugar food items such as sucrose (granular sugar, powdered sugar, or brown sugar), dextrose, fructose, lactose, hard candy, dry beverage mix, dried gelatin mixes, and similar specialty foods and ingredients; marketed by Agricultural Division, International Ingredient Corp., St. Louis, MO] was substituted for the concentrate mixture. The brown sugar food product was 1.5% of the dietary DM, and both TMR were formulated to have the same CP concentration. The concentration of sweetener was chosen based on previous data (8) that indicated that cows in early lactation (8 to 21 DIM) preferred a sweetened TMR (with a concentration of sucrose that was similar to that of the TMR containing the brown sugar food product) to an unsweetened TMR.

Cows were fed amounts to allow at least 10% orts at 1030 and 1630 h. Cows were milked at 0530 and 1530 h. Housing was in a tie-stall barn except during milking and during the exercise period on a dirt lot between the a.m. milking and feeding. Orts were removed during the exercise period. The feed bunks were divided in half (left and right) by a wooden partition, and water was available for ad libitum intake via cups that were suspended above the feed bunk on the right side of the cow.

Diets consisted of the control TMR fed on both sides of the feed bunks, the sweetened TMR fed on both sides of the feed bunks, or both TMR fed on alternating (daily) sides of the feed bunks. When a choice of diets was offered, sides were alternated to avoid the lateral preference effects that had been encountered in a previous experiment and that may have been related to water cup placement (6). The first 4 d of each 14-d period were for adaptation to the dietary treatments, and the next 10 d were for data collection. The 4-d adaptation period was included primarily to reduce short-term effects of treatment changes on DMI and secondarily for adjustment of rumen microbes. Orts were sampled from each side of the feed bunks of all cows daily before the a.m. feeding during the collection periods to allow calculation of DMI.

Milk fat, protein, and SCC concentrations were determined (Dairy Lab Services, Dubuque, IA) for samples of two consecutive milkings in wk 2 of each treatment period; samples had been composited based on milk yields. The SNF contents of the composite samples were determined according to methods of Golding (3).

The TMR were adjusted weekly based on the DM (55°C) contents of dietary ingredients. The nutrient concentrations of dietary ingredients and TMR (Table 1) were determined by wet chemistry (Northeast DHIA Forage Testing Laboratory, Ithaca, NY) for composites of the weekly samples, which had been kept frozen (–20°C) throughout the experiment. Weather data were from instruments in the center of a similar, adjacent barn and from an official weather station operated by the Illinois Water Survey, which was located approximately 1 km from the barns. Both sites provided data for daily maximum and minimum ambient temperatures, and relative humidity was recorded in the barn between 1200 and 1300 h.

Analysis of variance was as described in the computational example outlined by Lucas (5), except

TABLE 1. Nutrient composition of dietary ingredients and the TMR.

Measure	Alfalfa haylage	Corn silage	Concentrate mix[1]	TMR
DM, %	55.6	42.8	88.5	61.9
CP, % of DM	17.2	8.8	20.6	15.4
ADF, % of DM	45.8	24.4	3.8	22.3
NDF, % of DM	53.9	40.9	8.8	35.9
EE,[2] % of DM	2.1	3.2	3.7	2.9
NE_L, Mcal/kg of DM	1.06	1.63	1.83	1.56
Ca, % of DM	0.87	0.21	0.96	0.77
P, % of DM	0.27	0.25	0.52	0.36
Mg, % of DM	0.18	0.17	0.34	0.25
K, % of DM	2.77	0.97	0.97	1.63
Na, % of DM	0.014	0.003	0.748	0.428

[1]Contained 64.64% ground corn, 30.00% soybean meal, 1.64% calcium carbonate, 1.36% sodium bicarbonate, 0.91% dicalcium phosphate, 0.55% sodium chloride, 0.36% sodium sulfate, 0.27% magnesium oxide, and 0.27% of a trace mineral and vitamin mixture (Goodlife Inc., Effingham, IL) on an as-fed basis. The guaranteed analysis of the trace mineral and vitamin mixture was 0.25%, I, 2.0% Fe, 3.0% Mn, 0.5% Cu, 0.004% Co, 0.015% Se, 10% S, 7.5% K, 2200 IU/kg of vitamin A, 660 IU/kg of vitamin D, and 7709 IU/kg of vitamin E.

[2]Ether extract.

that two blocks of six cows each were used, treatment effects were partitioned into two single degree of freedom orthogonal comparisons, and two interactions of block and treatment were examined. One treatment effect was a comparison of the two diets fed alone, and the other was an overall effect of single diets versus a choice of diets. If either interaction of block with treatment was significant ($P < 0.10$), then both were included in the analysis; otherwise, the interactions were omitted from the ANOVA.

A separate ANOVA was conducted to examine potential differences in DMI between the control TMR and the sweetened TMR when a choice of diet was offered. In the switchback design, 4 cows never received a choice of diets, 4 cows received a choice of diet during one period, and 4 cows received a choice of diet during two periods. Because of this design, the model included the effects of cow (n = 8), period, the interaction of cow and period, diet, and the interaction of cow and diet. The effect of TMR was tested using the interaction of cow and diet.

RESULTS AND DISCUSSION

Treatment means and standard errors of the means are presented in Table 2. The DMI, BW, milk yield, and percentages of milk fat, protein, and SNF were similar ($P > 0.10$) when each diet was fed alone. A choice of diets did not affect any of these variables, and interactions of block and treatment were not significant.

The DMI and milk yields were 23% higher ($P < 0.001$) in block 2 than in block 1 (Table 3), and DMI and milk yields were closely correlated (r = 0.75). Milk protein percentages and BW were also higher ($P < 0.05$) for cows in block 2 than in block 1 by 10 and 6%, respectively. These differences are easily explained by the differences in environment and stage of lactation between the blocks (Table 4). Ambient temperatures were lower for cows in block 2, and cows in block 2 began lactation 2 wk earlier than did cows in block 1.

The SCC were affected ($P < 0.05$) by the interaction of block and treatment when the diets were offered alone. For block 1, the mean SCC were 144,000 and 98,000/ml for cows fed control and sweetened TMR, respectively. For block 2, the respective mean SCC were 806,000 and 480,000/ml. One cow fed the control diet had clinical mastitis during the first period of block 2, which probably explains the higher SCC in block 2.

During early lactation, cows demonstrated a preference for sweetened TMR in a sequential elimination trial (8); however, DMI was not significantly affected when a similar TMR was fed alone in a 12-wk trial (7). The results of the present experiment also indicated that a sweetened TMR was preferred

TABLE 2. Treatment means for DMI, BW, milk yield, and milk composition.

Measure	Control TMR	Sweetened TMR	Choice[1]	SEM[2]
DMI, kg/d	21.1	21.0	20.8	0.4
BW, kg	594	592	594	5
Milk				
Yield, kg/d	31.1	30.9	30.8	0.6
Fat, %	3.10	3.44	3.52	0.25
Protein, %	2.77	2.81	2.77	0.05
SNF, %	7.80	7.66	7.79	0.13
SCC, $\times 10^3$/ml	462	138	330	183

[1]Mean DMI for cows offered the control TMR and the sweetened TMR were 9.2 and 10.4 kg (SE = 0.3; $P < 0.02$), respectively, when a choice of TMR was offered.

[2]n = 12.

TABLE 3. Block means for DMI, BW, milk yield, and milk composition.

Measure	Block 1	Block 2	$P <$
DMI, kg/d	18.8	23.1	0.001
BW, kg	576	611	0.05
Milk			
Yield, kg/d	27.8	34.1	0.001
Fat, %	3.42	3.28	NS[1]
Protein, %	2.66	2.92	0.05
SNF, %	7.79	7.70	NS
SCC, $\times 10^3$/ml	146	474	NS

[1]$P > 0.10$.

TABLE 4. Block means for DIM and weather conditions.

Measure	Block 1	Block 2
DIM[1]		
$\bar{X}$	67	53
SD	15	10
Weather		
Barn[2]		
Maximum, °C	30.7	23.2
Minimum, °C	23.6	16.5
Relative humidity, %	72.2	68.1
Station[3]		
Maximum, °C	31.2	22.9
Minimum, °C	20.0	8.6

[1]At the start of the experiment.

[2]Data from instruments in the center of a similar, adjacent barn.

[3]Data from an official weather station operated by the Illinois Water Survey and located approximately 1 km from the barns.

when a choice of diets was offered (Table 2; $P < 0.02$). There were no intermediate (5 to 14 d) effects of either a sweetened TMR alone or a choice of diets on DMI or milk yield and composition. The absence of interactions of block and treatment for these variables indicated that the response was not affected by heat stress.

The results of this experiment may have been affected by the composition of the control TMR, its similarity to the sweetened TMR, availability of both TMR simultaneously when a choice of diets was offered, and use of a TMR rather than separate feeds or simpler mixtures. Additional studies are needed to address these issues specifically, to determine whether short-term effects are present, and to assess their practical importance.

ACKNOWLEDGMENTS

Appreciation is expressed to J. S. Zhu, K. A. Qian, and A. S. Heinzmann for their technical assistance.

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