Effect of Carbohydrate Source on Performance and Ruminal Responses of Dairy Cows Fed Low-Starch Diets

H. M. Dann[1], K. W. Cotanch[1], C. Kokko[1], K. Fujita[2], and R. J. Grant[1]

[1]William H. Miner Agricultural Research Institute, Chazy, NY

[2]ZEN-NOH National Federation of Agricultural Cooperative Associations, Tokyo, Japan

INTRODUCTION

- Regional field surveys indicate a shift to lower-starch diets for lactating cows
- Two basic feeding strategies for lower-starch diets include:
  - Increasing the forage to concentrate ratio of the diet
  - Replacing starch with nonforage fiber sources (NFFS)
- It is important to compare the relative cow responses to lower-starch diets with highly digestible NDF from either forage or nonforage feeds versus traditional higher-starch diets

OBJECTIVE

- To measure the effect of forage or NFFS on lactational and ruminal responses when fed to cows in lower-starch diets compared with a higher-starch control diet

MATERIALS & METHODS

3 × 3 Latin Square Design (21-d periods)

- 15 multiparous lactating Holstein cows (6 ruminally cannulated)
- Dietary treatments
  - Control diet (CON): 50% forage, 26% starch
  - High-forage diet (FOR): 63% forage, 21% starch
  - Nonforage fiber diet (NFFS): 50% forage, 21% starch

Data Collection

- Intake and milk yield (d 15 - 21)
- Milk composition (d 18 - 19)
- Chewing behavior (d 18 - 20)
- Ruminal fermentation measurements (d 18 - 20)

Statistical Analysis

- ANOVA with MIXED procedure of SAS
  - Repeated measures data, except ruminal measures, were reduced to period means for each cow and period
  - Fixed factors: treatment, period within square, and square
  - Random factor: cow within square

RESULTS

Table 1. Ingredients, chemical composition and digestibility of dietary treatments.

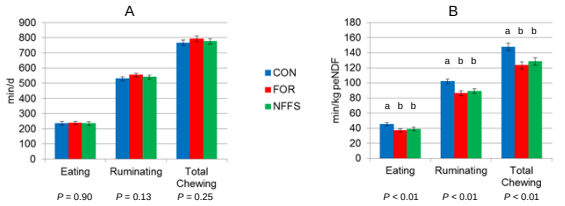
Item	CON	FOR	NFFS
Ingredients, % of ration DM			
Conventional corn silage	20.0	-	20.0
Brown midrib corn silage	20.0	53.3	20.0
Haycrop silage	10.0	10.0	10.0
Corn meal	15.0	-	3.7
Soybean meal	8.3	6.7	3.8
Beet pulp	5.0	5.0	10.8
Wheat middlings	5.0	5.0	10.8
Distillers dried grains with solubles	-	3.3	4.2
Canola meal	6.7	6.7	6.7
AminoPlus	4.3	4.3	4.3
Other	5.7	5.7	5.7
Analyses			
DM, %	45.7 ± 0.4	42.4 ± 0.5	45.7 ± 0.5
CP, %	16.6 ± 0.1	16.8 ± 0.1	16.3 ± 0.2
ADF, %	21.0 ± 0.2	23.1 ± 1.1	23.4 ± 0.6
NDR, %	34.7 ± 0.7	38.3 ± 1.6	38.0 ± 0.7
aNDF, %	32.0 ± 1.0	36.9 ± 0.4	35.8 ± 0.6
AD lignin, %	2.7 ± 0.0	2.7 ± 0.1	2.9 ± 0.0
peNDF, %	18.6 ± 1.0	24.5 ± 0.5	22.3 ± 0.4
Starch, %	26.0 ± 0.4	21.4 ± 0.7	21.3 ± 0.6
Sugar, %	7.0 ± 0.1	6.6 ± 0.3	6.9 ± 0.3
Fat, %	3.9 ± 0.1	3.7 ± 0.2	4.1 ± 0.2
24-h aNDF digestibility, % aNDF	54.1 ± 0.6	53.0 ± 1.1	51.6 ± 1.7
2-h starch digestibility, % starch	26.3 ± 1.1	29.2 ± 2.8	32.6 ± 2.4
7-h starch digestibility, % starch	75.2 ± 1.3	78.1 ± 2.1	79.7 ± 0.4

NDR = NDF with residual ash using α-amylase and without sodium sulfite.
aNDF = NDF with residual ash using α-amylase and sodium sulfite.

Table 2. Performance data.

Item	CON	FOR	NFFS	SE	*P*-value
DMI, kg/d	28.2^{x}	27.2^{y}	27.7^{xy}	0.8	0.08
DMI, % of BW/d	3.85^{a}	3.67^{b}	3.75^{ab}	0.10	0.02
aNDF intake, kg/d	9.1^{b}	10.0^{a}	9.9^{a}	0.3	<0.01
aNDF intake, % of BW/d	1.23^{b}	1.35^{a}	1.34^{a}	0.03	<0.01
peNDF intake, kg/d	5.2^{c}	6.5^{a}	6.1^{b}	0.2	<0.01
Milk, kg/d	51.6^{ax}	48.4^{by}	50.5^{abx}	2.3	<0.01
3.5% FCM, kg/d	52.6	51.7	52.4	2.0	0.78
SCM, kg/d	49.0	47.3	48.5	1.9	0.40
Fat, %	3.66^{y}	3.98^{x}	3.76^{xy}	0.17	0.07
Fat, kg/d	1.86	1.88	1.86	0.08	0.92
True protein, %	3.10	3.07	3.08	0.06	0.47
True protein, kg/d	1.58^{ax}	1.45^{by}	1.54^{abx}	0.05	0.01
MUN, mg/dL	11.2^{ab}	11.8^{a}	10.6^{b}	0.6	0.02
Milk/DMI	1.83	1.77	1.82	0.06	0.20
3.5% FCM/DMI	1.86	1.90	1.90	0.05	0.72
SCM/DMI	1.73	1.74	1.75	0.04	0.88
Milk N efficiency, %	35.7^{a}	33.9^{b}	36.4^{a}	0.7	<0.01

^{abc} Least squares means within a row without a common superscript differ ($P \leq 0.05$).
^{xy} Least squares means within a row without a common superscript differ ($P \leq 0.10$).



^{ab} Least squares means within a behavior without a common superscript differ ($P \leq 0.05$).

Figure 1. Chewing behavior expressed as minutes per day (A) and minutes per kilogram of peNDF (B).

Table 3. Ruminal fermentation data.

Item	CON	FOR	NFFS	SE	Trt	Time	Trt x Time
Mean pH	6.09	6.16	6.11	0.04	0.53	0.52	0.69
Range in pH	1.17^{x}	0.99^{xy}	0.92^{y}	0.08	0.06	-	-
SD pH	0.29^{ax}	0.22^{aby}	0.21^{by}	0.02	0.03	-	-
Time pH <5.8, min/d	292	133	190	64	0.23	-	-
Time pH <5.5, min/d	85^{x}	11^{y}	30^{xy}	22	0.09	-	-
Total VFA, m*M*	125.6	127.5	125.9	4.3	0.76	<0.01	0.44
Acetate, m*M*	72.2^{b}	76.2^{a}	74.7^{ab}	1.8	0.04	<0.01	0.19
Propionate, m*M*	26.8	24.4	25.3	1.8	0.39	<0.01	0.38
Butyrate, m*M*	13.7	14.7	14.7	0.8	0.25	<0.01	0.88
Acetate:Propionate	2.8	3.2	3.0	0.2	0.13	<0.01	0.48
Ruminal NH_3, mg/dL	7.2	7.2	5.7	0.7	0.24	<0.01	0.02
Microbial N, g/d	604	593	586	28	0.56	-	-

^{ab} Least squares means within a row without a common superscript differ ($P \leq 0.05$).
^{xy} Least squares means within a row without a common superscript differ ($P \leq 0.10$).

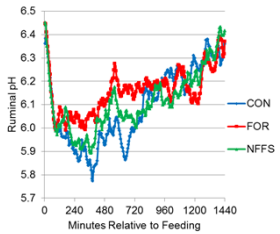


Figure 2. Ruminal pH.

CONCLUSIONS

- Lower-starch diets resulted in similar efficiency of production compared with a higher-starch, control diet.
- This study demonstrates the effectiveness of both a higher-forage and a NFFS strategy compared with the more traditional, higher-starch feeding approach.