Amount and digestibility of NDF affects rumen nutrient pool sizes and passage kinetics of dairy cows

Abstract W325

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INTRODUCTION

- Nutrient digestibility is a function of rate of digestion and passage
- NDF content is known to limit DMI of high producing dairy cows by contributing to gut fill
- Higher quality forage with improved NDF digestibility (NDFD) affects rates of digestion and passage, DMI, and milk yield
- Understanding how the amount and digestibility of NDF affect rumen pool size and turnover rate will allow improved feeding practices with higher quality forages

OBJECTIVE

To determine how the amount and digestibility of dietary forage NDF, primarily from corn silage, affects intake, production, rumen NDF pool size and passage kinetics in lactating dairy cows

MATERIALS & METHODS

Experimental Design

- 4 x 4 Latin square (21-d periods)
  - 13 d of dietary adaptation, 8 d of sampling
- 8 ruminally cannulated, multiparous lactating Holstein cows (88 DIM, 685 kg BW)

Diet Formulation

- 2 levels of forage – High (H) and Low (L)
- 2 sources of CS - Conventional (CCS) and BMR (BMR)
- Within forage level diets balanced on NDF basis, similar %NDF from CS
  - **LCCS** – Low forage conventional corn silage
  - **HCCS** – High forage conventional corn silage
  - **LBMR** – Low forage BMR corn silage
  - **HBMR** – High forage BMR corn silage

Table 1. Characterization of forages

Forage	DM	NDF	ADL	Starch	aNDFD$_{24}$
CCS	37.1	36.6	3.0	36.0	39.0
BMR	36.4	38.3	2.4	34.5	50.8
HCS	36.5	48.1	5.1	1.3	56.5

Table 2. Formulated Diets

	LCCS	HCCS	LBMR	HBMR
TMR NDF, %DM	29.1	33.7	30.0	34.5
NDF from CS, %DM	14.8	20.7	14.6	20.4
% NDF from CS	50.8	61.6	48.7	58.9

Table 3. Ingredient and nutrient composition of diets

Item	LCCS	HCCS	LBMR	HBMR
Ingredient, %DM				
CCS	39.3	55.0	-	-
BMR	-	-	36.1	50.2
HCS	13.4	13.4	13.3	13.3
Corn meal	17.3	1.6	20.4	6.3
Grain mix	30.1	30.1	30.1	30.1
% Forage	52.7	68.4	49.4	63.5
Chemical composition, %				
DM	52.2	45.8	52.8	47.0
CP	17.0	17.0	16.7	16.7
αNDF[1]	32.1	35.6	31.5	35.1
ADF	19.4	23.0	19.3	22.0
AD-Lignin	3.1	3.6	2.7	2.9
Starch	28.0	21.2	27.8	23.8
Fat	4.0	3.9	4.4	4.5
Ash	7.2	7.6	8.2	7.8
αNDFD$_{24}$[2], %αNDF	56.3	54.0	62.0	60.3

[1]αNDF = αNDF with residual ash using amylase and sodium sulfite
[2]αNDFD$_{24}$ = 24-h in vitro digestibility of NDF

Data and sample collection

- Performance DMI, NDF intake, milk, FCM
- Total Tract Digestibility
  - Fecal grab samples collected d 17 – d 20 and composited by cow
  - DM, OM, ADF, NDF, cellulose and hemicellulose
  - 120h IV digestion (Ankom Daisy system)
- Rumen pools of NDF and OM
  - Manual evacuations 4 h before and after feeding on d 20 and 21, respectively
  - Total contents weighed and volume determined
  - Subsamples analyzed for αNDF and OM content

Statistical Analysis

- Replicated Latin square with the MIXED procedure of SAS with fixed effects of diet, period, and replicate. Cow within square was the random effect

Interior of rumen after evacuation

RESULTS

Table 4. Performance data[1]

Item	LCCS	HCCS	LBMR	HBMR	SE	*P*-value
DMI, kg/d	29.0^{a}	26.5^{b}	29.3^{a}	29.2^{a}	0.7	<0.01
DMI, % of BW/d	4.31^{a}	3.96^{b}	4.37^{a}	4.36^{a}	0.12	<0.01
NDF intake , kg/d	9.36^{b}	9.47^{b}	9.32^{b}	10.25^{a}	0.22	<0.01
NDF intake, % of BW/d	1.39^{b}	1.41^{b}	1.39^{b}	1.53^{a}	0.04	<0.01
Milk yield, kg/d	47.0^{a}	43.1^{b}	48.6^{a}	47.2^{a}	1.6	<0.01

[1]Results from the performance study are presented in Abstract #
^{ab}Least squares means within a row without a common superscript differ ($P \leq 0.05$).

Table 5. Ruminal digesta characteristic and pool size data

Item	LCCS	HCCS	LBMR	HBMR	SE	*P*-value
Digesta volume, L	123^{ab}	128^{a}	113^{b}	119^{ab}	3	0.01
Digesta mass, kg	106^{ab}	112^{a}	98^{b}	105^{ab}	3	0.02
Ruminal pool, kg						
NDF	8.32^{ab}	8.45^{a}	7.64^{b}	8.36^{ab}	0.41	0.02
OM	13.0	12.5	12.1	12.6	0.6	0.40
Ruminal turnover rate, %/h						
NDF	4.84^{b}	4.76^{b}	5.12^{ab}	5.52^{a}	0.30	<0.01
OM	8.95^{ab}	8.31^{b}	9.44^{a}	9.57^{a}	0.51	<0.01
Ruminal turnover time, h						
NDF	21.1^{a}	21.4^{a}	20.3^{ab}	19.0^{b}	1.1	0.01
OM	11.4^{ab}	12.2^{a}	11.0^{b}	10.9^{b}	0.5	<0.01

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

Table 6. Total tract digestibility data

Item, %	LCCS	HCCS	LBMR	HBMR	SE	*P*-value
DM	72.1^{a}	68.0^{b}	72.9^{a}	71.9^{a}	0.71	<0.01
OM	73.7^{a}	70.0^{b}	74.7^{a}	73.9^{a}	0.71	<0.01
ADF	50.0^{a}	44.2^{b}	52.4^{a}	51.2^{a}	1.29	<0.01
NDF	54.0^{a}	49.0^{b}	56.9^{a}	55.9^{a}	1.25	<0.01
Cellulose	59.5^{ab}	56.2^{b}	62.5^{a}	62.9^{a}	1.38	<0.01
Hemicellulose	59.9^{ab}	56.7^{b}	64.2^{a}	63.7^{a}	1.74	0.01

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

SUMMARY

- The high forage diet of lower NDFD (HCCS) significantly reduced DMI and milk yield
- NDF intake was significantly higher on the HBMR diet
- Ruminal digesta mass (kg) and volume (L) was lowest for LBMR.
- HCCS diet had the lowest turnover rate, highest turnover time and lowest TTD of DM, OM, ADF, NDF cellulose and hemicellulose.
- Ruminal turnover rate of OM and NDF is higher for high NDFD forage-based rations (Low and High BMR)
- Ruminal turnover rate and TTD were reduced for low-NDFD forages at a high rate of inclusion in the ration (HCCS)

IMPLICATIONS

- High NDFD forage-based rations have increased turnover rate of OM and NDF regardless of % forage in diet
  - These nutritional considerations may affect the passage and digestion of other nutrients including starch, protein and fatty acids
- Optimal level of forage in TMR for production and rumen health will vary with quality of NDF (NDFD) and may be greater than 65% of ration