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Effects of dietary nonforage fiber sources and starch levels on nutrition digestion and rumen fermentation of fattening Hu lambs

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Abstract

The primary objectives of this experiment were to study the effects of fiber sources [beet pulp (BP) vs. soybean hull (SH)] and dietary starch levels [low = 22% dry matter (DM), medium = 25% DM, and high = 27% DM] on nutrition digestion, rumen parameters and rumen bacteria in fattening Hu lambs. A total of 360 Hu lambs were assigned a 2×3 factorial arrangements, including a 63-day experimental periods. Six diets were formulated to include two fiber sources and three starch levels, and the samples including feed, feces, rumen contents, and rumen fluids were collected in different experimental periods. Analysis of fiber sources and starch levels was performed using one-way ANOVA by SPSS software version 17.0 (IBM, Armonk, NY, United States). The digestibility of neutral detergent fiber (NDF) declined in (P = 0.005) increasing starch contents. Increasing starch levels increased the proportion of propionate (P = 0.002) and valerate (P = 0.001) and decreased the proportion of acetate (P < 0.001) and the ratio of acetate/propionate (P = 0.005). At the genus level, increasing starch levels reduced the abundance of Butyrivibrio_2 (P = 0.020). Nevertheless, the ADF digestibility was greater (P < 0.01) in lambs fed SH than lambs fed BP. The concentrations of butyrate were higher (P = 0.005) while the rumen pH was less (P = 0.001) in lambs fed BP than those fed SH. Fiber sources influenced the abundance of *Succiniclasticum*, *Candidatus_Saccharimonas*, *Ruminococcus_1* and *Christensenellaceae_R-7*, which were higher in lambs fed SH compared with those fed BP (P < 0.05). In summary, fiber sources mainly changed the abundance of cellulolytic bacteria in the rumen community.

Introduction

Feeding high cereal grains diets rapidly fermented and produced amounts of volatile fatty acids (VFA) and reduced rumen pH, and increased the risks of subacute ruminal acidosis (SARA) or acute ruminal acidosis (ARA) (Penner et al., 2007; Fernando et al., 2010). Previous studies reported the partial replacement of cereals grain with cost-effective, low-starch nonforage fiber sources (NFFS), which was a potential alternative to help overcome these issues (Ranathunga et al., 2010). However, to our knowledge, it is unknown how nutrient digestion, and rumen fermentation are affected by interaction of feeding NFFS and starch levels in ruminants. Thus, this study was performed to quantify the effects of NFFS and starch levels on nutrient digestion and microbial populations of fattening Hu lambs.

Materials and methods

A total of 360 weaning Hu lambs (BW = 24.72 ± 0.14 kg, 2 months old) were housed in pens. Lambs randomly assigned 6 treatments with 6 repetitions (10 lambs per unit) in each treatment according to their BW and age. Dietary treatments were administered according to a 2×3 factorial arrangements including two fiber sources (BP vs. SH) with three starch levels (low = 22% DM, medium = 25% DM, and high = 27% DM). All diets were prepared in the form of totally mixed ration (TMR) pellets. The trial started after two weeks of adaption and included 63 d of data collection. The feed was provided at 0800 h and 1800 h for ad libitum consumption, and the animals were provided free access to water. The samples including feed, feces, rumen contents, and rumen fluids were collected in different experimental periods

Results

Table 1 Effects of dietary fiber sources and starch levels on apparent digestibility

Fiber sources	Beet pulp			Soybean hulls			SEM[a]	*P*-value		
Starch levels (%)	27 High	25 Medium	22 Low	27 High	25 Medium	22 Low		Fiber sources	Starch level	Interaction
Intake, kg/d										
DM[b]	1.42	1.18	1.36	1.29	1.36	1.29	0.215	0.911	0.602	0.211
OM[c]	1.33	1.11	1.27	1.22	1.27	1.21	0.201	0.992	0.603	0.218
NDF[d]	0.32	0.32	0.35	0.37	0.45	0.46	0.105	0.004	0.284	0.574
ADF[e]	0.17	0.17	0.17	0.23	0.25	0.24	0.057	<0.001	0.899	0.660
Apparent digestibility, %										
DM	59.70	59.50	59.20	57.20	57.40	56.80	0.008	0.168	0.971	0.997
OM	63.10	63.40	63.10	62.80	62.40	61.90	0.007	0.599	0.967	0.970
CP[f]	58.30	58.70	56.00	60.10	62.70	58.30	0.007	0.052	0.114	0.767
NDF	36.50	44.40	50.40	41.90	51.60	52.20	0.017	0.106	0.005	0.746
ADF	28.80	32.90	37.40	37.70	45.00	45.40	0.019	0.009	0.154	0.873

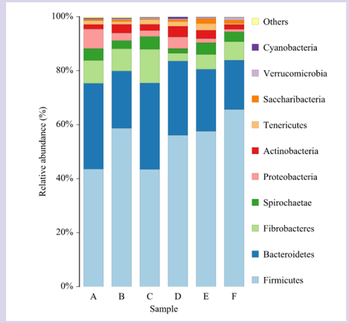
[a]SEM = standard error of the sample mean; [b]DM = dry matter; [c]OM = organic matter; [d]NDF = neutral detergent fiber; [e]ADF = acid detergent fiber; [f]CP = crude protein.

Table 2 Effects of dietary fiber sources and starch levels on rumen fermentation parameters

Fiber sources	Beet pulp			Soybean hulls			SEM[a]	*P*-value		
Starch level (%)	s 27 High	25 Medium	22 Low	27 High	25 Medium	22 Low		Fiber sources	Starch level	Interaction
TVFA[b], mmol/L	85.61	76.95	77.04	64.49	70.64	87.09	2.849	0.304	0.433	0.082
VFA molar ratios, mol/100 mol										
Acetate, %	55.19	59.63	59.93	55.45	60.76	60.14	0.589	0.631	<0.001	0.928
Propionate, %	30.02	26.09	25.45	32.31	26.38	26.90	0.681	0.301	0.002	0.817
Isobutyrate, %	0.40	0.75	0.59	0.55	0.56	0.70	0.041	0.751	0.128	0.158
Butyrate, %	11.58	11.23	11.62	8.76	9.91	10.18	0.333	0.005	0.656	0.576
Isovalerate, %	0.54	0.85	0.88	1.13	1.05	0.95	0.087	0.102	0.861	0.446
Valerate, %	2.27	1.46	1.53	1.80	1.36	1.14	0.088	0.052	0.001	0.629
A/P[c]	2.00	2.40	2.45	1.80	2.46	2.38	0.076	0.644	0.005	0.788
Rumen pH	6.18[c]	6.77[ab]	6.57[b]	6.89[a]	6.72[ab]	6.64[ab]	0.044	0.001	0.080	<0.001
Lactate, mmol/L	0.67	0.61	1.94	1.32	0.72	0.72	0.140	0.379	0.423	0.536

[a]SEM = standard error of the sample mean; [b]TVFA= total volatile fatty acids; [c]A/P= Acetate/Propionate.

Figure.1 The distribution histogram of the rumen bacteria by fiber sources and starch levels at the phylum level (%)



Note: A = 27 % starch of beet pulp; B = 25% starch of beet pulp; C = 22% starch of beet pulp; D = 27% starch of soybean hulls; E = 25% starch of soybean hulls; F = 22% starch of soybean hulls.

Conclusions

The digestibility of NDF declined in increasing starch contents. Increasing starch levels increased the proportion of propionate and valerate and decreased the proportion of acetate and the ratio of acetate/propionate. At the genus level, increasing starch levels reduced the abundance of *Butyrivibrio_2*.

ADF digestibility was greater in lambs fed SH than lambs fed BP. The proportion of butyrate were higher while the rumen pH was less in lambs fed BP than those fed SH. Fiber sources influenced the abundance of *Succiniclasticum*, *Candidatus_Saccharimonas*, *Ruminococcus_1* and *Christensenellaceae_R-7*, which were higher in lambs fed SH compared with those fed BP.

In summary, fiber sources mainly changed the abundance of cellulolytic bacteria in the rumen community.

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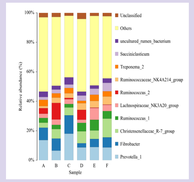
Figure. 2 The distribution histogram of the rumen bacteria by fiber sources and starch levels at the genus level (%)



Note: A = 27 % starch of beet pulp; B = 25% starch of beet pulp; C = 22% starch of beet pulp; D = 27% starch of soybean hulls; E = 25% starch of soybean hulls; F = 22% starch of soybean hulls.

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