



Effects of barley substitute corn in diet on growth performance, nutrient digestibility, rumen fermentation and rumen microorganisms of fattening Hu sheep

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Abstract

The purpose of this experiment was to study the effects of fattening Hu sheep diet with barley starch instead of corn starch in different proportions on the production performance, nutrient digestion, rumen fermentation parameters and rumen microbial of fattening Hu sheep. In this experiment, 72 Hu lambs (average BW:29.70 ± 1.70 kg) were selected and randomly divided into 4 treatments according to single factor block experiment. Each treatment included 18 replicates(n=18) and each sheep was raised in individual pen. Barely starch (BS) and corn starch (CS) were the starch source of the diets. Four treatments are BS-0 group(0%BS+100%CS), BS-33 group(33%BS+66%CS), BS-66 group(66%BS+33%CS), BS-100 group(100%BS+0%CS). The experiment lasted for 79 days with 7 days pre-feeding period and 63 days formal period(n=18), the last 6 days and 3 days were assigned to the digestibility(n=6) and sampled(n=10) after slaughter respectively. All data were analyzed using the one-way ANOVA of SPSS 25.0. The results showed that the DM, OM, NDF and ADF digestibility of BS-0 group were higher than BS-100 group (*P*<0.05), the DM, OM and NDF digestibility of BS-66 group were higher than BS-100 group. Total VFA concentration of BS-66 and BS-100 is significantly higher than BS-33 and BS-0 (*P*<0.05), the propionate concentration of BS-33 is lower than BS-66 (*P*<0.05). The ruminal pH and NH₃-N concentration of BS-33 are higher than BS-66 (*P*<0.05).BS-0 group with a higher ACE Chao1 and Shannon index has a more diversity ruminal microorganism than BS-100. At the phylum level, the abundance of Firmicutes decreased and the abundance of Proteobacteria increased in BS-100(*P*<0.05). At the genus level, treatment have not affect the rumen microorganisms. These results indicated that the feeding efficiency of corn starch has positive affect than barley starch. 66% barley starch substitutes corn starch can improve nutrient digestibility and be good for rumen health.

Introduction

In the traditional diet formula, the energy feed of livestock, poultry and ruminants is mainly corn, resulting in an increasingly tight supply of corn in China. Barley plays an important role in China's grain production, and its demand and supply are second only to rice, wheat and corn. Under the same treatment, the rapid degradation of barley grains has a higher risk of rumen acidosis than corn grains. Several studies have shown that the sources of cereals and the different proportions of additives have a positive impact on the performance and feed efficiency of fattening cattle. Therefore, we hypothesized that the mixed effects of barley grains and corn grains had positive effects on the productivity and total digestive digestibility of the fattening ruminants. The objective of this study was to evaluate the effect of replacement of corn starch with barley starch on growth performance, nutrient digestibility, fermentation parameters, fatty acid composition of meat and rumen microbial of fattening Hu sheep.

Research content and results

❖ Nutrient digestion and Rumen fermentation parameters

Table 1. Effects of the barley ration in diets on nutrient apparent digestibility of fattening Hu sheep (n=6)

Items	Barley ¹				SEM ²	P value	
	BS-0	BS-33	BS-66	BS-100		L ³	Q ⁴
Digestibility of DM ⁵	72.55 ^a	69.89 ^a	70.70 ^a	64.87 ^b	0.74	<0.001	0.293
Digestibility of CP ⁶	78.92	78.41	79.46	77.31	0.46	0.427	0.383
Digestibility of OM ⁷	74.30 ^a	72.70 ^a	72.79 ^a	67.39 ^b	0.67	<0.001	0.128
Digestibility of NDF ⁸	66.26 ^a	60.34 ^b	60.81 ^b	53.58 ^c	1.10	<0.001	0.808
Digestibility of ADF ⁹	46.25 ^a	39.71 ^b	41.69 ^{bc}	28.80 ^c	1.62	<0.001	0.322

^{a,b,c} Means within a row without a common superscript letter differ significantly at *P*<0.05;

¹ Dietary Barley levels defined by its proportion of starch in diets: BS-0, 0% starch in diets were provided by barley; BS-33, 33% starch in diets were provided by barley; BS-66, 66% starch in diets were provided by barley; BS-100, 100% starch in diets were provided by barley;² Standard error of the sample mean;³ Linear;⁴ Quadratic;⁵ Dry matter;⁶ Crude protein;⁷ Organic matter;⁸ neutral detergent fiber;⁹ acid detergent fiber.

Table 2. Effect of the barley ration in diets on rumen fermentation parameters of fattening Hu sheep (n=10)

Items	Barley ¹				SEM ²	P value	
	BS-0	BS-33	BS-66	BS-100		L ³	Q ⁴
TVFA ⁵ , mmol/L	103.88 ^b	93.68 ^b	121.37 ^a	126.12 ^a	3.441	<0.001	0.831
Acetate, mmol/L	48.70	46.03	55.61	56.23	1.662	0.061	0.853
Propionate, mmol/L	39.19 ^a	26.28 ^b	43.40 ^a	46.74 ^a	2.539	0.014	0.297
Isobutyrate, mmol/L	0.38	0.45	0.34	0.34	0.038	0.711	0.846
Butyrate, mmol/L	12.27	17.46	17.75	18.93	1.471	0.408	0.400
Isovalerate, mmol/L	0.73	0.93	0.41	0.47	0.080	0.070	0.822
Valerate, mmol/L	2.61	2.52	3.85	3.41	0.262	0.214	0.384
Acetate/propionate	1.32	1.79	1.30	1.35	0.093	0.203	0.501
pH	5.27 ^b	5.42 ^a	5.18 ^b	5.25 ^b	0.028	0.014	0.910
NH ₃ -N, mg/100ml	28.72 ^{ab}	30.49 ^a	25.63 ^b	27.49 ^{ab}	0.645	0.045	0.431

^{a,b,c} Means within a row without a common superscript letter differ significantly at *P*<0.05;

¹ Dietary Barley levels defined by its proportion of starch in diets: BS-0, 0% starch in diets were provided by barley; BS-33, 33% starch in diets were provided by barley; BS-66, 66% starch in diets were provided by barley; BS-100, 100% starch in diets were provided by barley.

² Standard error of the sample mean;³ Linear;⁴ Quadratic;⁵ Total volatile fatty acids.

The results for nutrient digestion of fattening Hu sheep of barley ration in diets are presented in Table 1. The digestibility of CP was not affected throughout the digestibility trail (*P*>0.05), while barley ration in diets were significantly affected the digestibility of DM, OM, NDF and ADF (*P*<0.001). The barley ration in diets was associated with a liner decrease in the digestibility of DM, OM, NDF and ADF. The digestibility of DM and OM were decreased at 100% barley starch levels compared to 66%, 33% and 0% barley starch levels (*P*<0.001). The digestibility of NDF was decreased at 100% barley starch levels compared to 66%, 33% and 0% barley starch levels (*P*<0.001), with higher values for the 0% treatments. The digestibility of ADF was decreased at 100% barley starch levels compared to 33% and 0% barley starch levels (*P*<0.001), with higher values for the 0% treatments

The nutrient digestibility measurement using a modified method of acid-insoluble ash (AIA). The results for rumen fermentation parameters of fattening Hu sheep of the barley ration in diets are presented in Table 2. The increase of barley in the diets had a liner and quadratic effect on propionic acid for the proportion of the total volatile fatty acids in rumen fluid, with lower values for the BS-33 treatments (*P*<0.05). The total VFA concentration in rumen fluid, and acetic acid, isobutyric acid, butyric acid, isopentanoic, pentanoic acid accounted for the proportion of the total volatile fatty acids were not affected by dietary treatments (*P*>0.05).The increase of barley in the diets had a quadratic effect on the ratio acetic/propionic acids, with higher values for the BS-33 treatments.

Research content and results

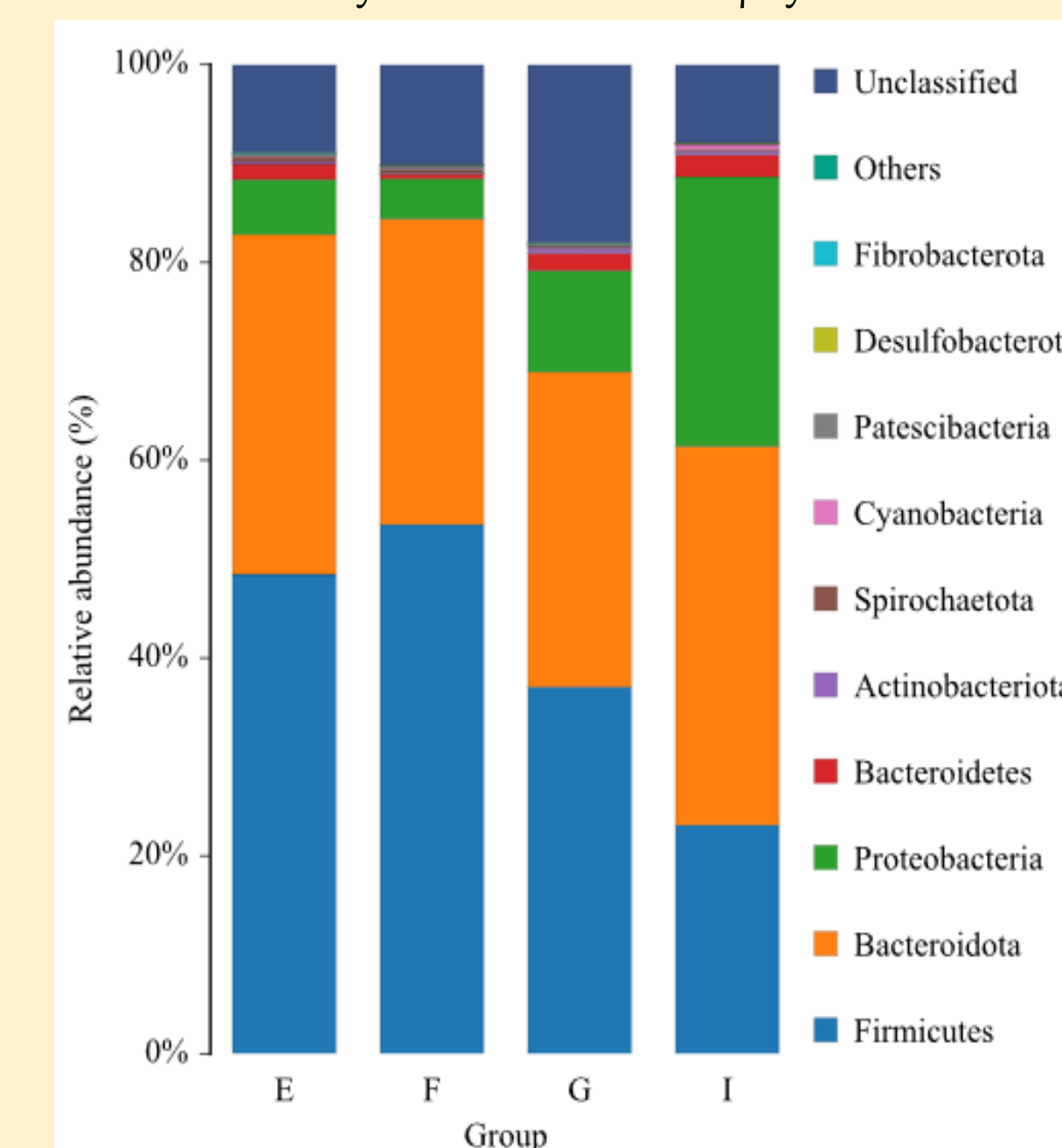
❖ The diversity of ruminal microorganism

Table 3. Effect of the barley ration in diets on differences in the diversity of ruminal microorganism of fattening Hu sheep

Items	Barley ¹				SEM ²	P value	
	BS-0	BS-33	BS-66	BS-100		L ³	Q ⁴
OTU	126.13	120.50	117.13	98.75	3.963	0.074	0.647
ACE	188.82 ^a	161.80 ^{ab}	157.60 ^{ab}	135.57 ^b	6.427	0.025	0.526
Chao1	174.52 ^a	160.89 ^{ab}	152.13 ^{ab}	128.88 ^b	5.699	0.028	0.966
Simpson	0.10	0.16	0.14	0.16	0.011	0.122	0.265
Shannon	3.21 ^a	2.87 ^{ab}	2.85 ^{ab}	2.64 ^b	0.071	0.027	0.387

❖ The rumen bacteria abundance at the phylum and the genus level

Figure 1. The distribution histogram of the rumen bacteria by barley starch levels at the phylum level

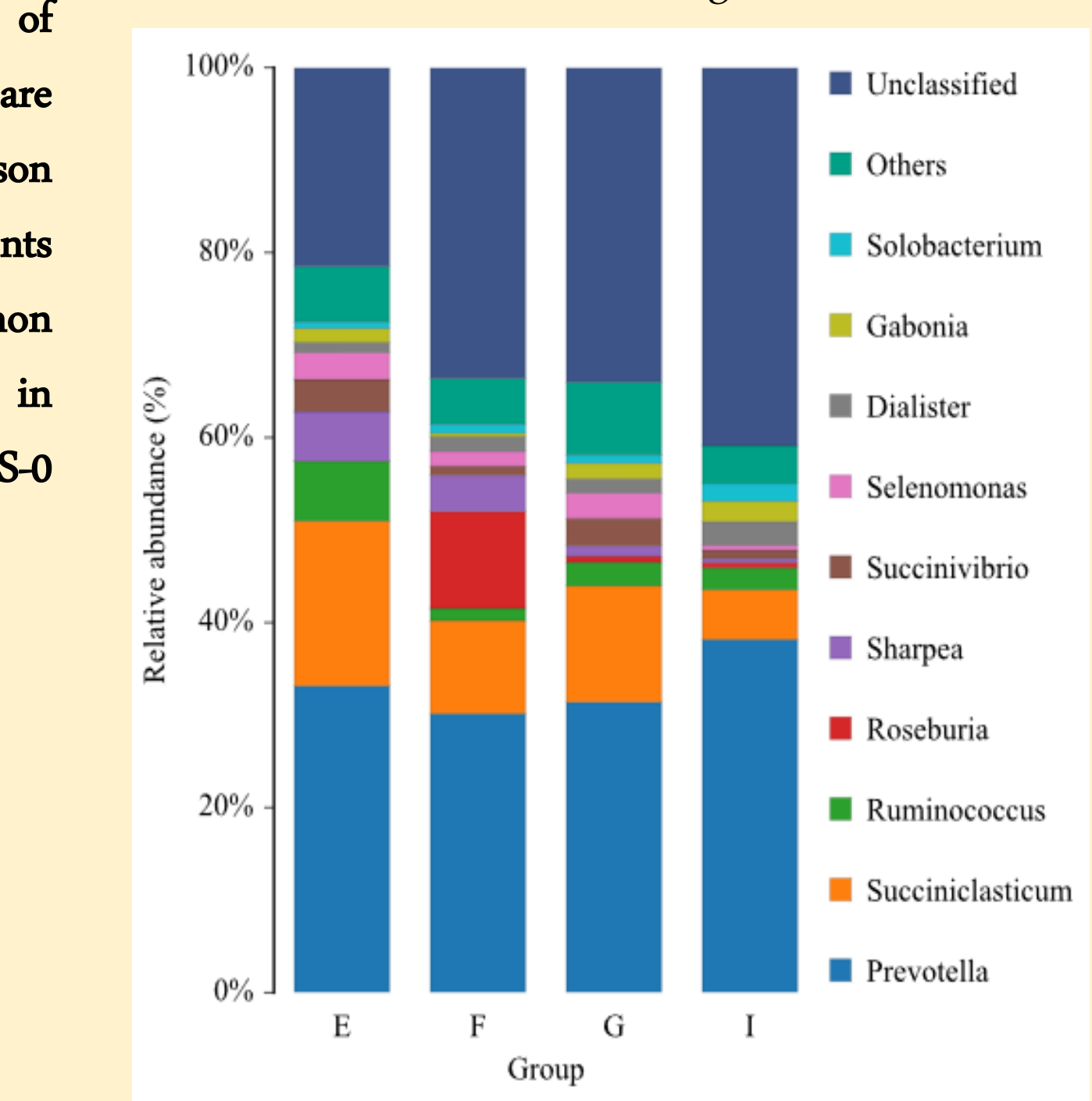


Note: E means BS-0 group, 0% starch in diets were provided by barley; F means BS-33 group, 33% starch in diets were provided by barley; G means BS-66 group, 66% starch in diets were provided by barley; I means BS-100, 100% starch in diets were provided by barley.

Table 4. Effect of the barley ration in diets on rumen bacteria abundance at the phylum level (%)

Items	Barley ¹				SEM ²	P value	
	BS-0	BS-33	BS-66	BS-100		L ³	Q ⁴
Firmicutes	47.89 ^{ab}	53.88 ^a	37.11 ^{bc}	24.99 ^c	2.965	0.001	0.373
Bacteroidota	34.47	28.56	32.45	36.78	2.686	0.756	0.461
Proteobacteria	5.71 ^b	5.23 ^b	11.39 ^b	25.92 ^a	2.633	0.011	0.317
Bacteroidetes	1.45	0.53	1.96	2.43	0.464	0.530	0.702
Actinobacteriota	0.20	0.08	0.50	0.35	0.068	0.137	0.472
Spirochaetota	0.50	0.32	0.18	0.20	0.058	0.195	0.233
Cyanobacteria	0.10	0.13	0.05	0.40	0.087	0.518	0.420
Patescibacteria	0.20	0.31	0.09	0.03	0.043	0.084	0.705
Desulfobacterota	0.03	0.08	0.09	0.14	0.019	0.205	0.765
Fibrobacterota	0.14	0.08	0.12	0.03	0.035	0.729	0.865
Unclassified	9.24	10.75	16.02	8.73	1.457	0.276	0.088
Planctomycetota	0.02	0.02	0.01	0.00	0.005	0.394	0.900
Synergistetes	0.04	0.03	0.04	0.01	0.008	0.621	0.847

Figure 2. The distribution histogram of the rumen bacteria by barley starch levels at the genus level



The results for ruminal microorganism of fattening Hu sheep of barley ration in diets are presented in Table 3. The OUT and Simpson indexes were not affected by dietary treatments (*P*>0.05), But the ACE, Chao1 and Shannon were significantly affected by barley ration in diets. The ACE, Chao1 and Shannon of BS-0 are higher than BS-100 group (*P*<0.05)

Table 5. Effect of the barley ration in diets on rumen bacteria abundance at the genus level (%)

Items	Barley ¹				SEM ²	P value	
	BS-0	BS-33	BS-66	BS-100		L ³	Q ⁴
Prevotella	33.21	27.86	32.05	36.66	2.673	0.729	0.487
Succinivibrio	16.33	11.45	12.59	5.86	1.963	0.311	0.953
Ruminococcus	7.18	1.24	1.99	2.60	1.236	0.330	0.174
Roseburia	0.02	7.62	0.81	0.83	1.900	0.472	0.497
Sharpea	5.08	2.76	0.93	0.48	1.130	0.482	0.497
Succinivibrio	3.50	1.97	3.68	1.03	0.933	0.729	0.748
Selenomonas	3.84	1.55	2.98	0.55	0.542	0.136	0.972
Dialister	1.04	2.38	1.44	2.41	0.476	0.687	0.889
Gabonia	1.40	0.42	1.89	2.39	0.466	0.504	0.677
Solobacterium	0.63	1.19	0.88	1.46	0.318	0.820	0.990
Unclassified	22.15	36.78	32.62	41.25	3.038	0.140	0.521

Conclusion and perspective

We did not observe the advantages brought by the combination of two cereals similar to previous studies. These results indicated that the feeding efficiency of corn starch has a positive affect than barley starch, which had a higher nutrients digestibility and diversity of ruminal microorganism. 66% barley starch substitutes corn starch can improve nutrient digestibility and be good for rumen health.

References

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