

Effects of Supplementing Different Combinations of Nitrogen Supplements on Digestibility and Performance in Sheep Fed Wheat Straw Diets

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ABSTRACT : Thirty-six (20 wethers and 16 rams) adult Gansu highland finewool sheep with an average liveweight of 19.42 ± 1.83 kg were used. The sheep were allocated to 4 treatments and confined in individual feeding stalls. The 80 day feeding trial was divided into 2 periods of 38 and 42 days. The sheep had access to clean water and were fed chopped wheat straw *ad libitum*. Daily supplemented diets of 150 g for the first period and 200 g for the later period were provided. The 4 types of supplements were: Wheat bran type (I), which is the traditional feeding practice in the area and the control group; Linseed cake type (II); Linseed cake+poultry litter type (III); Poultry litter+distiller grains type (IV). The digestibility trial was conducted using a total collection method at the end of the first period in the feeding trial. The results showed that the digestibilities of DM, OM, CP, CF, NDF and ADF in group II and III were increased to more than 50%. CP and NDF digestibility in group II were significantly increased by 23.6% and 25.5% respectively over group I ($p < 0.01$) and by 10.1% and 13.1% respectively over group III ($p < 0.05$). The digestibility of DM, OM, CP, CF, NDF and ADF in group IV was lower than group I by 4.4 to 8.4% ($p > 0.05$). Compared to group I, group II and III increased straw intake by 17.6% ($p < 0.01$) and 10.8% ($p < 0.05$). The ADG increased from 16.2 g in group I to 45.3 g and 32.8 g ($p < 0.01$) in group II and III respectively. The ratio of supplement intake to gain decreased from 10.7 in group I to 3.9 and 5.4 ($p < 0.01$) in group II and III respectively. The ratio of supplement cost to gain also decreased by 60.0% and 64.3%, respectively. The wool growth rate and wool strength in these 2 groups were noticeably improved. This significantly enhanced the wool's textile value. The above parameters in group IV were lower than in group I, except the ratio of supplement cost to gain. This research indicates that local low quality nitrogen resources could be used effectively and economically to improve the utilization of wheat straw fed to sheep on smallholder farms under harsh loess plateau conditions in the winter. (*Asian-Aust. J. Anim. Sci.* 2002, Vol 15, No. 10 : 1428-1432)

Key Words : Nitrogen Supplements, Wheat Straw, Digestibility, Performance, Sheep in Winter, Loess Plateau

INTRODUCTION

The digestibility of straw can be significantly improved by alkaline and ammonium treatment or microbial fermentation, but the popularity of these processes is very low in developing countries due to technical and cost reasons (Leng, 1990; Owen, 1994; Greek, 1984). Therefore, it is more attractive and practical to develop a technique of improving straw utilization for small ruminants throughout the regulation of rumen fermentation and optimizing the rumen digestion. Perdok (1988) reported there was a tendency for cottonseed meal supplementation to be superior to grain supplementation, it would be of special value for undeveloped regions to use cake and meal as local supplemental resources but research is limited, and almost none on linseed cake supplementation of straw.

This research combined nutrient supplementation theory

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with sheep raising practice under the harsh winter conditions of the Loess Plateau of Northwestern China. We examined the combination and amount of supplementation that would meet requirements of animals, resources available, seasons of the year, local economic levels, and farmer demand. To maintain body condition of sheep and avoid weakness and weight loss in winter and early spring, ample and inexpensive local low quality nitrogen and mineral resources were adopted as supplemental materials needed by rumen microorganisms. The experiment explored the digestion of nutrients in the total length of the digestive tract and the feeding effects on different supplement combinations of wheat straw diet fed to sheep in winter. The goal was to probe the balanced reaction and regulating potential of different supplement combinations with wheat straw in order to determine better supplement formulas and to provide supplementation and feeding recommendations for local conditions and resources available.

MATERIALS AND METHODS

Animals and feeding trial management

Thirty-six (20 wethers and 16 ewes) adult Gansu highland finewool sheep with an average liveweight of

19.42±1.83 kg were used. The sheep were allocated to 4 treatments with 9 sheep per treatment and confined in individual feeding stalls. The 80 day feeding trial was divided into 2 periods, of 38 and 42 days. The sheep had access to clean water and were fed chopped wheat straw *ad libitum*. Daily supplements of one hundred and fifty grams for the first period and two hundred grams for the later period were provided. The supplements were less than 30% of total feed intake. All the sheep were allowed to move about outside once each day. The experiment was conducted in winter (November to January) at Qingyang Loess Plateau Ecology Experimental Station in Gansu Province, China. The average temperature was 5 to 10°C inside the pen and -5 to 1°C outside.

Formulas of supplementation

Under the harsh winter environment of the Loess plateau of Northwestern China and the low productive level of sheep fed a wheat straw diet, and considering poor economic conditions of local sheep farmers, nitrogen and some minerals were added as main nutrient supplement for rumen microorganisms. Based on this and as determined by local available feed resources, the formulas of supplementation for each group were designed (Table 1).

The formula of wheat bran, type (I) commonly used by local small-scale farms, was used as a control group; in linseed cake group (II), linseed cake is the main inexpensive cheap protein source of the local area; in linseed cake+ poultry litter group (III), the poultry litter could be easily

obtained from many local small-scale poultry farms; for poultry litter+distiller group (IV), the formula was very cheap and the distiller grains were provided by several local large alcohol plants. Most materials in the mineral mixture also could easily be obtained locally at low cost.

All materials were purchased locally and the wheat straw was chopped to 12 mm long. The poultry litter was collected from the cement floor under the layer cages in the poultry house of the Ecology Station, dehydrated and disinfected in the sunshine. Nutrient composition of the supplemental materials is shown in Table 2.

Digestion trial and sample preparation

The 6 day digestion trial was conducted using a total collection method at the end of first period in the feeding trial (32 to 38 d). The conditions in the experiment were the same as the feeding trial. Feces, collected by putting a special bag on the animal, were weighed daily, thoroughly mixed and daily sampled (20% of total) from each sheep during the trial. Twenty grams of sub-sample were taken from the total sample for nitrogen analysis in diluted (10%) sulphuric acid. The samples were dried (60°C, 48 h) and mixed. The intake of wheat straw and supplement per sheep was recorded daily and diet samples were taken. All samples were ground through a 1 mm screen and preserved for chemical analysis.

Assay items and methods

The DM (dry matter), OM (organic matter), CP (crude protein), CF (crude fiber), NDF (neutral detergent fiber), ADF (acid detergent fiber) analysis of feed was conducted according to the methods described by Yang (1993), including the NDF and ADF analysis by Van Soest (1963). Straw intake, average daily gain (ADG) and feed conversion were recorded and determined according to common regulative methods.

A bundle of wool in same central part of right body aspect in each sheep was selected and marked near to skin with color at the beginning and the end of the experiment. The bundle of wool was cut at the end of the trial. And used to determine the growth during the feeding trial. The strength (N/Ktex)

Table 1. Formula and chemical composition and cost of concentrate supplements used in the experiment

Item	Groups			
	I	II	III	IV
Composition (%)				
Wheat bran	80	26	-	-
Linseed cake	20	70	40	-
Poultry litter	-	-	30	50
Distiller grains	-	-	26	46
Mineral mixture	-	4	4	4
Cost (RMB Yuan/kg)	0.52	0.59	0.38	0.21
Nutrient values (DM %)				
DE (MJ/kg)	14.34	14.59	13.61	12.62
DM	87.20	87.74	89.12	89.92
OM	94.34	94.52	94.17	93.97
CP	21.73	31.10	27.99	21.13
NDF	23.36	21.13	25.45	28.41
ADF	9.79	9.40	11.82	13.70

Note: 1) All nutrient values came from analyzed samples except DE calculated. 2) Costs were calculated by market price in the trial. 3) Mineral mixture formula: salt 35%, bone meal 25%, Na₂SO₄ 13%, CuSO₄·7H₂O 0.002%, ZnSO₄·5H₂O 0.015%, MnSO₄·5H₂O 0.007%, carrier 26.976%. 3) Group I is based on wheat bran, Group II is based on linseed cake, Group III based on linseed cake and poultry litter, and group IV is based on poultry litter and distiller grains. 4) RMB is the abbreviation of Ren Min Bi (China currency).

Table 2. Chemical composition (DM %) of ingredients of the supplements used in the experiment

	Linseed cake	Wheat bran	Poultry litter	Distiller grains	Wheat straw
DM	87.61	89.32	90.40	90.90	89.80
OM	95.66	93.62	73.80	94.10	89.15
CP	36.27	16.67	29.31	15.48	4.34
NDF	21.74	23.33	28.50	33.28	90.26
ADF	9.21	10.65	13.27	17.13	62.72

of wool bundles was analyzed with the testmeter of Agrotest Newtons AH-50-50 (Deng, 1989).

Statistics

The results were analyzed by one-way-anova and the statistical significance between means was tested using Duncan's multiple test. All data analyses were carried out using the SPSS statistical software system.

RESULTS AND DISCUSSION

Digestibility

The entire digestive tract digestibilities for main nutrients are shown in Table 3. The digestibility was significantly affected by different supplemental combinations. Digestibilities of OM, CP, CF and NDF in group II were increased ($p < 0.01$) over group I by 20.7, 23.6, 18.1 and 25.5%, respectively. Digestibilities of DM and ADF were higher ($p < 0.05$) in group II than in group I by 13.9 and 15.7%. The digestibilities of CP and NDF in group II were also higher ($p < 0.05$) than in group III by 12.4 and 11.0%. Other nutrient digestibilities were higher in group II than those in group III, but there was no significant difference ($p > 0.05$). Digestibilities of DM, OM, CP, CF, NDF and ADF in group III increased over group I by 7.6, 13.3, 10.1, 11.2, 13.1 and 10.2% ($p < 0.05$ except DM), respectively. The 6-nutrient digestibilities in group IV were lower than those in group I, but difference is not significant ($p > 0.05$).

This experiment showed that the digestibilities of 6 nutrients were increased to more than 50% when the linseed cake and the linseed cake+poultry litter supplements were added to the wheat straw fed to the sheep. In particular, the digestibilities of CP and NDF were greatly increased. Increased digestibility stimulated intake of the straw, increased the quantity of digested nutrients, and increased body gain and wool growth. However, with the wheat bran type supplement the digestibilities of nutrients, except for DM, were less than 50%, and the poultry litter+distiller grains type gave the poorest results of all 4 supplements with the lowest digestibilities, all less than 50%.

Table 3. Digestibility of nutrients of sheep (n=9) fed wheat straw and various concentrate supplement in the experiment

Item	Group I	Group II	Group III	Group IV	SEM	P value
DM	50.43 ^{bc}	57.46 ^a	54.27 ^{ab}	48.31 ^c	1.84	0.0031
OM	46.29 ^c	55.87 ^a	52.45 ^{ab}	44.28 ^c	1.77	0.0025
CP	49.73 ^c	61.49 ^a	54.73 ^b	47.26 ^c	1.62	0.0014
CF	46.52 ^c	54.93 ^a	51.74 ^{ab}	43.51 ^c	2.26	0.0027
NDF	46.83 ^c	58.78 ^a	52.94 ^b	43.22 ^c	2.03	0.0013
ADF	43.34 ^b	50.11 ^a	47.75 ^a	41.17 ^b	2.18	0.0032

The effect of incremental digestibility of nutrients in ruminants through supplementation on straw generally agrees with other similar trial results (Das et al., 1999; Dutta, 1999). In a trial with different ratios of supplemental energy and protein, with soy bean as the protein and cassava for energy, Bennison (1993) found that increasing the level of protein supplementation stimulated wheat straw intake and enhanced protein digestibility in sheep. A low energy: high protein supplement appeared to be more appropriate than a high energy: high protein supplement. In the present trial, supplementing linseed cake type or linseed cake+poultry litter to wheat straw also resulted in higher CP digestibility and better NDF digestibility. There are higher crude protein and a little oil in soy bean, linseed cake and rice bran. Thus, it can be concluded that supplementation with nitrogen containing a defined amount of oil could be more appropriate to balancing the deficiencies of wheat straw and stimulating digestion of cellulose.

Performance

Intake of wheat straw : As shown in Table 4, the average daily straw intake of group II (500 g) is significantly higher ($p < 0.01$) than that of group I and IV by 17.6 and 19.3% respectively in whole phase, and higher ($p < 0.05$) than group III. Group III (471 g) was also significantly higher ($p < 0.05$) than group I and IV by 10.8% and 12.4%. Group IV had the lowest wheat straw intake ($p > 0.05$). Improved digestibility caused high wheat straw intake.

The ADG on trial sheep : All sheep in each group had a positive body gain (Table 4). The ADG of group II (45.3 g) was significantly higher than that of group I and III by 180 and 31.8% ($p < 0.01$ and 0.05) respectively in the whole period. Group III (32.8 g) was higher than group I by 103% ($p < 0.01$). Group IV had the lowest ADG among all groups, lower than group I by 17.3% ($p > 0.05$).

It can be seen that the ADG of all groups corresponded to wheat straw intake. Compared with wheat bran type supplement, the linseed cake type showed better supplement results by increasing wheat straw intake and ADG of the sheep. The linseed cake+poultry litter type also showed satisfactory supplement result. The poultry litter+distiller type showed unsatisfactory supplement results, decreasing wheat straw intake and ADG of the sheep.

Wool growth : The results in Table 5 show that wool growth length had no significant difference between groups ($p > 0.05$). However, there are significant differences for wool strength. Group II had the highest strength (41.6 N/Ktex), 90.8% more than group I ($p < 0.01$) and 14.3%

Table 4. Effects of feeding various concentrate supplements on straw intake, average daily gain, feed conversion and cost efficiency in sheep fed wheat straw.

Item	Groups				SEM	P value
	I	II	III	IV		
Average daily straw intake (g/day/sheep)	425 ^b	500 ^a	470 ^a	419 ^b	24	0.03
Average daily gain (g/day/sheep)	16.2 ^c	45.3 ^a	32.8 ^b	13.4 ^c	3.82	0.0032
Total intake/gain (kg/kg)	37.1 ^d	14.9 ^a	19.7 ^b	444.4 ^d	2.74	0.0024
Supplement intake/gain (kg/kg)	10.7 ^d	3.9 ^a	5.4 ^b	13.1 ^d	0.35	0.0010
Supplement cost/gain (yuan/kg)	5.72	2.29	2.04	2.76	-	-

Table 5. Effect of feeding various concentrate supplements on wool growth by sheep (n=9) fed wheat straw

Item	Groups				SEM	P value
	I	II	III	IV		
Wool length (mm)	19.6	21.7	20.6	17.9	2.06	0.07
Wool strength (N/Ktex)	21.8 ^b	41.6 ^a	36.4 ^a	19.2 ^b	2.21	0.03

more than Group III. Group III was higher by 67.8% than in group I, but Group IV was lowest, 11.9% lower than group I ($p>0.05$).

This demonstrated that wheat straw diet with supplements from linseed cake type or linseed cake+poultry litter type, not only prevented 'hungry mark' on wool in winter but also increased wool growth and specifically increased wool strength greatly. Wool quality for textile use improved because strength was above 30 N/Ktex (Deng, 1989). This phenomenon might be because linseed cake contains high cysteine which is major amino acid for wool production and methionine which is a precursor of cysteine and cystin.

Feed conversion rate (FCR) : As shown in Table 4, group II had the best total FCR, better than group I and III by 59.8% and 24.4% ($p<0.01$ and 0.05) respectively. Group III was better than group I by 46.9% ($p>0.05$). Group IV had the poorest total FCR. The supplement FCR of each group had a similar tendency to total FCR. Linseed cake type and linseed cake+poultry litter type supplementation significantly increased the wheat straw FCR, and served as an effective balance to nutrient defects of wheat straw. However, the wheat bran type and poultry litter+distiller type had lower wheat straw FCR and little impact on balancing wheat straw nutrients.

Cost efficiency : The cost efficiency described as supplement cost/gain (Table 4). Group II, III and IV were lower than group I by 60.0, 64.3 and 51.8%, respectively. This showed that sheep fed wheat straw had a higher profit using the supplementation of linseed cake type and linseed cake+poultry litter type. The cost to get the same gain was greater with traditional wheat bran type supplement. Although the gain cost of poultry litter+distiller type supplement was lower than wheat bran type, the supplement type was not suitable to the sheep because of other bad effects.

Results of the feeding trial basically met those of the digestion trial. It was generally indicated that the supplements combined with local nitrogen resources (linseed cake type and/or linseed cake+poultry litter type), not only had an excellent effect of supplementing and balancing nutrients of a wheat straw diet fed to sheep in winter but also obviously decreased feed cost per unit gain. The combinations were a better match for sheep nutrient needs, local resources, seasons of a year, economic level and farmer demands. However, the supplements with wheat bran type and poultry litter+distiller type had bad effects mainly due to lower nitrogen contents. Similar results were observed by Manyuchi (1993) when supplementing steers and lambs grazing dry season pasture with a mixture of poultry litter and cotton seed meal. The combination of lower poultry litter: higher cotton seed meal (1:2) had a better effect than that of higher poultry litter: lower cotton seed meal (2:1), and ADG on mixed supplement increased significantly more than that on single supplement. It is commonly shown when ruminants at a low production level are fed low quality roughage, nitrogen supplement is of first importance to balance nutrients, and mixed supplementation with cake and meal with poultry litter can enhance roughage intake and ADG.

CONCLUSION

1. Sheep fed a wheat straw diet with supplements of linseed cake type and linseed cake+poultry litter type, had increased digestibilities of DM, OM, CP, CF, NDF and ADF in the diets and the values exceeded 50%. The CP and NDF were significantly higher than in wheat bran type by 23.6% and 25.5% ($p<0.01$) and by 10.1% and 13.1% ($p<0.05$), respectively. The wheat straw intake, ADG and FCR increased significantly and the ratio of

supplement cost to gain decreased greatly. Moreover, the wool's textile quality grade was enhanced significantly.

2. When supplementing sheep diets with poultry litter+distiller type, the 6-nutrient digestibilities of wheat straw diet were lower than when wheat bran type was added. Performance of the feeding trial sheep also decreased. It showed that this supplemental combination was not good and the distiller was not suitable to be used as a supplemental raw material.
3. The experiment indicated that under the harsh winter environment in loess plateau, it is practical to improve the wheat straw diet by increasing nutrient digestibility in the entire digestive tract by supplementation with local inexpensive nitrogen resources. Nitrogen supplementation, especially from sources easily degraded in the rumen and containing some oil, may balance the nutrient deficiencies of wheat straw with low levels of supplementation (below 30% of total intake), increasing cellulose and NDF digestibilities.

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