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Effect of programmed feed intake on performance, economic value, and ruminal fermentation of growing lambs

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Abstract: This experiment was conducted to determine the effects of ad libitum and programmed feed intake according to meeting the nutrient requirement of lambs on average daily gain, feed efficiency, profit margins, and ruminal fermentation of growing lambs. Twenty two lambs approximately 6 mo old (averaging 31 kg) were used in a randomized design. Lambs were offered ad libitum access to feed (Control Group) and were limit-fed according to meeting nutrient requirement (Treatment Group). At the termination of the study, ruminal fluid was collected 0, 2, and 4 h after feeding for 3 d. Feed efficiency improved in the treatment group. However, average daily gain was not different between groups. Programmed feed intake at levels being able to meet the nutrient requirement decreased the cost of 1 kg live weight gain. Ruminal pH and ammonia concentrations were similar for both groups. Concentrations of acetate, propionate, and butyrate were not affected by feeding methods. The results of this investigation indicate that programmed feed intake according to meeting the nutrient requirement of lambs was reduced cost of 1 kg live weight gain.

Key Words: Programmed feed intake, Performance, Profit, Ruminal fermentation.

Toklularda programlı yem tüketiminin performans, ekonomik değerlilik ve ruminal fermantasyon üzerine etkisi

Özet: Bu çalışma, tokluların besin madde ihtiyaçlarını karşılayacak şekilde düzenlenen programlı yem tüketimi ile ad libitum yem tüketiminin canlı ağırlık artışı, yemden yararlanma, kâr marjini ve ruminal fermantasyon üzerine etkisini belirlemek amacıyla yürütülmüştür. Araştırmada, yaklaşık 6 aylık (ortalama 31 kg) 22 toklu tesadüfü deneme düzeninde kullanılmıştır. Toklular ad libitum (Kontrol Grubu) ve besin madde ihtiyaçlarını karşılayacak düzeyde sınırlı (Deneme Grubu) yemleme programlarına göre beslenmişlerdir. Araştırma sonunda, yemlemeden önce ve yemlemeden sonra 2 ile 4. saatlerde üç gün boyunca rumen sıvısı örnekleri alınmıştır. Deneme grubunda yemden yararlanmada iyileşme gözlenirken, canlı ağırlık artışında gruplar arasında bir farklılık tespit edilmemiştir. Besin madde ihtiyacını karşılayacak düzeydeki programlı yem tüketimi 1 kg canlı ağırlık artışının maliyetini azaltmıştır. Rumen sıvısı pH değeri ve amonyak konsantrasyonu gruplarda benzerlik göstermiştir. Yemleme metotları ile asetik, propiyonik ve bütirik asit konsantrasyonları etkilenmemiştir. Sonuç olarak tokluların besin madde ihtiyaçlarını karşılayacak şekilde düzenlenen programlı yem tüketimi 1 kg canlı ağırlık artışının maliyetini azaltmıştır.

Anahtar Kelimeler: Programlı yem tüketimi, Performans, Kâr, Ruminal fermantasyon.

INTRODUCTION

Lambs are usually fed ad libitum to increase performance, especially, rate of daily gain in farms. The performance is affected directly by cost of feed. On the other hand, it is known that ad libitum intake has reduced feed efficiency as a result of digestive disturbances (1-4). Depending on this, feed intake may fluctuate greatly. Nevertheless, Glimp et al. (5) have reported that sheep restricted for 85 and 92.5% of ad libitum intake had daily weight gains similar to those of sheep allowed ad libitum access to feed. They observed that restricting feed intake improved feed efficiency. Similar results were reported for steers (6, 7). Old and Garreta (6) reported that there was 20% improvement in feed efficiency by steers as fedding 85% of ad libitum. There are several reasons for the improvement of feed efficiency. For example, restricting feed intake may reduce fat deposition and digestibility may be increased (8). It is known many researches (2-5) that are about restricting feeding or the effect of limit feeding on digestibility or performance. But, animals in those studies, (5-7) were fed ad libitum and restricting intake of the different levels of ad libitum (75, 85, 90,

92.5 %) not limiting according to nutrient requirement of lambs.

Therefore, the objective of the present study was to determine the effect of programming feed intake according to meeting the nutrient requirement of lambs and ad libitum intake on average daily gain, feed efficiency, economic value, and ruminal fermentation.

MATERIALS AND METHODS

Animals

Total twenty two lambs (averaging 31 kg initially, 6 mo old) eleven lambs were used in the experiments approved by the Veterinary Control and Research Institute of Agriculture Ministry. At the beginning of the study, lambs were treated for internal and external parasites and vaccinated against enterotoxemia and infectious necrotic hepatitis. Animals were allocated to two groups in a completely randomized design.

Dietary Treatments

Dietary treatments consisted of feeding intake level . One group was fed ad libitum (Control Group) and the other was limit-fed programming feed intake according to meeting the nutrient requirement of lambs (Treatment Group). Water was available ad libitum. The dry matter intake level for lambs was indicated to have been 1368 g (9) at the programmed feed intake group. The diet was formulated using NRC (10) guidelines. Ingredients composition and chemical analysis of the experimental diet is summarized in Table 1.

Growth Measures

Animals were fed twice daily (08.00 h and 17.00 h) as group during the experiment and forage mixed feed were given together. Lambs were weighed at the start of the experiment for initial weight and were weighed at 14 d intervals to monitor performance. All lambs were weighed between 08.00 h and 09.00 h before feeding and weights were taken at the same time each day without withholding feed or water. Average daily feed consumption for ad libitum group was measured and feed efficiency was calculated for both the groups. The experiment was carried out for 70 days.

Ruminal Fluid Samples Collection

Samples of ruminal fluid, for measurement of pH, ammonia, and VFA (Volatil Fatty Acids) were taken just prior to the 8.00 feeding and 2, 4 h after feeding for 3 d at the termination of the study. Ruminal fluid was collected by stomach tube using a metal strainer. The pH was measured immediately using a portable pH meter. Then, samples were centrifuged at 10.000xg for 15 min and a portion of the supernatant fluid was acidified with 25% (wt/vol) metaphosphoric acid and analyzed for ammonia concentration. On the other hand, 4.5 ml supernatant was transferred into a glass tube with 0.5 ml of metaphosphoric acid. The tubes were stored at -20 ^{0}C for later VFA analysis.

Economic Analysis

Profit estimates for each group were calculated from total feed intake, feed cost, and daily gain data as follows:

Cost of total feed intake,$/ per (70 d) = Total feed intake(kg/animal) x cost of feed,$/kg

Cost of feed of 1 kg live weight gain, $ = Cost of total feed intake,$ (70 d)/ total live weight gain, kg

Net Profit, $ = Cost of feed of 1 kg live weight gain for ad libitum group (Control Group), $ - Cost of feed of 1 kg live weight gain for programmed group (Treatment Group).

Chemical Analysis

Chemical composition of diet samples were analyzed after grinding using AOAC (11) procedures, and crude fiber was determined by the methods of Crampton and Maynard (12). Ruminal ammonia concentration was determined by a spectrophotometry procedure as described by Annino (13). Ruminal fluid centrifuged was filtered and analyzed for VFA as described by Ottenstein and Bartley (14) using Gas Chromatography on a 439 series (Hewlett Packard).

Statistical Analysis

Differences between groups for growth performance and ruminal fermentation criteria were determined by PROC TTEST using the procedures of SAS. Differences for ruminal criteria data with time after feeding were analyzed by PROC ANOVA and Duncan multiple-range test using the procedures of SAS (15).

RESULTS AND DISCUSSION

Lambs performance and economic analysis of data are shown in Table 2. Initial and final weights for ad libitum and programming feed intake groups respectively were obtained as 31.43, 31.83 and 50.19, 49.76 kg, in weights. Average dry matter intake during the period from 0 to 70 days was 1565 and 1368 g/d per lamb for ad libitum feed intake and programmed feed intake group. The difference between groups was statistically significant (P<0.01). but average daily gains were found as 275.23 and 274.61 g in the groups, respectively. Daily gain was similar in the groups, though feed intake level was different. It can be that the results of the present study are not compatible with other studies. Likewise, Hicks et al. (16) reported that live weight gains were reduced by 7.4% with the

programmed feeding. The differences may result from the feed intake levels.

The programmed feed intake improved feed efficiency according to the ad libitum group and the feed efficiency was 5.68 and 4.98 in groups, respectively. Improvement in the feed efficiency could be due to the improved diet digestibility. Several sheep studies (1, 17, 18) indicated that restricting intake to different levels increased diet digestibility. Murpy et al. (19) reported that restricted feeding of diets in percentage of concentration led to linear improvements in dry matter, organic matter, acid detergent fiber and neutral detergent fiber digestibility. Other reasons for the improvement of feed efficiency were reduced daily variation in feed intake with the programmed feeding. For example, Zinn (20) reported that animals with ad libitum access to feed wide daily fluctations in feed intake, which may result in digestive disturbances and decreased feed utilization and feed efficiency was improved by the programmed feed intake. Hicks et al. (7) reported that the feed efficiency was improved during the trial by controlled feeding of steers. Hicks et al. (7) also reported that feed efficiency was improved with programmed feeding. This is in agreement with the present study.

The increase in feed efficiency of the present study was greater than that reported by Glimp et al. (5). However, they reported that feed efficiency was similar to the 90% and the 72.5% concentrate diets fed ad libitum and the feed efficiency was improved by the 92.5% restricted intake treatment and restricted of feed to 85% of ad libitum tended to improve feed efficiency over the ad libitum. The results of the study were not similar to the present study. In the present study, lambs were fed with the programmed feed intake at levels which meet the nutrient requirement. Hicks et al. (7), reported that feed efficiency was 4.8% poorer in the final 84 of trial, but was improved by 14% during the second half of the trial by the controlled feeding of steers. This is in agreement with the present study. On the other hand, Zinn (20) reported that the feed efficiency was improved 4.3% by programmed feed intake.

Comparisons among the groups were especially made with respect to economics of the feed intake. The economic coefficients assumed for lambs as feedstuff were based on the average feed prices in Elazığ. The price of feed per kg was 0.18 $. The average total feed intake in ad libitum and programmed feed intake groups was 109.55 and 95.75 kg during treatment of period per lamb. The cost of total feed intake was 19.72 $ and 17.24 $ per lamb, respectively. The average total gains were 19.26 kg and 19.22 kg in the groups, respectively. There was a difference between the groups in feed cost of 1 kg live weight gain . Net profit in feed cost of 1 kg live weight gain was 0.13 $ between the groups. The reason for improving the economic value with the programmed feed intake was to feed intake level or improve feed efficiency. The difference in feed consumption was 13 kg per lamb during treatment ($P<0.01$) which is equalvalent to 2.48 $.

Table 1. Composition of diet fed to lambs (DM basis).

Item	%
Hay	17.12
Barley	64.81
Soybean meal	15.94
Limestone	1.45
Salt	0.35
Dicalcium phosphate	0.03
Mineral + Vitamins mix *	0.30
Chemical analysis, % DM basis	
Dry matter	88.70
Ash	6.20
Organic matter	82.50
Crude fiber	13.00
Crude protein	14.50
Ether extract	1.82
ME, kcal/kg	2510

*: Provided : 12000000 IU Vit A, 2400000 IU Vit D3, 30000 mg Vit E, 2000 mg K3, 2000 mg B1, 6000 mg B2, 3000 mg B6, 15 mg B12, 8000 mg Cal. D. Panth. 40000 mg Nicotin amid, 800 mg folic acid, 50 mg biotin, 125 000 mg Cholin cloride, 80000 mg Mn, 40000 Fe, 60000 mg Zn, 5000 mg Cu, 500 mg Co, 2000 mg I, 150 mg Se, 10000 mg antioxidant.

Ruminal pH was unaffected by feeding methods ($P>0.05$), whereas, there was decrease by time of sampling in both groups. Average ruminal pH was higher in the programmed feed intake group than ad libitum group($P>0.05$). Ruminal pH was decreased with time after feeding in both groups. Average ruminal ammonia concentrations were similar for lambs fed ad libitum and programmed feeding at levels meet the nutrient requirements ($P>0.05$), whereas, the ammonia concentrations decreased by time of sampling in both the groups ($P<0.01$).

Concentrations of acetate, propionate and butyrate were not affected for lambs fed ad libitum and the programmed feed intake level ($P>0.05$). The concentrations of acetate and butyrate decreased, whereas, the concentrations of propionate increased in time after sampling ($P<0.01$).

Hart and Glimp (21) and Galyaen et al. (22) observed the similar results in the feed intake level of lamb diets. These results agree with our results. Such that Hart and Glimp (21) reported that ruminal pH, ammonia, and VFA levels were similar for different levels of intake and fermentation criteria were affected in time after feeding.

Table 2. Effect of feeding methods on performance of growing lambs (n=11).

Item	Control	Treatment	SEM	*P*
No. of lambs	11	11	11	-
Days fed	70	70	-	-
Initial live wt,kg	31.43	31.83	0.42	NS
Final live wt, kg	50.19	49.76	3.55	NS
DMI, g/d	1565	1368	0.06	**
Daily gain, g				
0-14	305.89	301.84	4.13	NS
14-28	294.23	292.16	3.67	NS
28-42	283.44	282.10	2.15	NS
42-56	230.81	234.21	5.34	NS
56-70	261.28	258.84	6.40	NS
Overall	275.23	274.61	2.88	NS
Feed/gain	5.68	4.98	-	-
Total gain, kg/per animal	19.26	19.22	0.42	NS
Total feed consumed, kg/per animal	109.55	95.75	0.78	*
Ration cost, $/kg	0.18	0.18	-	-
Tot. Feed intake cost, $/per animal	19.72	17.24	-	-
Feed cost of kg live weight gain, $	1.02	0.89	-	-
Net profit, $/per animal		0.13		

NS: P>0.05, *: P<0.05, **: P<0.01.

Table 3. Effect of feeding methods on ruminal fermentation of growing lambs (n=11).

Item	Control	Treatment	SEM
PH	5.98	6.07	0.11
Ammonia,mg/dl	3.84	4.23	3.43
VFA, mol/100 ml			
Acetate	61.60	59.83	3.12
Propionate	18.64	22.59	3.00
Butyrate	8.00	6.13	2.42

P>0.05

As it can be summarized from the results discussed above that the programming of feed intake to meet the nutrient requirement of lambs improved more feed efficiency and reduced the feed cost of 1 kg live weight gain. On the other hand, ruminal fermentation criteria was not affected by the feeding methods.

Table 4. Effect of time after feeding on ruminal fermentation (n=11).

Item	Control					Treatment				
	Time after feeding (h)					Time after feeding (h)				
	0	2	4	SEM	P	0	2	4	SEM	P
Ph	6.10^{a}	5.68^{b}	5.60^{b}	0.05	**	6.00^{a}	5.55^{b}	5.50^{b}	0.07	**
Ammonia,mg/dl	4.18^{a}	3.22^{b}	3.34^{b}	0.45	**	4.44^{a}	3.96^{b}	3.99^{b}	0.52	**
VFA, mol/100 ml										
Acetate	63.12^{a}	61.22^{b}	60.12^{b}	0.09	**	60.12^{a}	58.82^{b}	58.13^{b}	0.06	**
Propionate	16.10^{b}	22.14^{a}	23.14^{a}	1.88	**	20.12^{b}	22.14^{a}	22.18^{a}	0.11	**
Butyrate	7.16^{b}	8.22^{a}	8.53^{a}	0.24	**	6.10^{b}	7.58^{a}	7.85^{a}	0.13	**

a, b, c: Means in the same row with different superscripts differ (P<0.05), **: P<0.01.

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