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Effect of different feeding systems on the fattening performance, slaughter-carcass characteristics and meat quality in lambs

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ABSTRACT

The aim of the study was to find out the effect of different feeding systems on the fattening performance, slaughter and carcass characteristics, and meat quality of Norduz male lambs. Lambs were randomly divided into 3 groups of 15 each, as follows: 2M (2 meals/day), 4M (4 meals/day) and SF (self-feeder). Then, lambs were fed according to these regimes for 70 days to determine the feed conversion ratio, dressing percentage, carcass fatness and meat quality traits such as pH, color and water holding capacity. Although live weights and daily weight gains were found to be similar among the groups, significant differences were found in the daily feed intake (2M: 1.53 kg; 4M: 1.70 kg; SF: 1.89 kg) among groups ($p<0.05$). No significant differences were observed in slaughter and carcass characteristics except dressing percentage (2M: 49.69%; 4M: 50.59%; SF: 48.46%). Meat quality traits were also similar among groups, except for pH_{24h} (2M: 5.77; 4M: 5.95; SF: 6.10) ($p<0.01$).

Key words: Bunk management, Dressing percentage, Feed intake, Norduz, Self-feeding.

INTRODUCTION

Intensive small-ruminant breeding may employ various feeding strategies for finishing lambs, each of which has certain advantages and disadvantages. For instance, self-feeding systems require a smaller labor force and less bunk space than hand-feeding systems, whereas observing lambs is easier with hand-feeding systems. Moreover, differences between hand-feeding and self-feeding systems, as well as variations among them, such as frequency of meals with hand-feeding, may affect fattening performance and product quality. Furthermore, low feed refreshing rate or meal frequency usually causes feed contamination and animals tend to refuse consuming the feed (Keskin *et al.* 2007). On the other hand, one of the most important issues affecting animal performance is digesting efficiency, which is dependent upon various factors related to feeding strategies, including optimization of diet form and content and dry matter intake (DMI). Previous studies have stated that the most preferable feeding strategy for the finishing period is the one that provides the highest DMI intake with minimal negative effects on digestion.

Previous studies investigating the effect of feeding frequency on fattening performance of beef (Goonewardene *et al*., 1995; Schutz *et al*., 2011; Carrara *et al*., 2013) and lamb (Keskin *et al*., 2007; Abouheif *et al*., 2010; Ribiero *et al*., 2011) have reported conflicting results. It was reported that high-concentrate rations distributed over 4 or more meals per day, rather than 1 or 2 meals per day, result in greater live weight gain, especially in young animals (CSIRO, 2007), and several studies have stated that more frequent daily intervals stabilize ruminal pH and improve digestion (Kaufmann, 1976; Yang and Varga, 1989; Shabi *et al*., 1999). However, a number of other studies (Abouheif *et al*., 2010; Soto-Navarro *et al*., 2000) have suggested that increasing feeding frequency has a negative effect on the efficiency of energy utilization. The considerable variability in study findings can be attributed to extrinsic factors (e.g. diet quality and bunk management) as well as intrinsic factors (e.g. animal age, sex and physiological state).

Overall, it can be suggested that determining the effect of feeding frequency on fattening performance, carcass and meat quality parameters needs further investigation. Few studies (Keskin *et al*, 2007; Ribiero *et al*, 2011) have examined the effects of feeding frequency on fattening performance, carcass characteristics and meat quality. Therefore, the present study aims to obtain useful knowledge on feeding frequency to be used in improving fattening performance and meat quality in intensive feeding systems.

MATERIALS AND METHODS

Location of experiment and animals: The study was conducted with 45 male Norduz lambs raised in breeder conditions until 6 months of age. Norduz sheep are a fat-tailed breed native to the Eastern Anatolian province of Van. Animals were cared for in accordance with guidelines established by the Local Animal Studies Ethics Committee of Yuzuncu Yil University in Van, Turkey.

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Animal management and experimental design: Lambs were randomly divided into 3 groups according to the feeding system i.e. hand-feeding: 2 meals/day (2M); hand-feeding: 4 meals/day (4M) and self-feeding (SF). Lambs were fed as a group in paddocks, with feeder height and other parameters designed to prevent feed loss. In order to avoid any stimulation of feed intake at meal times, visual contact among lambs from different treatment groups was prevented. Feeding in each group was intended to slightly exceed NRC (1985) requirements of finishing lambs and be ad libitum as much as possible. This was important especially in allocating feed in meals. In order this to be accomplished animals' average feed consumption values during accustoming period and their weekly live weights were considered to calculate the amount of daily feed concentrate to be provided. Accordingly, rations of 200 g of sainfoin hay and ad-libitum concentrate per lamb per day were provided over a fattening period of 70 days (Table 1). In the 2M group, feed was apportioned into 2 equal amounts and given at 08:00 and 17:00 h. In the 4M group, feed was apportioned into 4 equal amounts and provided at 8:00, 11:00, 14:00 and 17:00 h. The SF group feeder was monitored frequently and refilled weekly whereas the 2M and 4M feeders were monitored and cleaned of refusals on a daily basis.

Data collection and instrumental analysis: Average daily feed intake (ADFI) was calculated weekly for all groups. Lambs were weighed weekly, and weight and ADFI data were used to calculate the feed conversion ratio (FCR) and feed intake/body weight (FIW) for each group.

At the end of the fattening period, 5 lambs from each group were randomly selected and slaughtered after 12 h of fasting in order to determine slaughter-carcass characteristics. Jointing of carcasses was performed according to Colomer-Rocher *et al*. (1987). Dress-off items (heart, spleen, lungs, liver, omental and mesenteric fat, 4 feet, hide and head) and hot carcasses (including skinned tail, thymus, diaphragm, kidneys, perinephric and pelvic fat and testicles) were weighed, and carcasses were refrigerated at 4°C for 24 h. Then, chilled carcass weights were recorded before tail, kidneys, testicles and perinephric and pelvic fat were removed. Carcasses were splitted in half along the sagittal plane of the vertebral column, and left sides were jointed into 6 anatomical regions: Shoulder (foreleg, with scapula), Hind Leg (including last lumbar vertebra), Neck (7^{th} cervical vertebra), Flank (lower part of the carcass, jointed in a straight line from sternum to hind leg), Back Loin (jointed from the 6^{th} thoracic vertebra to the end of the 6^{th} lumbar vertebra), and Best End of Neck (from 1^{st} to 5^{th} dorsal vertebrae).

Table 1: Ingredients and chemical composition of concentrate

Ingredient	%
Barley	72.5
Cotton seed pulp	24.0
$CaCO_3$	2.4
Salt	0.5
Preliminary vitamin mix	0.5
Preliminary mineral mix	0.1
Chemical Composition	(% of dry matter)
Dry matter	95.66
Crude protein	14.72
Ether extract	2.47
Acid detergent fiber	17.50
Neutral detergent fiber	35.92
Ash	9.63
Metabolic Energy (kcal.kg^{-1} % DM)	2664.29

Meat quality analysis was conducted using longissimus dorsi muscles (6^{th} to 13^{th} chops). Meat pH was measured directly from the longissimus thoracis muscle between the 12^{th} to 13^{th} thoracic vertebrae at 45 minutes and 24 hours after slaughter using a digital pH meter equipped with a penetrating electrode.

Meat color was assessed by taking 5 separate measurements from fat-free areas of each sample at 24 h after slaughter using a Lovibond RT-300 portable spectrophotometer (CIELAB-illuminant $D_{65}/10^{o}$). Measurements were performed on fresh cut surfaces of 2.5 cm thick longissimus thoracis (12^{th} to 13^{th} ribs), after allowing the muscle surface to bloom in the chiller for 45 minutes. Hue angle and chroma were calculated as $\tan^{-1}(b^*/a^*)$ and $[(a^*)^2+(b^*)^2]^{1/2}$, respectively. Water-holding capacity (WHC) was determined according to Wierbicki and Deatherage (1958). A 0.5 g sample of muscle tissue was placed on filter paper and pressed between 2 Plexiglass plates at 500 psi per minute. The results were expressed as the percent free water.

Longissimus muscle samples were vacuum packed and frozen to -20°C for use in chemical analysis. Nutrient matter contents were analyzed according to AOAC (2000) by homogenizing the longissimus dorsi muscles and measuring dry matter, ash, fat and protein contents [moisture (950.46); ash (920.153); fat (960.39-ether extract in meat); protein (928.08-Kjeildahl method)].

Statistical analysis: Data analysis was performed using the Minitab® software program. Data were analyzed using one-way ANOVA (Minitab, 2000) and Tukey's multiple comparison test using the formula: $Y_{ij} = \mu + g_i + e_{ij}$, where Y_{ij} refers to the observation; μ, the population mean; g_i, the group effect (i=feeding system); and e_{ij}, the random error normally distributed with a mean 0 and variance σ^2_e. Moreover, weekly average values of FCR, FIW and ADF of each group were considered as replications and comparisons of groups were performed by Friedman test.

RESULTS AND DISCUSSION

The body weight, average daily weight gain (ADG) and feed consumption data are presented in Table 2. There were no significant differences in body weight, ADG and FCR among the groups. However, feeding system had a significant effect on feed intake in terms of both ADFI and as a percentage of body weight (FIW) ($p<0.05$). The ADFI of the self-feeding group exhibited no observable pattern, but was higher than that of both hand-feeding groups throughout the experiment, with the exception of the final 2 weeks (Figure 1). Despite the significant differences in ADFI, growth curves for all groups were similar after the second week of treatment (Figure 2).

The present study found that the feeding system had no effect on the overall ADG or body weight of male Norduz lambs. Coefficient of variations (CV) for initial body weights, final body weights and ADG of the 2M, 4M and SF groups were 10.98%, 11.60% and 7.90%; 9.22%, 10.56% and 9.29%; and 18.43, 20.54 and 37.52%, respectively. Whereas uniformity of body weights increased in the 2M and 4M groups, it decreased in the SF group over the course of the experiment. Management practices characterized by limited feed or limited trough space that create high levels of competition among animals generally result in greater variation in individual feed intake (Bowman and Sowell, 1997; CSIRO, 2007). The results of the present study suggest that when competition is low – as is the case when feed is offered ad libitum – hand-feeding and self-feeding may have different effects on uniformity of body weight.

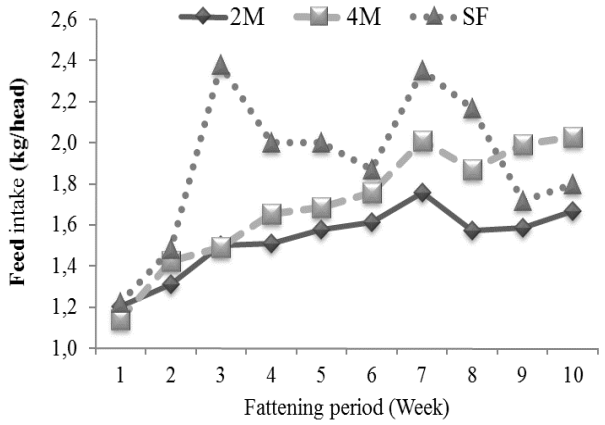
Previous studies have reported conflicting findings regarding the relationship between feeding frequency and ADG and ADFI, with some studies on lambs (Rhodes and Woods, 1962; Zali and Ganjkhanlou, 2007; Abouheif *et al*., 2010; Ribiero *et al*., 2011) and steers (Goonewardene *et al*., 1995) reporting feeding frequency to have no significant effect on ADG or ADFI, and others (Keskin *et al*., 2007, Schutz *et al*., 2011) reporting increases in ADG and ADFI in line with increases in feeding frequency. Carrara *et al*. (2013) reported that increasing feeding frequency positively affected ADG and final body weight, while there was no significant effect on DMI in Nellore bulls.

In the present study, FCR of the 4M and SF lambs were found to be 25%-30% higher than the FCR of the 2M lambs; however, these differences were not statistically significant. Studied reported by Rhodes and Woods, (1962); Goonewardene *et al*., (1995); Keskin *et al*., (2007); Ribiero *et al*., (2011); Schutz *et al*., (2011) had no significant effect of feeding frequency on FCR whereas, Abouheif *et al.* (2010) reported better FCR in lambs fed once per day than among those fed twice per day. Moreover, Rhodes and Wood (1962)

Table 2: Fattening performance parameters of lambs (n=45) under different feeding regimens

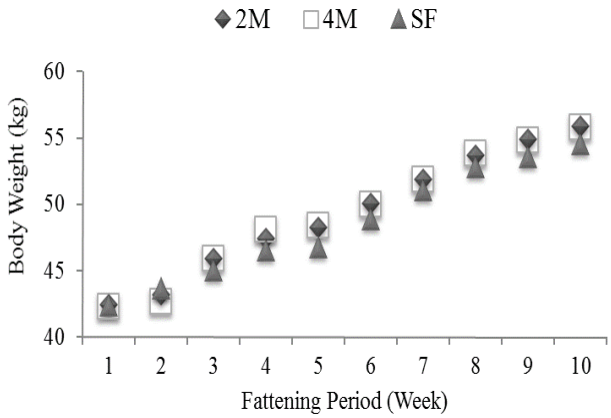
Traits	2M	4M	SF	SEM	CV	p
Initial body weight (kg)	40.81	40.80	40.70	1.084	10.06	ns
Final body weight (kg)	55.89	55.77	54.49	1.420	9.58	ns
Average daily gain (g)	215.38	213.90	196.95	14.632	26.22	ns
Average feed/gain (FCR)	7.29	9.13	9.52	1.452	49.71	ns
Feed intake/body weight (%)(FIW)	3.19^{a}	3.54^{ab}	4.03^{b}	0.156	16.50	**
Average daily feed intake (kg)(ADFI)	1.53^{a}	1.70^{ab}	1.89^{b}	0.090	18.47	*

2M: 2 meals per day, 4M: 4 meals per day, SF: fed by self-feeder
ns: not significant; * P < 0.05, **P< 0.01
SEM: Standart error of mean; CV: Coefficient of variation



2M: 2 meals per day, 4M: 4 meals per day, SF: fed by self-feeder

Fig 1: Feed intake of lambs during the experiment



2M: 2 meals per day, 4M: 4 meals per day, SF: fed by self-feeder

Fig 2: Body weight of lambs during the experiment

reported that ADG and FCR were not affected by feeding practice (hand-feeding *vs* self-feeding), however, self-feeding lambs had higher feed intake than 2M lambs.

In the present study, fattening performance data showed higher feed consumption in the SF than in 2M ($p< 0.05$) and 4M groups. However, there was an increasing trend in FCR for the 4M and SF groups. As a result, the final body weights were found to be similar among all 3 groups. The negative effect of higher feed intake on FCR in both SF and 4M groups is in line with some previous studies. Robles *et al*. (2007) suggested that increased frequency of daily feeding might also increase the rate of ingesta removal from the rumen resulting in greater escape of potentially degradable substrate. Keskin *et al.* (2007) reported that increased feeding frequency tended to increase the rate at which feed passed through the gastrointestinal tract, it could also reduce feed digestibility resulted to negative FCR. Contrary to this report, feeding schedules in which small meals were offered at more frequent daily intervals had been reported to have a stabilizing effect upon ruminal fermentation which improved the efficiency of digestion in dairy cows (Yang and Varga, 1989; Shabi *et al*., 1999). Dehority and Tirabasso (2001) reported that number of feedings per day did not markedly affect microbial concentrations, rumen volume, or liquid turnover time if the total daily amount of feed remained constant and, based on those findings, the authors suggested that there was no practical or biological advantage of feeding animals more than once or twice per day. Despite earlier studies (Ceceva *et al*., 1990; Liboux and Peyraud, 1999; Robles *et al*., 2007; Abouheif *et al*., 2010) with no significant advantages in terms of rumen parameters due to increased feeding frequency, Shabi *et al*. (1999) recommended that increase feeding frequency had positive effects on feed consumption, digestion and retention time in the rumen.

Slaughter and carcass characteristics of the groups are presented in Table 3. With the exception of dressing percentages, which were significantly higher for the 4M group when compared to the SF group ($p < 0.05$), none of the slaughter or carcass characteristics varied significantly among the groups. It is possible that differences in feed intake just prior to 12 h fasting could account for the differences in dressing percentages among groups.

Some previous studies (Walker *et al*., 1967; Abouheif *et al*., 2010) reported that increased meal size and reduced feeding frequency decreased dressing percentage with increased gastrointestinal tissue weight. However, Ribiero *et al*. (2011) and Carrara *et al*. (2013) reported that the feeding frequency had no effect on dressing percentages or any other carcass characteristics. Zali and Ganjkhanlou (2007) and Towhidi *et al*. (2010) suggested that increasing feeding frequency decreases fat synthesis and deposition. In

Table 3: Slaughter and carcass characteristics of lambs (n=15) under different feeding regimens (kg)

Traits	2M	4M	SF	SEM	CV	p
Slaughter Traits						
Slaughter weight	55.32	54.88	54.28	0.792	3.10	ns
Hot carcass	27.48	27.76	26.32	0.508	4.54	ns
Dressing percentage (%)	49.69[ab]	50.59[a]	48.46[b]	0.520	2.84	*
Storage loss (%)	1.45	2.45	1.66	0.346	45.48	ns
Head	3.09	3.07	3.06	0.099	6.71	ns
4 feet	1.11	1.10	1.12	0.034	6.50	ns
Skin	7.22	6.77	6.76	0.232	7.64	ns
Omental-mesenteric fat	0.18	0.18	0.18	0.043	48.51	ns
Lung-liver-heart	2.16	2.26	2.18	0.064	6.30	ns
Spleen	0.15	0.11	0.13	0.015	26.60	ns
Carcass Traits						
Cold carcass	27.08	27.08	25.88	0.493	4.41	ns
Testicle (couple)	0.43	0.43	0.38	0.051	26.00	ns
Kidney (couple)	0.14	0.13	0.14	0.007	11.64	ns
Kidney-knob pelvis fat	0.16	0.21	0.15	0.033	42.67	ns
Tail	4.63	4.62	3.60	0.427	23.72	ns
Left-half carcass	11.24	11.22	10.96	0.338	6.39	ns
Fore leg	1.97	1.95	1.97	0.039	4.14	ns
Hind leg	3.70	3.63	3.72	0.163	9.26	ns
Neck	0.90	1.02	0.93	0.079	17.96	ns
Flank	1.59	1.46	1.37	0.087	13.82	ns
Back loin	2.26	2.56	2.17	0.187	18.16	ns
Shoulder	0.72	0.59	0.68	0.057	19.52	ns

2M: 2 meals per day, 4M: 4 meals per day, SF: fed by self-feeder
ns : not significant; *P < 0.05
SEM: Standart error of mean; CV: Coefficient of variation

Table 4: Meat quality traits of M.longissimus dorsi of lambs (n=15) under different feeding regimens

Traits	2M	4M	SF	SEM	CV	p
pH $_{45min}$	6.47	6.40	6.38	0.044	2.66	ns
pH $_{24h}$	5.77[a]	5.95[ab]	6.10[b]	0.047	3.06	**
L*	37.40	38.85	37.95	0.315	3.21	ns
a*	22.52	20.56	21.50	0.365	6.58	ns
b*	7.53	6.06	6.55	0.320	18.50	ns
C*	23.75	21.46	22.50	0.415	7.12	ns
h^o	18.48	16.36	16.90	0.646	14.51	ns
WHC[a]	15.20	16.80	15.83	1.325	17.73	ns
Nutrient Matter Content (%)						
Moisture	75.48	74.64	74.83	0.218	1.13	ns
Protein	20.05	21.35	21.50	0.274	5.07	ns
Ether extract	3.40	2.97	3.12	0.324	39.70	ns
Ash	0.83	0.92	0.86	0.022	10.03	ns

2M: 2 meals per day, 4M: 4 meals per day, SF: fed by self-feeder
ns: not significant, ** P < 0.01
[a]The percent of free water
SEM: Standart error of mean; CV: Coefficient of variation

the present study, the self-feeding group had lower tail fat weight than the hand-feeding groups; however, the differences among groups were statistically insignificant. This finding is in agreement with Keskin *et al*. (2007) and Ribiero *et al*. (2011).

Meat quality characteristics of the groups are presented in Table 4. No significant differences in meat pH were observed among the groups at 45 minutes after slaughter (pH_{45min}). However, pH at 24 hours after slaughter (pH_{24h}) was significantly higher in the SF group when compared to the 2M group ($p<0.01$).

To our knowledge, the literature contains no data on the effect of feeding frequency on meat quality. In the present study, pH_{24h} was higher in the SF group when compared to both hand-feeding groups; however, the difference was only significant for the 2M group ($p<0.01$). Various stressors have been shown to deplete muscle glycogen and potentially result in elevated pH. Although the lambs in this study were reared with minimal environmental stressors, and no factors were observed in pre-slaughter handling that might produce different effects on the treatment groups. Further studies may be conducted to examine possible connections between the slaughter process and meat quality. Although the meat pH was affected tissue color and water-holding capacity the earlier study reported by Sanudo *et al*. (2007), in the present study there was no differences in color or water-holding capacity. In the present study, there was also similar nutrient content in the meat of different experimental groups.

CONCLUSIONS

Feeding system was found to have a significant effect on feed intake, but only a limited effect on carcass and meat quality traits of Norduz lambs except for pH_{24h}. It can be concluded from the above study that feeding with a self-feeder or feeding with 4 times per day rather than twice a day had no advantages in terms of fattening performance, slaughter-carcass characteristics and meat quality in lambs.

REFERENCES

Abouheif, M. A., Al-Saiady, M.Y., Makkawi, A.A., Ibrahim, H.A. and Kraidees, M.S. (2010). Effect of either once or twice daily feeding of pelleted high-concentrate diet on performance and digestion in growing lambs. *J. Anim. Vet. Adv*. **9:** 925-931.

AOAC. (2000). Official Methods of Analysis. 17th ed. Association of Official Analytical Chemists, Maryland, USA.

Bowman, J.G and Sowell, B.F. (1997). Delivery method and supplement consumption by grazing ruminants: a review. *J. Anim. Sci*. **75:**543-550.

Carrara, T.V.B, Silva, J., Pereira, M.C.S., Rigueiro, A.L.N., Watanabe, D.H.M., Estevam, D.D., Silva, D.P., Vicari, D.V.F., Oliveira, C.A., Batista Junior, I.C., Arrigoni, M.D.B., Pereira, F.T.V., Oliveira, D.J.C., Mateus, G.P. and Millen, D.D. (2013). Effects of different feeding frequencies on feedlot performance and carcass traits of feedlot Nellore cattle. *J. Anim. Sci.* **92:** E-Suppl. 2. 873.

Cecava, M.J., Merchen, N.R., Berger, L. and Nelson, D.R. (1990). Effect of energy level and feeding frequency on site of digestion and postruminal nutrient flows in steers. *J. Dairy Sci*. **73:** 2470-2479.

Colomer-Rocher, F., Morand-Fehr, P. and Kirton, A.H. (1987). Standard methods and procedures for goat evaluation, jointing and tissue seperation. *Livest. Prod. Sci*. **17:** 149-157.

CSIRO. (2007). Application. [In: Freer, M., Dove, H. and Nolan, J.V., editors]. Nutrient Requirements of Domesticated Ruminants. Melbourne, Australia., pp. 205-230.

Dehority, B.A and Tirabasso, P.A. (2001). Effect of feeding frequency on bacterial and fungal concentrations, pH, and other parameters in the rumen. *J. Anim. Sci*. **79:** 2908-2912.

Goonewardene, L.A., ZoBell, D.R. and Engstrom, D.F. (1995). Feeding frequency and its effects on feedlot performance in steers. *Can. J. Anim. Sci*. **75:** 255-257.

Kaufmann, W. (1976). Influence of composition of the ration and the feeding frequency on pH regulation in the rumen and on feed intake in ruminants. *Livest. Prod. Sci*. **3:**103-114.

Keskin, M., S. Gül, A. Sahin, S. Kaya, M. Duru, Ö. Görgülü, S. Sahinler and O. Biçer., O. (2007). Effects of feed refreshing frequency on growth and carcass characteristics of Awassi lambs. *S. Afr. J. Anim. Sci*. **37:** 248-255.

Liboux, S.L and Peyraud, J.L. (1999). Effect of forage particle size and feeding frequency on fermentation patterns and sites and extent of digestion in dairy cows fed mixed diets. *Anim. Feed Sci. Tech.* **76:** 297-319.

Minitab, (2000). Minitab for windows 13.0. Minitab Inc. PA, USA.

NRC, (1985). Nutrient Requirements of Sheep. Sixth revised edition. National Academy Press, Washington DC, USA.

Rhodes, R.W and Woods, W. (1962). Influence of frequent feeding on the performance of growing and fattening lambs. *J. Anim. Sci*. **21:** 108-111.

Ribiero, E.L.A., Mizubuti, I.Y., Silva, L.D.F., Paiva, F.H.P., Sousa, C.L. and Castro, F.A.B. (2011). Performance, ingestive behavior and carcass characteristics of feedlot lambs submitted to different feeding frequencies. *R. Bras. Zootec.* **40:** 892-898.

Robles, V.L.A., Gonzalez, Ferret, A., Manteca, X. and Calsamiglia, S. (2007). Effects of feeding frequency on intake, ruminal fermentation, and feeding behavior in heifers fed high-concentrate diets. *J. Anim. Sci*. **85:** 2538-2547.

Sanudo, C., Campo, M., Olleta, J.L., Joy, M. and Delfa, R. (2007). Evaluation of carcass and meat quality in cattle and sheep. In: C. Sanudo, S. Gigli and D. Gabina, editors. Methodologies to evaluate meat quality in small ruminants. Wageningen Academic Publishers, The Netherlands., pp. 81-105.

Schutz, J.S., Wagner, J.J., Sharman, E.D., Davis, N.E. and Eagle, T.E. (2011). Effect of feeding frequency on feedlot steer performance. *The Prof. Anim. Scient.* **27:** 14-18.

Shabi, Z., Bruckental, I., Zamwell, S., Tagari, H. and Arieli, A. (1999). Effects of extrusion of grain and feeding frequency on rumen fermentation, nutrient digestibility and milk yield and composition in dairy cows. *J. Anim. Sci*. **82:** 1252-1260.

Soto-Navarro, S.A., Krehbiel, C.R., Duff, G.C., Galyean, M.L., Brown, M.S. and Steiner, R.L. (2000). Influence of feed intake fluctuation and frequency of feeding on nutrient of digestion, digesta kinectics, and ruminal fermentation profiles in limit-fed steers. *J. Anim. Sci*. **78:** 2215–2222.

Towhidi, A., Zali, A., Khoshsokhan, A., Khazali, H., Zhandi, M., Rezayazdi, K., Masoumi, R. and Gholami, H. (2010). The effect of feeding frequency on the hormonal profile, carcass characteristics, and feedlot performance in Iranian Holstein calves. *Turk J. Vet. Anim. Sci*. **34:** 137-142.

Walker, D.M., Cook, L.J. and Jagusch, K.T. (1967). Nitrogen balance studies with the milk-fed lambs. V. Effect of frequency of feeding. *Br. J. Nutr*. **21:** 275-287.

Wierbicki, E and Deatherage, F.E. (1958). Water content of meats, determination of water-holding capacity of fresh meats. *J. Agr. Food Chem*. **6**: 387-392.

Yang, C.M and Varga, G.A. (1989). Effect of three concentration feeding frequencies on rumen protozoa, rumen digesta, and milk yield in dairy cows. *J. Dairy Sci*. **72:** 950-957.

Zali, A and Ganjkhanlou, M. (2007). Effect of feeding frequency on non-carcass components and wholesale cuts of Iranian fat-tailed lambs. *Pak. J. Biol. Sci*. **10:** 4539-4542.