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The Optimum Energy Density in Diets for Lori-Bakhtiari Lambs during a Fattening Program

Research Article

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ABSTRACT

Forty growing ram lambs (Lori-Bakhtiari breed) averaging 28 kg (±1.5) were allocated in this study to evaluate the optimal dietary energy density in a lamb fattening enterprise in Iran. The feed intake (FI), body weight (BW), gain to feed ratio (G:F) and carcass characteristics were studied. Four treatments differed in metabolizable energy content (ME) as follow; 2, 2.3, 2.6 and 2.9 Mcal/kg for treatments 1 to 4, respectively. The study lasted 120 days and all the experimental lambs were slaughtered and carcass composition was compared among treatments. Average daily gains were 230, 252, 267 and 259 g/d for treatments 1 to 4, respectively ($P<0.01$). Moreover, lower energy density resulted in up to 19% greater FI ($P<0.01$) and higher F:G ratio ($P<0.01$) and therefore lower carcass growth efficiency ($P<0.05$). Higher energy density improved G:F ratio; but caused fatter carcasses compared to lower dietary energy levels. In addition to fatter carcasses for higher energy diets, the greatest tail-fat weight was observed for treatment 4 (2.9 Mcal/kg) and may explain the lower feed efficiency in this treatment. The values for lean mass weights were 12.7, 14.1, 14.7 and 12.7 kg for treatments 1 to 4, respectively. Overall, the best carcass efficiency was found with treatment 3. Based on these results, energy density of 2.6 Mcal/kg may be recommended for growing Lori-Bakhtiari male lambs in a fattening enterprise under the conditions of this trial.

KEY WORDS fattening, lamb, lean mass, optimum energy density.

INTRODUCTION

Lamb meat production is the main purpose of most sheep-breeding enterprises throughout the world (Yakan and Unal, 2010). Through intensive management, the performance of sheep is improved; with higher growth rates and more desirable carcass composition as compared to those raised under traditional systems. While it has been shown that initial live weight can have a major effect on lamb fattening (Gatenby, 1986; Landim *et al.* 2011), nutrition also could have major effects on weight gain and carcass composition (El-karim and Owen 1987; Perez *et al.* 2002). Among nutritional factors, the energy density might be the most important factor in this regard (Mahgoub *et al.* 2000; Shadnoush *et al.* 2004). Increasing dietary digestible energy levels in Omani growing lambs (12.2, 12.6 and 13.9 MJ/kg) improved carcass quality in this breed (Mahgoub *et al.* 2000). They found a linear effect of energy density on feed efficiency and also on carcass composition. Furthermore, Haddad and Husein (2004) compared 2.4 *vs.* 2.94 Mcal/kg of metabolizable energy (ME) in Awassi lambs diets. They also found that greater ME caused better performance and carcass quality in this breed. Sheep breeds in Iran are generally multipurpose and are reared for meat, milk and wool production; however, lamb meat production is the first goal and differences among breeds have an important role in slaughter weight and carcass characteristics (Snowder *et al.* 1994). Among the Iranian sheep breeds, the Lori-Bakhtiari (a fat-tail breed) is well known for its favorable meat quality and profitability for producers (Shadnoush *et al.* 2004).

Iranian sheep are raised under harsh environmental conditions characterized by low rainfall and high temperatures. The fat-tailed Lori-Bakhtiari sheep is a local breed which is reared in the tropical area of Lorestan province in Iran. Dietary energy is the major limiting factor of growth. The feed available from natural grazing is limited and of low quality. Most of the energy they acquire from grazing is likely to be spent on walking to and from home (Koc, 1996; Sayili *et al.* 2009). Often, the energy requirement of these animals cannot be met by grazing, even with limited energy supplementation (Farid *et al.* 1977; Farid 1991; Shadnoush *et al.* 2004; Yousefi *et al.* 2012). It seems logical to determine the energy requirements of local breeds based on the local situations. In this study, the objectives were to determine the impact of different dietary energy densities on the efficiency of growth and on carcass characteristics.

MATERIALS AND METHODS

Animals, diets and management

The present study was conducted in Lorestan province, Iran which is where the breed used was originally from. The experimental conditions were was similar to commercial fattening enterprise conductions. The vaccinations and other farm practices were carried out for all sheep routinely as in a commercial rearing system. Forty Lori-Bakhtiari non-castrated male lambs with an average BW of 28 kg (±1.5) were assigned to a completely randomized design with four treatments (10 animals per treatment). The animals were kept in group pens (four separate pens one for each treatment). The composition of experimental diets is presented in Table 1. Experimental diets were based mainly on (NRC, 1985) but some real available data for feed analyses such as protein content of feed was used as well. The diets were relatively isonitrogenous and mainly differed in their metabolizable energy content as follows: 1) 2 Mcal/kg, 2) 2.3 Mcal/kg, 3) 2.6 Mcal/kg and 4) 2.9 Mcal/kg. The study lasted 4 months and the first week was considered as adaptation period to experimental conditions. Animals had free access to water. The diet was offered as a total mixed ration (TMR). Lambs were fed twice daily at 0800 and 1600 h. Orts were collected and weighed, and feeding rate was adjusted daily to yield orts of about 5-10% of intake.

Experimental procedures and chemical analyses

Dry matter (DM) was determined in composites of feed by drying at 60 ˚C for 48 h (AOAC, 2000). Intake of DM was computed based on the 60 ˚C DM determinations for total mixed ration and orts. Animals were weighed at 10-day intervals before offering fresh feed on the day (totally 12 records throughout the experiment). Feed to gain ratio (F:G) was calculated by dividing BW changes by average intake. Lambs were slaughtered on d 120 of experiment. The slaughter process was based on that reported by Haddad and Husein (2004). All lambs were slaughtered after a 12-h fast. The bodies were skinned; the head and feet were removed.

The carcass was eviscerated and the hot carcass weight was determined. Shrinkage was calculated as the weight lost after chilling at 4 ˚C for 24 h. The left sides of the carcasses were cut into different pieces and the lean meat, bone, subcutaneous and intramuscular fat and tail fat were determined by dissection.

Statistical analysis

Data were analyzed using Proc Mixed in SAS (1996). The following model was fitted to variables that did not have repeated measurements over time;

$$Y_{ij}= \mu + S_i + T_j + \varepsilon_{ij}$$

Where:
Y_{ij}: dependent variable.
μ: overall mean.
S_i: effect of sheep i.
T_j: effect of treatment j.
ε_{ij}: residual error.

The following model was used for variables in which the measurements were repeated over time (such as body weight, F:G ratio, FI):

$$Y_{ijk}= \mu + S_i + T_j + Z_k + ZT_{jk} + \varepsilon_{ijk}$$

Where:
Y_{ijj}: dependent variable.
μ: overall mean.
S_i: effect of sheep i.
T_j: effect of treatment j (i.e. dietary energy level).
Z_k: effect of data recording time k.
ZT_{jk}: interaction between time k and and treatment j.
ε_{ijk}: residual error.

All terms were considered fixed except for S_i and ε_{ijk} which were considered random. Differences between least square means were considered significant at $P < 0.05$.

RESULTS AND DISCUSSION

There was no difference in initial BW between treatment groups (Table 2, P=0.86). The lowest BW gain (P=0.047) and average daily gain (ADG) (P=0.0094) were for treatment 1 (2 Mcal/kg).

Table 1 Composition of the experimental diets containing different energy densities for growing male Lori-Bakhtiari lambs

Item (% of DM)	Energy density, Mcal/kg			
	2.0	2.3	2.6	2.9
Alfalfa hay chopped	35	31	27	20
Barely grain	2.6	22.9	45.7	55.7
Cottonseed meal	15	9	3	3
Wheat bran	4.5	9.0	10.0	10.0
Beet pulp	14	11	5	5
Wheat straw chopped	28	16	7	4
Fat	0	0	0.72	1.32
Urea	0.2	0.4	0.8	0.2
Salt	0.2	0.2	0.2	0.2
Limestone	0.5	0.5	0.5	0.5

Table 2 Effect of different dietary energy density on feed intake and performance of male Lori-Bakhtiari growing lambs

Item	Energy density, Mcal/kg				SEM	P-value
	2.0	2.3	2.6	2.9		
Initial BW (kg)	27.7	27.7	28.0	27.7	1.1	0.86
Final BW (kg)	55.2[b]	57.6[ab]	60.1[a]	58.7[ab]	2.6	0.038
BW gain (kg)	27.1[b]	30.2[ab]	32.0[a]	31.0[ab]	2.6	0.047
Average daily gain (ADG) (g/d)	230[b]	252[ab]	267[a]	259[ab]	50	0.0094
Feed intake (kg)	262.5[a]	237.4[ab]	221.7[b]	220.8[b]	6.6	0.0001
Dry matter intake (DMI) (kg/d)	1.97[a]	1.78[ab]	1.66[b]	1.64[b]	0.08	0.003
Feed to gain (F:G)	9.52[a]	7.85[ab]	6.91[c]	7.12[b]	0.28	0.0026

The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.

The F:G ratio was significantly different among treatments in this experiment (P=0.0026) and the lowest energy density showed the greatest F:G ratio (9.52 for treatment 1). Although treatment 1 showed the greatest FI among treatments, the greatest ADG was achieved in treatment 3 and therefore, the best F:G ratio was observed in the latter (6.91). Regarding carcass characteristics data (Table 3), animals in treatment 1 had the lowest carcass efficiency, carcass fresh and cold weight (P<0.05). The results indicated that subcutaneous fat, total fat weight and tail fat weight increased significantly (P<0.05) as energy density increased in treatments 3 and 4. Deposition of both subcutaneous and intramuscular fat was increased significantly by increasing energy content in the diet (P<0.05). Carcass weight was increased with dietary energy up to 2.6 Mcal/kg (treatment 3; 31.30 kg) and then depressed when energy levels were increased to 2.9 Mcal/kg (treatment 4; 30.15 kg).

The dressing percentage (carcass weight/live weight at the time of slaughter) also showed the highest value when the energy level was 2.6 Mcal/kg compared to other treatments (P=0.023). The best lean mass weight was found for treatment 3 (14.7%) with 2.6 Mcal/kg energy density (P=0.007). Total fat weight was increased significantly (P=0.009) in treatment 4 compared to other treatments. This value was 12.5% for treatment 4 and the lowest carcass fat content was observed for treatment 1 (9.7%). The subcutaneous fat and fat-tail weights also were the highest for energy content of 2.9 Mcal/kg as well.

However the greatest value for intramuscular fat content was found for treatment 3 with 2.6 Mcal/kg ME in diet (P=0.051).

The results obtained in this study showed that when energy density was low (treatment 1), was 42 kg greater over the course of the trial than with the highest energy density level (treatment 4, P=0.0001). Dinius and Baumgardt (1970) stated that, when digestible energy is less than 2.5 Mcal/kg, feed intake in sheep is regulated by gut fill. Boggs *et al.* (1987) stated that feed consumption on higher energy diets is regulated via the involvement of energy in the chemostatic regulation of voluntary intake. Therefore lower intake in both treatment 3 and 4 may be caused by chemostatic regulation while animals receiving the lower energy treatments compensated by increasing intake. Considering ADG, data revealed that energy density is a critical determinant for body weight gain. When energy density was increased 0.3 Mcal/kg in treatment 2 over that in treatment 1, ADG was improved by an average of 22 g/d. Elevating the energy density from 2.6 to 2.9 Mcal/kg (treatments 3 to 4) daily gain was decreased. These results indicate a positive response of ADG to dietary energy density with the highest values seen in 2.6 Mcal/kg (treatment 3). High-energy diets have been shown to improve growth rates in different sheep breeds. Beauchemin *et al.* (1995) studied the effect of dietary energy density on growth performance of Rambouiller, Dorset, Finn, Sufflok and Ramanov breeds and observe that reducing the dietary digestible energy reduced growth rate and decreased growth efficiency.

Table 3 Effect of different dietary energy density on carcass characteristics of Lori-Bakhtiari growing lambs

Item	Energy density, Mcal/kg				SEM	P-value
	2.0	2.3	2.6	2.9		
Carcass efficiency (%)	50.1^{b}	51.8^{ab}	52.0^{a}	51.4^{ab}	0.4	0.023
Carcass fresh weight (kg)	27.4^{b}	30.0^{ab}	31.3^{a}	30.2^{ab}	0.3	0.031
Carcass cold weight (kg)	27.4^{b}	29.8^{ab}	31.0^{a}	29.9^{ab}	0.3	0.038
Total fat weight (kg)	9.7^{c}	10.7^{bc}	11.7^{b}	12.5^{a}	0.3	0.009
Lean mass weight (kg)	12.7^{b}	14.4^{a}	14.7^{a}	12.7^{b}	0.4	0.007
Bone weight (kg)	4.20^{b}	4.25^{b}	4.30^{b}	4.75^{a}	0.50	0.058
Subcutaneous fat (kg)	3.95^{c}	4.41^{b}	5.21^{ab}	5.82^{a}	0.48	0.005
Intramuscular fat (kg)	0.67^{b}	0.81^{ab}	0.96^{a}	0.71^{b}	0.60	0.051
Fat-tail weight (kg)	5.10^{b}	5.48^{ab}	5.51^{ab}	5.62^{a}	0.33	0.005

The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.

Similar results were found for nearly all examined breeds. In the present study the lowest energy density led to the lowest carcass efficiency, carcass weight and lean mass weight. Animals on treatment 3, in spite of a greater fat deposition, showed a greater lean mass weight and carcass efficiency compared to treatments 1 and 2. Results indicated that moderate increments in energy density for fat-tailed sheep (treatment 2 and 3) may cause greater carcass efficiency but severe increment in energy density (treatment 4) may increase fat deposition in different parts of the carcass and subsequently decrease efficiency by yielding fattier carcass. Within a same breed and sex, nutrition could have major effects on weight gain and carcass composition (El-karim and Owen 1987; Perez *et al.* 2002). Among nutritional factors, the energy level might be the most important factor in this regard (Mahgoub *et al.* 2000; Shadnoush *et al.* 2004). Because the single nutritional variable in this study was energy content, different energy levels have significant effects on all slaughter characters. Feeding Omani sheep breeds with three different energy density levels (8.67, 9.95 and 11.2 MJ ME/kg DM), Mahgoub *et al.* (2000) revealed that both meat production and carcass quality were improved in the highest energy level (11.2 MJ ME/kg DM). They found that fat content of carcass were increased numerically but not statistically by increasing energy content (fat content of 28.1, 29.22 and 30.86% for energy contents of 8.67, 9.95 and 11.2 MJ ME/kg, respectively). However, they found that the greater the energy content in the Omani breed diet, the greater the daily gain observed and hence feed efficiency was improved. Although Mahgoub *et al.* (2000) found that the highest energy value resulted in the best results, but we found that the highest energy value content decreased carcass efficiency with greater fat content. Differences between sheep breeds in their ability to ingest, digest, adapt and respond to dietary treatments have been reported by Lourenco *et al.* (2000), Givens and Moss (1994) and Ranilla *et al.* (1997). Therefore it seems that responses of local breeds to different experimental treatments might be different and therefore there is need to conduct further studies for different local breeds in each region.

It seemed in the present study that greater levels of energy were necessary to make statistical differences in the fat content of carcass. Shadnoush *et al.* (2004) investigated two different dietary energy levels (2.64 *vs.* 2.4 Mcal/kg) accompanied by three slaughter weights (45, 52.5 and 60 kg) in Lori-Bakhtiari breed.

They showed that different energy levels influenced performance parameters and also carcass characteristics. However, a slaughter weight of 60 kg was recommended in that study. It seems that in the study carried out by Shadnoush *et al.* (2004) differences in energy level in two treatments were not enough to make differences in animal responses and greater experimental levels of energy content might be better to be included.

Since the experimental animals had similar age, sex and breed in the present study and taking into accounts all traits in the Lori-Bakhtiari breed, energy density of 2.6 Mcal/kg may be recommendable for better performance and optimum efficiency.

CONCLUSION

The results of the present study showed that lower dietary energy density (less than 2.3 Mcal/kg) decreased daily gain, lean mass weight and efficiency of growth. On the other hand, energy density greater than 2.6 Mcal/kg may lead to fatter carcasses which subsequently decrease efficiency. Based on the acquired data, energy density of 2.6 Mcal/kg may be recommended for growing male lambs diet formulation.

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