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Effect of Energy and Protein Levels on Feedlot Performance and Carcass Characteristics of Mehraban Ram Lambs

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Abstract: Fifty four Mehraban ram lambs (6-to 8-month old, initial live weight 35.4±4.2 kg) were assigned to a completely randomized design consisting of 9 groups and were fed for 70 days with diets containing three levels of energy (2.3, 2.5 and 2.7 Mcal metabolizable energy per kg dry matter) and three levels of protein (10.5, 12.5 and 14.5 percentage in dry matter). Either energy or protein levels alone significantly affected most of the parameters of lamb performance, but their interaction effect was significant only for feed conversion ratio, cold carcass weight, tail weight, flap weight and back fat (subcutaneous fat) depth. The lowest level of energy (2.3 Mcal ME per kg DM) resulted in a significant decrease in lamb performance as compared with other energy levels. Increasing energy concentration of the diet resulted in significant increases in fat percentage, but significantly decreased the moisture and protein content of the *Longissimus dorsi* muscle. Increased dietary protein level increased the daily DMI and ADG and at the same time improved the FCR. Hot and cold carcass weights increased significantly with increasing dietary CP levels, but dressing percentage was similar amongst the dietary protein densities. Dietary CP levels had no significant effect on the chemical composition of the *Longissimus dorsi* muscle. At the lowest energy level (2.3 Mcal ME per kg DM), dietary protein level had a significant effect on FCR (Table 4); with the diet containing 10.5% protein having the highest FCR. At the medium and low energy levels the lowest level of dietary protein concentration resulted in smaller carcasses. The highest level of protein along with the medium energy concentration resulted in smaller tail weights. Flap weight was significantly smaller at low energy concentration along with medium and low protein level. The lowest back fat depth was found in lambs fed on the low energy diet containing medium to high levels of protein.

Key words: Energy, protein, feedlot lambs, carcass

INTRODUCTION

Many studies have been conducted to determine the effects of varying energy and protein levels in the diet on sheep (see Craddock *et al*., 1974 and the references therein; Pond, 1985; Ahmad and Davies, 1986; Purroy *et al*., 1993; Mahgoub *et al*., 2000; Karim *et al*., 2001). In general, average daily gain increased and feed efficiency was improved as protein and energy levels in the diet were increased. Most studies are in agreement that feed intake increased with increasing protein levels and decreased with increasing energy levels. Increasing energy levels in the diet usually resulted in greater fat deposition. Crouse *et al*. (1978) reported that increasing energy density of the diet resulted in a decreased ash and protein contents of the ram lamb carcasses but increased the percentage of the kidney and pelvic fats; however, no significant effect was observed for the subcutaneous fat depth over the *Longissimus* muscle. Interaction between protein and energy levels of the diet has also been reported. As percent protein in the diet increased, carcass fat measures increased on the low energy diets but decreased on the high energy diets. As energy level in the diet increased, carcass fat measures increased on the low protein diets but decreased on the high protein diets (Craddock *et al*., 1974).

Sheep are the most important meat producing livestock in Iran, which are slaughtered at 15 to 36 months of age and with a mean carcass weight of about 16 kg (FAO, 1994). Majority of male lambs are fed with a combination of feedstuffs for periods lasting up to 100 or more days, without paying attention to their actual requirements. At best, the rations are based on data from

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exotic breeds and large variations have been reported in their feedlot performance. Such practices can result in overfeeding or underfeeding of the feedlot lambs and therefore can make the feedlot operation uneconomical. Few researches have been conducted on the effect of dietary protein and (or) energy on Iranian fat-tailed lambs (Gharahbash, 1991; Parsaie and Khadivi, 1995; Shiran, 1995; Zamani *et al*., 1996; Foroozandeh *et al*., 2001; Raisianzadeh *et al*., 2004; Shadnoush *et al*., 2004).

Mehraban is one of the major sheep breeds in Iran but their nutritional requirements have not been studied. Studies are needed to determine the optimum dietary energy and protein levels of Mehraban lambs; therefore, the present investigation was carried out to address this question.

MATERIALS AND METHODS

Fifty four Mehraban ram lambs (6 to 8 month of age) with a mean initial live weight of 35.4±4.2 kg were used during a 70 day feeding trial. Lambs were fed with 9 diets in a completely randomized design arranged as a 3×3 factorial experiment with 3 levels of energy (2.3, 2.5 and 2.7 Mcal ME/ kg DM) and 3 levels of protein (10.5, 12.5 and 14.5% DM). A 21 day period was included for adaptation to the diet. The lambs were housed in individual boxes with water being freely available. The metabolizable energy concentration of the diet was calculated based on the digestible energy and ADF contents (Khalil *et al*., 1986). Chemical analysis of the ration ingredients were performed using standard methods (Van Soest, 1963; Van Soest and Wine, 1976; AOAC, 1990). The ingredients and chemical composition of rations are presented in Table 1. The diets were prepared as total mixed rations on weekly basis. A generous weighed amount of the ration was placed in the feed trough at 8.00 am and 6.00 pm and orts were removed and weighed for calculation of the daily Dry Matter Intake (DMI).

At the end of the experiment, the feed and water were removed for 18 h after which the lambs were weighed and slaughtered according to the local practices (Zamiri and Izadifard, 1997). Cavity fat (cardiac, renal, pelvic and gastrointestinal) was removed and weighed. Cold carcass weight was determined after 24 h at 4°C and the tail was removed and weighed. Fat depth over carcass was measured at the cross section of the 12th and 13th thoracic ribs at 4 points and the values were averaged as a measure of Subcutaneous Fat Depth (SCFD). Cross sectional area of the eye muscle (*Longissimus dorsi* muscle) was measured on both sides of the carcass between the 12th and 13th ribs. The cross section of the eye muscle was traced on a nylon sheath and the area was then measured by using a planimeter (Tamaya Digitising Area-Meter, Tamaya Technics, Japan). The carcass was cut into the legs, shoulders, back, neck and flap. The *Longissimus dorsi* muscle was ground twice and mixed thoroughly before sampling for chemical analysis. Duplicate samples were analyzed for Dry Matter (DM), crude fat (ether extract, EE), Crude Protein (CP) and ash (AOAC, 1990).

The data were analyzed by using the GLM procedure of the SAS for windows program on a personal computer (SAS, 1996). The effects of energy level, protein level and their interactions were included in the model. Initial live weight was used as the covariate for analysis of data. Means were compared by the least squares means adjusted for Tukey (p = 0.05).

Table 1: Ingredients and composition of the experimental diets

Diets*	HEHP	HEMP	HELP	MEHP	MEMP	MELP	LEHP	LEMP	LELP
Ingredients (% in diet)									
Corn silage	-	-	13.50	5.40	5.00	17.60	17.05	20.30	33.80
Alfalfa hay	15.00	15.00	15.00	25.00	28.00	29.00	37.00	40.00	40.00
Barley grains	68.20	71.20	70.00	50.00	53.00	52.00	25.00	25.00	25.00
Wheat bran	4.50	9.00	-	8.00	9.00	-	8.00	9.00	-
Cotton seed meal	10.60	3.30	-	10.00	3.60	-	11.50	4.50	-
Limestone	0.55	0.55	0.55	0.45	0.45	0.45	0.20	0.20	0.20
Vitamin/mineral premix**	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Urea	0.25	0.05	0.05	25.00	0.05	0.05	0.25	0.06	0.10
Salt	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Approximate chemical analysis (on DM basis)									
Dry matter (%)	89.00	89.00	65.00	78.00	79.00	67.00	62.50	59.50	47.50
Crude protein (%)	14.50	12.50	10.50	14.50	12.50	10.50	14.50	12.50	10.50
Metabolizable energy (Mcal/kg)	2.70	2.50	2.30	2.70	2.50	2.70	2.70	2.50	2.30

*HEHP (2.7 Mcal ME/kg DM and 14.5% CP), HEMP (2.7 Mcal ME/kg DM and 12.5% CP), HELP (2.7 Mcal ME/kg DM and 10.5% CP), MEHP (2.5 Mcal ME/kg DM and 14.5% CP), MEMP (2.5 Mcal ME/kg DM and 12.5% CP), MELP (2.5 Mcal ME/kg DM and 10.5% CP), LEHP (2.3 Mcal ME/kg DM and 14.5% CP), LEMP (2.3 Mcal ME/kg DM and 12.5% CP), LELP (2.3 Mcal ME/kg DM and 10.5% CP); **Each kg of Vitamin/mineral premix contained: 500000 IU vitamin A, 100000 IU vitamin D3, 100 mg vitamin E, 190 g Ca, 90 g Mg, 50 g Na, 2 g Mn, 3 g Fe, 0.3 g Cu, 3 g Zn, 0.1 g Co and 1 mg Se

RESULTS

Either energy or protein levels alone significantly affected most of the parameters of lamb performance in this study (Table 2 and 3), but their interaction effect was significant only for feed conversion ratio, cold carcass weight, tail weight, flap weight and back fat (subcutaneous fat) depth (Table 4).

The lowest level of energy (2.3 Mcal ME per kg DM) resulted in a significant decrease in lamb performance as compared with other energy levels (Table 2). Increased dietary energy level was generally associated with increased weight of the body parts. Increasing energy concentration of the diet resulted in significant increases in fat percentage, but significantly decreased the moisture and protein content of the *Longissimus dorsi* muscle (Table 3). Ash content was not significantly affected by the energy level ($p>0.05$).

Increased dietary protein level increased the daily DMI and ADG and at the same time improved the FCR (Table 2). Final live weight was significantly higher for the diet containing 14.5% Crude Protein (CP) in dry matter. Hot and cold carcass weights increased significantly with increasing dietary CP levels, but dressing percentage was similar amongst the dietary protein densities. Mean weights of the heart, lungs, neck and pelvic and pericardial fats were not significantly affected by the dietary CP level, but weights of other organs and abdominal and perinephric fats were heavier for the lambs receiving diets containing higher CP levels. Dietary CP levels had no significant effect on the weights of pelvic and pericardial fats (Table 2) and the chemical composition of the *Longissimus dorsi* muscle (Table 3).

At the lowest energy level (2.3 Mcal ME per kg DM), dietary protein level had a significant effect on FCR (Table 4); it was increased as the protein level increased, with the diet containing 10.5% protein having the highest FCR (17.8). At the highest energy level (2.7 Mcal), the cold carcass weight was not significantly affected by the protein level, but for the medium and low energy levels the lowest level of dietary protein concentration resulted in smaller carcasses. Dietary protein density did not significantly affect the tail weight at high and low energy levels, but the highest level of protein along with the medium energy concentration resulted in smaller tail weights. Flap weight was significantly smaller at low

Table 2: The main effects of energy and protein levels on lamb performance

	Energy (Mcal ME/kg DM)			Protein (% in DM)		
Items	2.7	2.5	2.3	14.5	12.5	10.5
Initial body weight (kg)	35.40	35.40	35.30	35.90	34.80	35.30
Final body weight (kg)	50.70^{a}	49.60^{a}	43.60^{b}	51.40^{a}	46.80^{b}	45.60^{b}
Average daily gain (g)	218.70^{a}	202.80^{a}	118.70^{b}	221.40^{a}	178.00^{b}	147.80^{b}
Feed conversion ratio	7.10^{b}	7.80^{b}	12.40^{a}	7.10^{b}	8.80^{b}	11.30^{a}
Dry matter intake (kg day^{-1})	1.50^{a}	1.40^{a}	1.20^{b}	1.50^{a}	1.40^{b}	1.30^{c}
Hot carcass weight (kg)	27.80^{a}	27.00^{b}	22.20^{c}	27.40^{a}	25.50^{b}	23.90^{c}
Cold carcass weight (kg)	27.10^{a}	25.80^{b}	21.40^{c}	26.90^{a}	24.40^{b}	23.00^{c}
Tail weight (kg)	4.40^{a}	4.20^{a}	3.20^{b}	4.20^{a}	4.00^{ab}	3.50^{b}
Back fat thickness (cm)	0.60^{a}	0.48^{b}	0.38^{c}	0.49^{a}	0.48^{a}	0.49^{a}
Dressing percentage	54.90^{a}	54.70^{a}	51.00^{b}	53.90^{a}	5440^{a}	52.40^{a}
Back (kg)	5.00^{a}	4.90^{a}	4.20^{b}	5.20^{a}	4.60^{b}	4.30^{c}
Flap (kg)	4.46^{a}	4.43^{a}	4.20^{b}	4.55^{a}	4.10^{a}	3.90^{b}
Neck (kg)	1.20^{a}	1.10^{b}	1.00^{b}	1.10^{a}	1.10^{a}	1.10^{a}
Leg (kg)	6.70^{a}	6.30^{b}	5.80^{c}	6.80^{a}	6.10^{b}	5.80^{b}
Shoulder (kg)	4.20^{a}	4.00^{b}	3.60^{c}	4.10^{a}	3.90^{b}	3.80^{b}
Heart (kg)	0.21^{a}	0.20^{a}	0.17^{b}	0.20^{a}	0.19^{a}	0.19^{a}
Kidney (g)	121.60^{a}	121.90^{ab}	111.80^{b}	127.70^{a}	117.20^{ab}	112.50^{b}
Liver (kg)	0.90^{a}	0.80^{b}	0.56^{c}	0.84^{a}	0.75^{b}	0.68^{b}
Lungs (kg)	0.60^{a}	0.56^{ab}	0.52^{b}	0.59^{a}	0.53^{a}	0.56^{a}
Abdominal fat (kg)	0.57^{a}	0.52^{a}	0.28^{b}	0.57^{a}	0.46^{ab}	0.34^{b}
Pelvic fat (kg)	0.12^{a}	0.13^{a}	0.07^{a}	0.14^{a}	0.10^{a}	0.08^{a}
Perinephric fat (kg)	0.16^{ab}	0.20^{a}	0.09^{b}	0.22^{a}	0.13^{b}	0.09^{b}
Pericardial fat (kg)	0.06^{a}	0.05^{a}	0.06^{a}	0.06^{a}	0.06^{a}	0.06

$^{a, b, c}$ For each category and within each row, the means with similar superscript(s) are not significantly different ($p>0.05$).

Table 3: The main effects of energy and protein levels on chemical composition of *Longissimus dorsi* muscle

	Energy (Mcal ME/kg DM)			Protein (% in DM)		
Diets	2.7	2.5	2.3	14.5	12.5	10.5
Crude fat (% in DM)	35.80^{a}	33.80^{b}	33.20^{b}	34.40^{a}	33.90^{a}	34.50^{a}
Crude protein (% in DM)	39.90^{b}	40.80^{b}	44.30^{a}	42.10^{a}	41.40^{a}	41.50^{a}
Ash (% in DM)	1.44^{a}	1.52^{a}	1.79^{a}	1.48^{a}	1.56^{a}	1.71^{a}
Moisture (%)	39.00^{c}	40.90^{b}	43.30^{a}	40.70^{a}	40.80^{a}	41.80^{a}

$^{a, b, c}$ For each category and within each row, the means with similar superscript are not significantly different ($p>0.05$).

Table 4: Interaction effects of dietary energy and protein levels on feed conversion ratio, carcass weight, tail weight, flap weight and back fat depth in Mehraban lambs

Diets*:	1	2	3	4	5	6	7	8	9
Metabolizable energy (Mcal kg^{-1})	2.70	2.70	2.70	2.50	2.50	2.50	2.30	2.30	2.30
Crude protein (%)	14.50	12.50	10.50	14.50	12.50	10.50	14.50	12.50	10.50
Item									
Feed conversion ratio	5.90^{c}	8.20^{bc}	7.10^{bc}	7.00^{bc}	7.20^{bc}	9.20^{bc}	8.30^{bc}	11.00^{b}	17.80^{a}
Cold carcass weight (kg)	29.60^{a}	26.10^{b}	25.60^{ab}	28.00^{ab}	26.20^{ab}	23.10^{c}	23.20^{c}	20.80^{cd}	20.20^{d}
Tail weight (kg)	4.70^{a}	4.50^{a}	4.10^{ab}	5.00^{a}	4.20^{a}	3.30^{b}	2.90^{b}	3.40^{b}	3.20^{b}
Flap weight (kg)	4.80^{ab}	4.30^{be}	4.20^{be}	4.60^{be}	4.60^{be}	4.00^{de}	4.20^{be}	3.30^{c}	3.50^{cd}
Back fat depth (cm)	0.60^{a}	0.61^{a}	0.60^{a}	0.55^{ab}	0.50^{abc}	0.39^{bc}	0.33^{c}	0.34^{c}	0.47^{abc}

*(1), HEHP (2.7 Mcal ME/kg DM and 14.5% CP), (2), HEMP (2.7 Mcal ME/kg DM and 12.5% CP), (3) HELP (2.7 Mcal ME/kg DM and 10.5% CP), (4) MEHP (2.5 Mcal ME/kg DM and 14.5% CP), (5) MEMP (2.5 Mcal ME/kg DM and 12.5% CP), MELP (2.5 Mcal ME/kg DM and 10.5% CP), (7) LEHP (2.3 Mcal ME/kg DM and 14.5% CP), (8), LEMP (2.3 Mcal ME/kg DM and 12.5% CP), (9), LELP (2.3 Mcal ME/kg DM and 10.5% CP).$^{a\text{-}d:}$ Within each row, the means with similar superscript (s) are not significantly different ($p>0.05$). Other interaction effects were not significant

energy concentration along with medium and low protein level. The lowest back fat depth was found in lambs fed on the low energy diet containing medium to high levels of protein.

DISCUSSION

The energy and protein levels used in the present experiment affected most of the parameters of Mehraban lamb performance but their interaction effect was significant only for a few measurements. The average daily gain of lambs in our experiment was affected by the dietary protein and energy, although the difference between the two lowest levels of protein and that between the two highest levels of energy was not significant. This almost followed the DM intake of the lambs, although a protein by energy interaction was noted for the FCR whereby it was lowest for the HEHP diet and highest for LEMP and LELP diets.

Previous studies in sheep have generally indicated that average daily gain increased and feed efficiency was improved as protein and energy levels in the diet were increased. Most studies have shown that feed intake increased with increasing protein levels and decreased with increasing energy levels (see references in the introduction). Increased feed intake and ADG with increasing levels of energy and protein in the present experiment were associated with increases in the final weight and the weights of several organs and carcass cuts as indicated in Table 2. Only the lowest level of energy resulted in a significant depression of the carcass efficiency. It seems for protein level to seriously affect the dressing percentage of Mehraban lambs, it has to be lower than the lowest level used in the present experiment (10.5%). Similarly, dietary protein levels of 12 to 15% did not affect the carcass efficiency of Naeini lambs (Foroozandeh *et al*., 2001). Mahgoub *et al*. (2000) studied the effect of high, medium and low levels of energy from weaning to 30 kg live weight in Omani male lambs. Increasing dietary energy levels resulted in increases in DM digestibility, apparent gross energy digestibility, daily DM intake and daily weight gain. Feed conversion ratio improved with increasing energy density. Sheep fed high energy diet had heavier body weight, carcass weight, higher dressing percentage but lower gut content than lambs fed medium and low energy diets. Effects of diet on carcass chemical composition were small. Low energy density animals had higher carcass protein (% DM) than both medium and high energy density animals. There was a trend of increasing fat deposition in the carcass and non-carcass with increasing energy density with the results being significant in the non-carcass.

Most measurements of the performance were not significantly affected in Lori-Bakhtiari lambs receiving a dietary energy level equivalent to 90% of that for the standard breeds, except for the shoulder and flap weight that were reduced (Shadnoush *et al*., 2004). Saleh *et al*. (1972) found small differences in the weight of neck, shoulder, flap, back and leg for different energy levels. Studies of the effect of dietary energy intake on back fat depth and the eye muscle area of fat-tailed lambs indicated no significant effect (Gharahbash, 1991; Shadnoush *et al*., 2004) or decreased area with increased energy level (Shiran, 1995). These discrepancies are mainly due to variation in experimental setup of these studies.

The palatability and digestibility of the diet increase with rising energy density which results in higher feed intake. Mahgoub *et al*. (2000) found that gut fill of Omani lambs fed a low energy diet was higher as also reported by Lu and Potchoiba (1990) in goats. This is because of the higher fiber content in the low energy diet causing rumen expansion, lower fermentation rate and higher retention time (Church, 1988). Improvement in FCR with increases in dietary energy levels could be due to improved nitrogen utilization (Black and Griffiths, 1975) and increased propionic acid production in the rumen (Church, 1988).

Abdominal and perinephric fats followed the changes in the dietary energy and protein levels, but pelvic and pericardial fats were unaffected. Increasing energy levels of the diet usually have resulted in greater fat deposition. Crouse *et al.* (1978) reported increases in the percentage of kidney and pelvic fats; however, no significant effect was observed for the SCF depth over the *Longissimus dorsi* muscle.

Jones *et al.* (1973) showed when diets containing insufficient protein were offered to growing wethers, dry matter intake and digestible dry matter and energy intakes were depressed. Dietary protein content was positively correlated to nitrogen retention, but DM digestibility had a greater effect upon voluntary feed intake than did nitrogen retention. Weston (1971) observed that DM intake of a diet containing 11.7% crude protein was less than that for diets with 15.8 or 19.1% crude protein. Campling (1970) suggested that the low nitrogen levels would limit rumen fermentation as well as the rate of passage of digesta in sheep and this was postulated as one reason for the decreased feed intake.

In the present study, increased dietary energy level resulted in increased percentage of fat (ether extract) and decreased percentage of crude protein and moisture in *Longissimus dorsi* muscle, although the ash content was not affected by either the energy level. Similar to studies in Naeini lambs (Foroozandeh *et al.*, 2001), protein content of the diet did not affect the chemical composition of the *Longissimus dorsi* muscle in our experiment. Crouse *et al.* (1978) reported that increasing energy density of the diet resulted in decreased ash and protein contents of the ram lamb carcasses.

Interaction between protein and energy levels of the diet has also been reported. As percent protein in the diet increased, carcass fat measures increased on the low energy diets but decreased on the high energy diets. As energy level in the diet increased, carcass fat measures increased on the low protein diets but decreased on the high protein diets (Craddock *et al.*, 1974). We also noted a significant interaction for the fat-tail weight and SCF depth. Karim *et al.* (2001) in a study of pre-weaning growth response of lambs which were fed with creep mixtures having varying levels of energy and digestible protein found that high energy-high protein mixture resulted in higher digestibility of dry matter, organic matter, crude protein and NDF, although ADF digestibility was higher for the low energy-low protein mixture.

Foroozandeh *et al.* (2001) showed that the optimum energy and protein levels for 10-months-old Naieni feedlot ram lambs with an average body weight of 30 kg to be 2.5 Mcal ME per kg dry matter and 11.7% CP. The optimum energy and protein levels for 5-month-old Baluchi feedlot ram lambs with a mean live weight of 19.5 kg were reported as 2.6 Mcal ME per kg DM and 14% CP (Raeisianzadeh *et al.*, 2004). Parsaie and Khadivi (1995) recommended a diet containing 2.6 Mcal ME/ kg DM and 13% CP for 8-month-old Kurdi feedlot lambs with a mean live weight of 37.5 kg. However, no significant effect of the diets containing 2.4 and 2.6 Mcal ME per kg DM on the carcass characteristics of Lori-Bakhtiari ram lambs (Zamani *et al.*, 1996; Shadnoush *et al.*, 2004). The results of this study indicated that a fattening ration containing 2.5 Mcal ME and 14.5% crude protein (DM basis) can be recommended for 6-to 8-month-old Mehraban ram lambs with an initial live weight of 35 kg.

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