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The Effect of Dietary Energy Level and Length of Feeding on Performance and Carcass Characteristics of Imported Merino Wethers

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Abstract. Thirty-two imported Australian Merino wethers of similar age were equally assigned to two dietary energy levels (2.32 and 2.74 Mcal of ME/kg) and subdivided into two feeding periods (25 and 45 days). All wethers were group-fed at 3% of their body weight daily and slaughtered at the end of each feeding period. The following performance measures and carcass traits were evaluated: average daily gain, feed efficiency, dressing %, kidney and pelvic fat, fat thickness, body wall thickness and longissimus dorsi area. The carcass of each wether was boned and proximate analysis was determined. Wethers fed on a high energy diet or those kept for 45 days on feed excelled ($P<0.05$) in the following measurements: final body weight, average daily gain, feed efficiency, dressing percentage, kidney and pelvic fat weight, body wall thickness, dissectible lean and fat weights and chemical fat weight in their carcasses. Also, the high energy fed group had significantly ($P<0.05$) more fat thickness and yielded more protein in their carcasses than those fed on the medium level of energy diet.

Introduction

During the process of assembling and transporting Australian Merino wethers to Saudi Arabia, various stresses are imposed. Periods of fasting and realimentation are part of this system and these can result in a loss of appetite and body weight [1]. Sheep that have experienced stressful periods have higher than normal rates of weight gain when the feed-energy supply is restored. These gains are normally associated with improved efficiency of food utilization [2-4]. Also, several workers have indicated that tissue weight gain of animals were altered during the realimentation depending on the various dietary treatments used [5-7].

Little or no information is available on the effect of various feeding and management schemes on compensatory gain, feed required per unit gain and carcass characteristics of Merino wethers. Logically, these parameters may be helpful guides in the evaluation of specific treatments; however, more complete carcass composition data are needed to determine the efficiency of pre-marketing conditions. Therefore, the present study was conducted to evaluate the effects of dietary energy level and length of feeding on feedlot performance and carcass characteristics of imported Australian Merino wethers.

Materials and Methods

Thirty-two imported Merino wethers, 1.5 to 2 years old as determined according to the stage of permanent incisors eruption, and 54±1.2 kg live weight were purchased from Saudi Livestock Transport and Trading Co. and trucked to the Department of Animal Production Farm, King Saud University the day they arrived from Australia. Upon arrival, all wethers were individually identified and equally allotted to a 2 × 2 factorial arrangement involving diets containing two energy densities and 25 and 45 day feedlot periods. At the initiation of the experiment, animals were vaccinated, dewormed and vitamin A-D-E injections were given. Diets were formulated to contain 2.32 (medium) or 2.74 (high) Mcal metabolizable energy / kg dry matter as presented in Table 1. The diets were group-fed to each group at the rate of 3 % of body weight daily; however, wethers were weighed and feed intake was adjusted once weekly.

All wethers were slaughtered in a commercial slaughterhouse at two times. The first group (8 wethers of each of the medium and high level dietary energy) was slaughtered after 25 days on feed, while the second group (same as the 1st group) was slaughtered after 45 days on experiment. Immediately before slaughter, all wethers were weighed after an 18 hr shrink without feed and water. Thereafter, carcasses were allowed to chill at 5 C° for 24 hr. After chilling, the cold carcass weights were recorded and the total kidney and pelvic fats were removed and weighed. Each carcass was then ribbed between the 12th and the 13th ribs and an acetate tracing was made of the longissimus dorsi muscle (Longissimus thoracis et lumborum); a planimeter was used to determine the area of longissimus dorsi muscle. Fat thickness over the center of the longissimus muscle and body wall thickness 11 cm lateral to the dorsal process between the 12th and the 13th ribs also were measured.

Each carcass was trimmed of all external fat (subcutaneous fat), boned and the intermuscular fat was removed. Intermuscular fat included all fat lying between muscles and between muscles and bones. The total weight of fat trim and intermuscular fat in each carcass was used as an estimate of dissectible fat. Total lean weight from each carcass was used as the estimate of dissectible lean and the total bone weight from each carcass was the estimate of bone. The dissectible lean of each carcass was

Table 1. Feed ingredients and composition (Dry matter basis)[a]

Item	Medium energy diet	High energy diet
Ingredients, %		
Alfalfa hay	15.0	25.0
Wheat straw	25.0	10.0
Barly		34.8
Yellow corn	35.6	24.8
Wheat bran	24.0	
Molasses		5.0
Salt	.3	.3
Limestone	.1	.1
Trace mineral premix[b]	.03	.03
Vitamin premix[c]	.01	.01
Composition		
Metabolizable energy, Mcal/kg	2.32	2.74
Crude protein	12.03	12.07
Crude fiber	16.48	12.78

[a]Diets do not total 100% due to rounding
[b]Contained 10% Mn(as $MnCO_3$); 10% Fe(as $FeCl_2 . 4H_2O$); 10% Zn(as ZnO);1% Cu(as $CuSO_4 . 5H_2O$); .3% I(as KI) and .1% Co(as $CoCl_2 . 6H_2O$), Calcium carbonate used as carrier.
[c]Contained 30 000 IU vitamin A/g; 6 000 IU vitamin D/g; and 7.5 IU vitamin E/g.

ground through a 0.3 cm plate, mixed and reground, and eight grab samples were taken. The grab samples from each carcass were remixed, and a 100 gm sample was placed in an airtight, sealed plastic bag and frozen at -25°C for chemical analysis. Chemical analysis was determined separately on each carcass. Moisture, chemical fat (intramuscular and some inseparable intermuscular fat), protein (N × 6.25) and ash were measured in duplicate using the procedures outlined by AOAC [8].

Least-squares analysis of variance was used to partition variance associated with the main effects of energy level of diet and length of feeding period. All statistical computations were accomplished by the use of computer program entitled: Statistical Analysis System [9].

Results and Discussion

Feedlot performance data are presented in Table 2. Merino wethers fed on the high level of energy diet averaged 3.3 % or 2.2 kg more total gain ($P<0.05$) than those wethers fed on the medium level of energy. Average daily gain also favored the higher level of energy. Wethers fed the high energy grew faster ($P<0.05$) and gained 50 g/day more than those fed the medium level. Feed efficiency greatly favored the group ($P<0.05$) fed the high level of energy. In this regard, wethers on the high

Table 2. Least-squares means and standard errors (SE) for feedlot performance of Merino wethers as affected by energy level of diet and days on feed.

Character	Energy level		Days on feed		SE
	Medium	High	25	45	
No. observations	16	16	16	16	
Initial weight, kg	53.7	54.1	53.7	54.0	1.14
Final weight, kg	57.5[a]	59.7[b]	56.7[a]	60.7[a]	1.21
Daily gain, kg	.11[a]	.16[b]	.12[a]	.15[b]	.02
daily feed, kg[c]	1.65	1.63	1.58[a]	1.71[b]	.03
daily ME, Mcal[d]	3.83[a]	4.47[b]	3.98[a]	4.34[b]	.09
Feed, kg/gain, kg	15.0[b]	10.2[a]	13.2[b]	11.4[a]	.09
ME, Mcal/gain, kg	34.8[b]	27.9[a]	33.2[b]	28.9[a]	1.07

[a,b]Means within an energy level or days on feed treatment that do not have a common superscripts differ ($P<0.05$).
[c]Based on dry matter weight.
[d]Metabolizable energy.

energy level required 4.8 kg and 6.9 Mcal less feed and metabolizable energy, respectively, per kilogram of gain than the medium level energy group. Increased energy intake would be expected based upon published data [10,11]. Also, it seems that these wethers express compensatory or catch-up growth when the feed-energy supply was restored during post-assembly feeding [3]. Several workers [4,12] have indicated that dietary energy was used with a high efficiency for body gain during realimentation of sheep.

Wethers fed 45 days averaged 6.8 % or 4.0 kg more total feedlot gain ($P<0.05$) than those fed 25 days. Average daily feed intake significantly increased ($P<0.05$) with increased days on feed. Daily gain and feed efficiency, however, were higher ($P<0.05$) for the 45 day feeding period. These results partially agree with the findings by Lloyd *et al.* [3] who showed that the average daily gain during the first half of the feedlot period was less than that calculated for the second half. Wethers kept for 45 days on feed required 1.8 kg and 4.3 Mcal less feed and metabolizable energy, respectively, per kilogram of body gain than those fed 25 days. It seems that the energy stores in the imported Merino bodies were depleted during the importation process and did not recover until 25 days post-realimentation. Graham and Searle [2] found a substantial improvement in the efficiency of utilization of metablolizable energy only after two weeks of realimentation. Further, Cole *et al.* [1] and Hutcheson *et al.* [13] showed that plasma glucose concentrations declined during assembly and transit and did not recover until 7 to 14 days post-transit. Generally the feed conversions are poorer than those reported by Lloyd *et al.* [3]. This may be due to the older age of the wethers. Black [10] indicated that the plane of nutrition effect on growth decreased as the animals approached mature size.

Carcass characteristics data are presented in Table 3. Cold carcass weights increased ($P<0.05$) as dietary energy density increased. This result probably reflects the heavier live weights of the Merino wethers receiving the higher energy diet. Also, dressing percent increased ($P<0.05$) as dietary energy level increased and favored the high-over the medium-level wethers. All fatness measurements, namely kidney and pelvic fat weight, fat thickness and body wall thickness increased ($P<0.05$) as energy density increased. However, it can be concluded that the increase in fatness largely negated advantages of heavier carcass weights associated with the higher energy diet. On the other hand, there was no significant difference between the longissimus dorsi muscle area from high-and medium-level of energy diet groups. This disagrees with the results reported by Crouse *et al.* [14]. Other workers [15,16], however, found that level of feeding had no effect on longissimus dorsi muscle area in cattle and sheep, respectively.

Table 3. Least-squares means and standard errors (SE) for various carcass characteristics of Merino wethers as affected by energy level of diet and days on feed.

Character	Energy level		Days on feed		SE
	Medium	High	25	45	
No. observations	16	16	16	16	
Cold carcass weight, kg[a]	29.2^b	31.8^c	28.6^b	32.4^c	.81
Dressing %	50.8^b	53.3^c	50.4^b	53.3^c	.59
Kidney and pelvic fat, kg	1.39^b	1.52^c	1.28^b	1.63^c	.07
Fat thickness, cm	$.55^b$	$.68^c$	.53	.60	.04
Body wall thickness, cm	2.32^b	2.54^c	2.28^b	2.58^c	.12
Longissimus dorsi area, cm^2	13.84	14.07	13.60	13.91	.14

[a]Included kidney and pelvic fat.

[b,c]Means within an energy level or days on feed treatment that do not have a common superscripts differ ($P<0.05$).

Cold carcass weights, dressing percent, kidney and pelvic fat weights and body wall thickness were greater ($P<0.05$) for the wethers fed 45 days than for those kept for 25 days (Table 3). However, fat thickness and longissimus dorsi area were not significantly influenced by the time on feed. Lack of time on feed effect on longissimus muscle area is consistent with that reported by Matulis *et al.* [7] who found that longissimus dorsi muscle area in cull cows did not increase significantly between 28 and 56 days of feeding. This is contrary to several studies which have shown that the feeding for longer period increases the area of longissimus muscle [7,14]. In the present study this finding could have been due to the combined effect of the wethers age and the short feeding duration.

The effect of dietary energy and time on feed on deposition of dissectible lean, dissectible fat and bone in the carcasses of Merino wethers are presented in Table 4. The wethers fed on the high energy level laid down more lean and deposited more fat in their carcasses ($P<0.05$) than did the medium-level animals. Similar results were reported by Gaili [6] and Notter *et al.* [17]. These data, however, are in apparent disagreement with those reported by Searle and Graham [5] and Crouse *et al.* [16] who found that a variety of dietary treatments failed to influence body composition. Generally, the dissectible fat weight tended to accelerate at a faster rate than the dissectible lean as dietary energy increased. As a result, the dissectible lean: dissectible fat ratio in the high-level fed group was lower than the medium-level fed group, 2.0 vs 2.1, respectively. This is consistent with results of Ferrell *et al.* [18] who found that carcasses from steers receiving the high energy diet contained more total fat and a similar amount of protein than carcasses from steers receiving the low energy diet. When the chemical fat weight was subtracted from the dissectible lean weight, for each energy level there was still a significant difference ($P<0.05$), although markedly reduced. The fat free lean content favored the high energy fed animals.

Table 4. Least-square means and standard errors (SE) for various carcass compositions of Merino wethers as affected by energy level of diet and days on feed.

Character	Energy level		Days on feed		SE
	Medium	High	25	45	
No. observations	16	16	16	16	
Cold carcass composition:					
Dissectible lean, kg	15.42[a]	16.50[b]	15.69[a]	16.63[b]	.29
Dissectible fat, kg	7.35[a]	8.31[b]	6.90[a]	8.99[b]	.24
Bone, kg	5.08	5.48	4.77	5.16	.12
Cold dissectible lean composition:					
Protein, kg	2.74[a]	2.95[b]	2.80	2.84	.10
Chemical fat, kg	2.85[a]	3.49[b]	2.93[a]	3.51[b]	.09
Moisture, kg	9.63	9.84	9.78	10.07	.23
Ash, kg	.20	.22	.18	.21	.02

[a,b]Means within an energy level or days on feed treatment that do not have a common superscripts differ ($P<0.05$).

Wethers fed on the high energy level diet averaged 0.4 kg more carcass bone than the medium-level wethers, but this difference was not significant. A similar result has been reported by Gaili [6]. It appears that bone development was more related to animal age than to the dietary energy levels imposed; these wethers were 18 to 24 months old at the start of the experiment. This conclusion was in accordance with the findings of Plasson [19] that bone tissue is the earliest maturing of the major carcass tissues. Also, the slight increases in bone weight may be due to increased lipid

content in the bone after feeding [7]. Further, no significant differences were noted in carcass moisture and ash weights with respect to dietary energy. On the other hand, the high-level fed wethers produced more ($P<0.05$) chemical fat and protein in their carcasses than the medium-level fed wethers. Data for chemical fat deposition, however, appeared to follow the same pattern observed with dissectible fat, although greater in magnitude. This result is in disagreement with the findings of Cianzio *et al.* [20] who found that intramuscular fat (mainly chemical fat) increased in proportion to total fat and at a similar relative rate.

The data in Table 4 also show that the Merino wethers fed 45 days produced more dissectible carcass lean and fat ($P<0.05$) than the wethers fed for 25 days. Similar results were reported by Matulis *et al.* [7], they found increased fatness in mature cows fed 56 days compared to 28 days. When the chemical fat was excluded from the dissectible lean weight, a nonsignificant difference was noted in the fat-free lean content. These results imply that the rate of dissectible fat deposition increases faster than the rate of fat-free lean deposition as length of time on feed increases. This supports the conclusions of Plasson [19] that fat is the latest maturing of the carcass tissues. Furthermore, the dissectible lean to dissectible fat ratio continued to decrease as the feedlot period was extended, 2.3 vs. 1.8. No clear-cut influence on bone development was exerted by the time on feed. This result is probably due to the fact that bone maturity occurred early in the wether's life. Also, little differences were observed in the rate of carcass protein, moisture and ash deposition with respect to the time on feed. However, these results appeared to follow the same pattern observed with fat-free lean content, indicating that fat-free lean and its components were related more to the nutritional treatments than to the duration on feed imposed. On the other hand, wethers kept for 45 days on feed produced more ($P<0.05$) chemical fat weight than did the wethers kept for 25 days on feed. In a similar connection, Matulis *et al.* [7] indicated that marbling scores in mature cows increased between 28 and 56 days of feeding.

Data from this study show that feeding a high energy diet to the freshly imported Merino wethers during the post-transit and post-assembling operations is probably one way to exploit their potential for compensatory growth. Thus, although realimentation with a high energy diet resulted in improved rates of gain and efficiency of food utilization, a high proportion of the extra gain was made up of fat. The high energy diet therefore, resulted in relatively smaller increases in edible meat available for the Saudi Arabian market. However, the economic feasibility of such a feeding program must be considered.

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تأثير مستوى طاقة الغذاء ومدة التغذية على خواص ومكونات ذبائح أغنام المرينو المستورد

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ملخص البحث. استخدم في هذه الدراسة ٣٢ رأس من المرينو المستورد والمتساوية الأعمار، وتم تغذيتها على مستويين من طاقة الغذاء (٢,٣٢ ميجاكالوري، ٢,٧٤ ميجا كالوري طاقة ممثلة/ كجم غذاء جاف) ولمدة ٢٥ يوم أو ٤٥ يوم. وقد تمت التغذية خلال فترة الدراسة بنظام التغذية الجماعية وبمعدل ٣٪ من الوزن الحي لكل رأس، ثم ذبحت الأغنام في نهاية كل فترة غذائية وتم دراسة كل من الصفات التالية: متوسط الزيادة اليومية، الكفاءة التحويلية، نسبة التصافي، وزن دهون الكلية والحوض، سمك الدهن، سمك جدار الجسم، مساحة العضلة العينية. وقد تم أيضًا عزل المكونات المختلفة للذبيحة ثم حللت كيميائيًا بغرض تقدير محتواها من البروتين والرطوبة ودهن بين العضلات والرماد. ودلت الدراسة على أن تغذية الأغنام المرينو على مستوى عالٍ من الطاقة الممثلة أو لمدة ٤٥ يوم بالمقارنة مع التغذية على مستوى متوسط من الطاقة أو لمدة ٢٥ يوم قد أدى إلى زيادة معنوية إحصائيًا ($p<0.05$) في كل من: متوسط الزيادة اليومية، الكفاءة التحويلية للغذاء نسبة التصافي، وزن دهن الكلية والحوض، سمك جدار الجسم، وزن اللحم والدهن المفصول، وزن دهون بين العضلات. وقد أوضحت الدراسة أيضًا أن التغذية على مستوى عالٍ من الطاقة قد أدى إلى زيادة معنوية إحصائيًا$p<0.05$)6 في كمية البروتين المترسب في الذبيحة وفي سمك طبقة دهن حول الجسم.