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**Abstract:** This experiment was conducted to determine the effects of diets containing barleys having different liter weights (lt wt) on average daily gain, feed efficiency, profit margins, ruminal fermentation, and carcass characteristics of lambs and diet digestibility. 16 Akkaraman lambs approximately 8 mo old (averaging 30 kg) were used in a randomized design. Treatment groups consisting of barley grains and barley grains were classified to liter weights as follows: 1. Barley has 643 g lt wt (Group 643). 2. Barley has 570 g lt wt (Group 570). Lambs were fed a diet of 80 % concentrate feed (98 % barley, 2% supplement) and 20 % straw. Average daily gains and average daily dry matter intake for lambs fed diets containing barleys having 643 and 570 g lt wt were 209.6, 169.6 g and 1361, 1357 g, respectively. Lambs fed diet containing barley having 643 g lt wt had more efficient feed conversion than other group. Hot carcass quality of lambs fed diet containing barley having 643 g lt wt was better than lambs fed diet containing 570 g lt wt. Diet containing barley having 643 g lt wt had higher digestibility of dry matter, organic matter, crude protein , crude fiber, ether extract and nitrogen free extract than diet containing barley having 570 g lt wt. Barley having high lt wt decreased the cost of 1 kg live weight gain. Molar percentage of ruminal acetate was lower but molar percentage of propianate and butyrate was higher in lambs fed diet containing barley having 643 g lt wt compared to the other barley.

**Key Words:** Barley, Liter Weight, Performance, Profit, Ruminal Fermentation, Digestibility.

## Farklı Litre Ağırlıklarına Sahip Arpaların Kuzularda Besi Performansı, Ekonomik Değerlilik, Ruminal Fermantasyon ve Besin Maddelerinin Sindirimi Üzerine Etkisi

**Özet:** Bu çalışma, farklı litre ağırlıklarına sahip arpa içeren rasyonların kuzularda, ortalama günlük canlı ağırlık artışı, yemden yararlanma, karlılık, ruminal fermantasyon ve besin maddelerinin sindirilme derecesine etkisini belirlemek amacıyla yürütüldü. Çalışmada, yaklaşık 8 aylık (ortalama 30 kg) 16 adet Akkaraman kuzu tesadüfü deneme düzeninde kullanıldı. Arpalar litre ağırlıklarına göre aşağıdaki gibi gruplandırıldı. 1) 643 g litre ağırlığına sahip arpa (Grup 643) 2) 570 g litre ağırlığına sahip arpa (Grup 570). Kuzular % 80 konsantre yem (%98 Arpa+ %2 Katkı Maddesi) ve % 20 saman içeren rasyonla beslendi. 643 ve 570 g litre ağırlığına sahip arpa içeren rasyonlarla beslenen kuzularda ortalama günlük canlı ağırlık kazancı ve kuru madde tüketimi sırası ile, 209.6, 169. 6 ve 1361, 1357 g olarak belirlenmiştir. Kuzularda yemden yararlanma düzeyi ve sıcak karkas kalitesi 643 grubunda daha iyi bulunmuştur. Kuru madde, organik madde, ham protein, ham yağ, ham selüloz ve azotsuz öz maddenin sindirlme derecesi 643 grubunda, 570 grubuna göre daha yüksek bulunmuştur. Litre ağırlığı yüksek olan (643 grubu) arpa, 1 kg canlı ağırlık kazancının maliyetini azaltmıştır. Ruminal asetik asit düzeyi, 643 grubunda daha düşük bulunurken, propiyonik ve bütirik asit düzeyi bu grupta daha yüksek bulunmuştur.

**Anahtar Sözcükler:** Arpa, Litre Ağırlığı, Performans, Kâr, Ruminal Fermentasyon, Sindirilebilirlilik.

## Introduction

Barley is the principal feed grain used for animals in most of countries and in large parts of Turkey. It is known that the nutrient density grains vary during the period of harvested and vegetation of plants depending on some harm factors, and during storage as subject to some insects. This subject is most important in the countries where it is customary to use grain for animals as an undermost in the sieve feed but not used for human being. Grains used in feed factory to flour factory is richer in terms of foreign matters (stem, straw, soil) and weeds. This recall that diets formulated in balance were not enough for nutrient requirements of animals. Even as, Akyıldız et al. (1) and Tepe (2) reported that barlyes have different density of nutrients in eastern Turkey. It is seen that grain wheat, barley (3) and oat (4) are classified to liter weights and grains having different liter weights have varying nutrient density. In this study, barleys having different liter weights were used by taking as a basis research done by Çerçi and Şahin (3) about liter weights. On the other hand, several studies have shown improvement in the performance of animals as a result of addition the barley variety to diets (5, 6, 7). However, no studies have compared barleys having different liter

weights as feed ingredients in high concentrate diets for lambs. Consequently, trial was conducted to determine the effects of barleys having different liter weights on growth performance, ruminal fermentation, and carcass characteristics of lambs and diet digestibility.

## Materials and Methods

### *Animals*

16 lambs (averaging 30 kg initially, approximately 8 mo of age) were used to evaluate on average daily gain, feed efficiency, profit margins, ruminal fermentation, and carcass characteristics of growing lambs in experiments. 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 by weight into two pens with 8 lambs in a completely randomized design. Initial weights was recorded at beginning of the experiment, and subsequent weights were recorded by two week.

### *Dietary Treatments*

The dietary treatments were based on barley having different liter weights that were blended into experimental diets and barley grains were classified to liter weights as follows 1. Barley has 643 g liter weight 2. Barley has 570 g liter weight. The barleys were grown at the eastern of Turkey. Lambs were fed a diet of 80% concentrate feed (98 % barley; 2% supplement) and 20% straw. Composition and chemical analysis of barleys, concentrate feed the experimental diets are summarized in Table 1, 2 and 3.

Table 1. Chemical composition of straw, barleys having 643 and 570 g liter weight

| Item | Straw | 643 g | 570 g |
|---|---|---|---|
| Dry matter | 90.65 | 94.70 | 94.60 |
| Ash | 5.90 | 2.91 | 3.31 |
| Organic matter | 84.75 | 91.82 | 91.30 |
| Crude fiber | 39.00 | 6.20 | 9.00 |
| Crude protein | 3.02 | 12.37 | 9.52 |
| Ether extract | 1.55 | 2.93 | 3.00 |
| Nitrogen free extract | 41.18 | 70.32 | 69.48 |

Table 2. Composition of concentrates fed to lambs.

| Item | % |
|---|---|
| Barley | 98.00 |
| $NaHCO_3$ | 1.00 |
| Salt | 0.50 |
| Mineral + Vitamins mix* | 0.50 |

*: 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, 125000 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.

Table 3. Composition of diets fed to lambs.

| Item | 643 g | 570 g |
|---|---|---|
| Concentrate feed | 80 | 80 |
| Straw | 20 | 20 |
| Dry matter | 93.89 | 93.81 |
| Ash | 3.50 | 3.82 |
| Organic matter | 90.39 | 89.99 |
| Crude fiber | 12.76 | 15.00 |
| Crude protein | 10.50 | 8.22 |
| Ether extract | 2.63 | 2.85 |
| Nitrogen free extract | 64.50 | 63.92 |

*Feedlot Trial*

Barleys having 643 g and 570 g liter weights were evaluated in this experiment. Akkaraman ram lambs were assigned two groups on the basis of live weight. Animals were fed twice daily (08.00 h and 17.00 h) on an ad libitum during the experiment. Lambs were weighed at the start of the experiment. Lambs were weighed between 08.00 h and 09.00 h weights were taken at the same time each day without withholding feed or water. The lambs were fed from an initial weight of approximately 30 kg to a slaughter weight of approximately 42 kg live weight. Intake and gain: feed were determined on a pen basis. All lambs were slaughtered at the end of study. Slaughter data were collected on hot carcasses. Slaughter data consisted of hot carcass weight, quality grade and cooking fat wt.

*Ruminal Fluid Samples Collection*

Samples of ruminal fluid, for measurement of pH, ammonia, and VFA (Volatile 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 10.000 x g for 15 min and a portion of the supernatant fluid was acidified with 25% (wt/vol) metaphosphoric acid and analyzed for ammonia concenration. 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°C for later VFA analysis.

*Metabolism Trial*

Twelve ram lambs were used in a completely randomized design with six lambs per treatment to determine digestibility of the diest containing barleys having different liter weights, fed in the lamb feedlot trial. The lambs were housed in metabolism cages during the digestibilty trial. No problems with feet, legs, stiffness, or health of the lambs were noticed. Lambs were individually fed their diets twice daily at 08.00 h and 17.00 while in metabolis crates. Adaptation of diets occured during the first 3 wk and betweend 22 and 31, total collection of feces was conducted. The lambs were fitted with a canvas bag to collect feces. Feed was offered ad libitum throughout the trial and voluntary intake was measured between d 22 and 31. Samples of feed were taken daily during the feces collection period and composited for analyses. Daily output of feces were weighed thoroughly mixed, and sampled, 5% of total weight. Daily fecal samples were stored frozen and then thawed, composited and thoughly mixed before drying at 60°C for 48 h before analysis. Dry fecal samples were ground using laboratory grounding mill.

*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 animal (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, $ (70d)/ total live weight gain, kg

Net profit, $ = Cost of feed of 1 kg live weight gain for lambs fed diet containing barley having 643 g lt wt, $- Cost of feed of 1 kg live weight gain for lambs fed diet containing barley having 570 g lt wt, $

*Chemical Analysis*

Chemical composition of feed ingredients, diet and feces samples were analyzed after grinding using AOAC (8) procedures, and crude fiber was determined by the methods of Crampton and Maynard (9). Ruminal ammonia concentration was determined by a spectrophotometry procedure as described by Annino (10). Ruminal fluid centrifuged was filtered and analyzed for VFA as decribed by Ottenstein and Bartley (11) using Gas Chromatography on a 610 series (Unicam).

*Statistical Analysis*

All data were subjected to analysis of student-t test using procedures of Snedecor and Cochran (12) according to randomized design.

**Result and Discussion**

Feedlot performance and economic analysis data are presented in Table 4. Lambs fed diet containing barley having high liter weight had higher ($P<0.05$) average daily gains and improved ($P<0.05$) feed conversion than lambs fed diet containing barley having low liter weights. Initial and final weights were 30.28, 30.35 and 45.28, 42.28 kg for lambs fed diet containing barley having 643 g liter weight and for lambs fed diets containing barley having 570 g liter weights, respectively. Average daily gains and average dry matter intake was 209.6 and 169.8 and 1361, 1357 g/d per lamb for 643 and 540 g liter weight. It is shown that average daily gain was higher for lambs fed barley having high liter weight than the low liter weight. The difference was significant ($P<0.05$). This indicates that lambs are very sensitive to the liter weights. The differences may be due to nutrients of density of barley e.g. barley having 643 g liter weight have high crude protein, ether extract, nitrogen free extract and the barley has low crude fiber (Table 1). On

the other hand, the barley having 570 g liter weight has higher crude fiber, and lower other nutrients than the barley having high liter weight. Likewise, barley having low liter weight had higher levels weeds, foreign matter as straw and stem. Foreign matter (stem, straw) and weeds may be effect on performance. This is in agreement with Çerçi and Şahin (3). However, the researchers (3) reported that liter weights were decreased in connection with increase of foreign matter and weeds in barley and the level of dry matter, organic matter, crude protein and nitrogen free extract were increased with concomitant increase in liter weight of barley grain. The same researcher reported that there were linear effect between liter weight and organic matter, crude protein, nitrogen free extract. On the other hands, in the most of studies (13, 14, 15) that it is shown that live weight gains increased by increasing energy and protein levels. Lu and Pochoiba (16) and Fluharty et al. (15) reported that average daily gain was increased with increasing nutrient density.

High liter weight improved feed efficiency over the low liter weight (Table 4). Even as, feed efficiency was 6.49 and 8.00 in groups, respectively. It is shown that feed efficiency was affected by different liter weights. Improvement in feed efficiency could be due to density of nutrients of barleys. Fluharty et al (15) reported that nutrient density and source in receiving diets resulted in 8.7 % improvement in feed efficiency.

Comparisons among groups were especially made with respect to economic of barleys. Economic coefficients assumed for diets were based on average of Elazığ prices. The price of diets containing barley having 643 and 570 g lt wt per kg were 0.15 $ and 0.14 $. The average total feed intake for lambs fed diet containing barley having 643 g liter weights and for lambs fed diet containing barley having 570 g liter weight was 95.27 and 94.99 kg during treatment of period. The cost of total feed intake were 14.29 $ and 13.30 $ per lamb, respectively. There was difference in average total gains when compared between groups. Likewise, average total gains were 15 kg and 11.93 kg in groups, respectively ($P<0.05$). In feed cost of 1 kg live weight gain were 0.95 $ and 1.11 $ in groups. Net profit in feed cost of 1 kg live weight gain between groups was 0.16 $. It is meant that, in low liter weight group, nutrient intake was lower than high liter weight. Likewise, total feed intake per lamb was 95.27 and 94.99 kg in groups during treatment (70 d), respectively. Another reason for the improvement of economic value with feeding barley having high liter weights was to improve feed efficiency. Even as, feed efficiency was 6.49 and 8.00 in groups, respectively. In summary, result of this experiment indicate barleys having high liter weights tended to improve profitable. When compared barleys, lambs fed barley having high liter weight produced gain more cheaply than lambs fed barley having low liter weights.

Table 4. Effect o barleys on performance and economic value of lambs.

| Item | 643 g | 570 g | SEM | Significance |
|---|---|---|---|---|
| No. of lambs | 8 | 8 | - | - |
| Days fed | 70 | 70 | - | - |
| Initial live wt, kg | 30.28 | 30.35 | 0.85 | NS |
| Final live wt, kg | 45.28 | 42.28 | 0.75 | ** |
| DMI, g/d | 1361 | 1357 | 2.15 | NS |
| Daily gain, g | | | | |
| 0-14 | 224.42 | 147.30 | 6.5 | * |
| 14-28 | 183.25 | 132.00 | 3.4 | * |
| 28-42 | 224.31 | 193.24 | 5.5 | * |
| 42-56 | 193.91 | 193.05 | 3.0 | * |
| 56-70 | 224.35 | 183.61 | 6.7 | * |
| Overall | 209.55 | 169.75 | 5.00 | * |
| Gain/feed | 6.49 | 8.00 | - | - |
| Total gain, kg/per animal | 15.00 | 11.93 | 0.28 | * |
| Total feed consumed, kg/per animal | 95.27 | 94.99 | - | - |
| Diet cost, $/kg | 0.15 | 0.14 | - | - |
| Tot. feed intake cost, $/per animal | 14.29 | 13.30 | 0.36 | * |
| Feed cost of 1 kg live weight gain, $ | 0.95 | 1.11 | - | - |
| Net profit, $/per animal | | 0.16 | | |

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

Hot carcass data show that the level of liter weights affected carcass charcteristics (Table 5). Hot carcass weight was higher (p<0.05) for lambs fed diet containing barley having 643 g lt wt than for lambs fed diet containing barley having 570 g lt wt. Carcass quality grade were higher for lambs fed barley having 643 g liter weights of carcass, hot carcass, cooking fat of parts of lambs fed diet containing barley having high liter weight were greater than lambs fed diet containing barley having low liter weight. These results conflict with those of most researches whose reported densitiy of nurient had effect on carcass yield or quality grade (14, 17).

Ruminal characteristics are presented in Table 6. Ruminal pH values for lambs fed diet containing barley having 643 g lt wt were lower than barley having 570 g lt wt (P<0.05), whereas, there was decrease by time of sampling for both groups. Ruminal pH was decreased with time after feeding for both groups, it was significantly affected by time in advance after feeding. Average ruminal ammonia concentrations were higher for lambs fed diet containing barley having 643 liter weights (P<0.05), whereas, ammonia concentrations decreased by time of sampling (P<0.01) for both the groups. Concentrations of acetate were lower for lambs fed barley having 643 g lt wt, whereas, concentrations of propionate and butyrate were higher for lambs fed diet containing barley having 643 g lt wt than diet containing barley having 570 g lt wt (P<0.05). The concentrations of total VFA increased for lambs fed diet containing barley having 643 g lt wt. The concentrations of acetate and butyrate decreased, whereas, concentrations of propionate and total VFA increased in time after sampling (P<0.05). It is well known that protein and energy supplementation of low quality roughages were affected as these results. Several researches have observed similar results for ruminants fed similar diets. This results confirm the results obtained in the present study. For example, Cecava et al. (17) reported that ruminal pH, ammonia, and VFA levels were similar for different levels of nutrient denstiy.

Table 5. Carcass characteristics of slaughter lambs

| Item | 643 g | 570 g | SEM | Significance |
|---|---|---|---|---|
| Final wt, kg | 45.28 | 42.286 | 0.75 | ** |
| Hot carcass wt, kg | 18.50 | 17.00 | 0.62 | * |
| Yield grade, % | 40.85 | 40.20 | 0.02 | * |
| Cooking fat wt. kg | 4.50 | 3.91 | 1.55 | NS |

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

Table 6. Effect of barleys on ruminal fermentation

| | 643 g | | | 570 g | | | | |
|---|---|---|---|---|---|---|---|---|
| Item | Time after feeding, h | | | Time after feeding, h | | | | |
| | 0 | 2 | 4 | 0 | 2 | 4 | SEM | Significance |
| pH | 6.09 | 5.98 | 5.60 | 6.17 | 5.95 | 5.70 | 0.03 | * |
| Ammonia, mg/lt | 144.7 | 154.2 | 144.1 | 142.6 | 151.2 | 140.6 | 4.31 | * |
| VFA, mol/100 ml | | | | | | | | |
| Acetate | 63.84 | 65.83 | 64.01 | 64.58 | 66.69 | 64.57 | 0.10 | * |
| Propionate | 17.06 | 24.42 | 23.24 | 16.87 | 23.98 | 22.89 | 0.21 | * |
| Butyrate | 7.61 | 8.84 | 8.26 | 7.38 | 8.44 | 7.89 | 0.03 | * |
| Tot. VFA, mM | 93.35 | 94.62 | 94.00 | 89.14 | 92.85 | 92.10 | 0.29 | * |

Average values are differ with P<0.05

Apparent digestibility coefficients (Table 7) for dry matter, ash, organic matter, crude fiber, crude protein, ether extract, and nitrogen free extract were higher for lambs fed diet containing barley having 643 g lt wt compared with values of the 570 g lt wt. It is showed that apparent digestibilty of the nutrients increased with increasing nutrient concentration. These differences are caused by the content of the barley containing stem, straw and weeds. Therefore, crude fiber level was higher in the barley having low liter weights. Crude fiber has negative effect on digestibilty of nutrients (18). Even as, Şahin et al (19) reported that apparent digestibility of dry matter, organic mater, crude protein, crude fiber, nitrogen free extract, and ether extract in lambs fed with diets containing high crude fiber were lower than diets containing low crude fiber. Morever, crude fiber contents of diets containing barley having 570 g and 643 g liter weight were 15.00 and 12.76 %. On the other hand, protein or energy supplementation of low quality roughage to improve their digestibility is well known. Wiedmeier et al. (20) reported that digestibility of nutrient was maximized at a protein level of increasing for diets based on wheat straw. Fluharty et al. (15) reported that digestibility of the high-nutrient diets was high, whereas, the digestibility of low nutrient diets was low.

## Conclusion

Feedlot performance was improved more by barley having high liter weight and reduced the feed cost of 1 kg live weight gain by barley having liter weight. Ruminal fermentation products were affected by barleys having different liter weigts. Depending on this, results of this experiment indicate that barleys having high different liter weights tended to improve profitable and lambs fed barley having liter weights produced gain more cheaply than lambs fed barley having low liter weight.

Table 7. Effect of barleys on digestibility of nutrients, % (n=6)

| Item | 643 | 570 | SEM | Significance |
|---|---|---|---|---|
| Dry matter | 73.58 | 67.15 | 0.92 | ** |
| Ash | 62.15 | 59.12 | 1.23 | * |
| Organic matter | 74.52 | 69.13 | 0.58 | ** |
| Crude fiber | 37.35 | 34.59 | 0.24 | ** |
| Crude protein | 73.12 | 68.00 | 3.45 | * |
| Ether extract | 82.13 | 80.31 | 0.93 | * |
| Nitrogen free extract | 79.23 | 75.34 | 1.21 | * |

* : P<0.05, ** P<0.01

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