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Comparison of hooded barley and other barley varieties on fattening performance and nutrient digestibility of Awassi sheep

Mehmet Paydas[1], Burhan Atalar[1], Esma Paydas[1], Mahmut Yüksel[1], Mustafa Apaydın[1], Fuat Serkan Kapucuk[1], Ibrahim Halil Cetiner[1] and Abdullah Can[2*]

[1] *GAP Agricultural Research Institute Directorate, Haliliye, Şanliurfa, Turkey*
[2] *Department of Animal Science, Faculty of Agriculture, University of Harran, 63300 Sanliurfa, Turkey*
[*] *Corresponding author:* acan@harran.edu.tr

Abstract

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A lamb fattening study and a digestion study were carried out for comparison of three types of barley grain using a total of 36 male lambs and 16 ram lambs, respectively. Fattening rations included 100 g/day of alfalfa hay. The first group received hooded barley grains, the second group was fed white barley, and the third group received black barley, each constituting 75% of the concentrate feed. The total fattening period lasted 84 days, including a 14-day adaptation period. A total of 16 Awassi ram lambs were selected for the classical digestion experiment and divided into four groups. Live weight gains at the end of 70 days of fattening were determined as 244 g/day in the hooded barley group, 249 g/day in the black barley group and 237 g/day in the white barley group. Feed efficiency was determined as 5.79 in the hooded barley group, 6.31 in the black barley group and 5.69 in the white barley group. As a result of the classical digestion experiment although there was no significant difference in the nutrient digestibility of DM, OM, CP, NDF and CF values, the group including hooded barley had a higher ADF digestibility rate than the groups containing the black barley variety. As a result, it was determined that there was no difference in terms of nutrient composition or its effect on the fattening performance of lambs consuming new hooded barley and other two barley varieties.

Keywords: Awassi lamb; hooded barley; alfalfa hay; apparent digestion; fattening performance

Introduction

The intense fattening system used after weaning produces the most lamb meat. Intensive lamb fattening is mostly accomplished using concentrated feed. Barley is currently one of the most important cereal crops and is typically used for human consumption, animal feed, and malting (Jedmowski and Brüggemann, 2015). In previous years, many researchers have reported that barley-based feeds provide sufficient performance in lamb fattening in Turkey (Çelik and Alaslan, 1998). A novel variety of barley (*Hordeum vulgare*), known as hooded barley, is distinguished by a genetic mutation that results in the formation of an additional non-fertile flower within the spikelet, producing spikes without beards (Roig et al., 2004; Ajenjo-Puigderrajols, 2018). Therefore, it could enhance the plant's overall nutritional value (Guaman et al., 2023). According to Karren et al. (1994), awns can cause damage to the cattle's mouths and digestive mucosa. Cetiner (2024) reported that the awnless barley genotypes had higher hay yields than standard barley varieties and triticale in terms of dry hay yield in this study region. The performance and nutritive value of hooded barley as fodder for ruminants

have been tested in some studies (Hadjipanayiotou et al., 1981; Park et al., 2008; Ajenjo-Puigderrajols, 2018). However, the nutritional value of hooded barley as a grain feed source and its impact on lamb fattening performance and nutrient digestion have not been studied in ruminant animals.

The purpose of this study was to establish the nutritional potential of a novel variety of hooded barley grain, by comparing it to black and white barley varieties in terms of fattening performance and nutrient digestibility of Awassi sheep.

Materials and Methods

Lamb fattening trial: The animal material used in the study was provided by Tektek Research Station – a small livestock farm belonging to GAP Agricultural Research Institute Directorate, located in Sanliurfa province. The trial study was also conducted in the same location. A lamb fattening study was carried out for comparison of three types of barley grain and each experimental group consisted of 4 subgroups (3 × 4 = 12 lambs), with 3 animals in each subgroup, and a total of 36 male lambs. In lamb fattening rations, in addition to roughage, the first group was fed hooded barley grains, the second group was fed white barley, and the third group was fed black barley, accounting for 75% of the concentrated feed. The overall fattening duration was 84 days, including a 14-day adaption period. Prior to the study, medicine was given to prevent internal and external parasites, a foot and mouth disease immunization was performed, and vitamins A, D3, and E were injected intramuscularly. The hooded barley grain was derived from registered candidate lines, while the white barley came from the registered Ayhan variety and the black barley from the Karahan variety. A daily amount of 100 g of dry alfalfa hay per animal served as the roughage component in the feed. In diets for fattening lambs, alongside roughage, the first group was given hooded barley grains, while the second group received white barley, and the third group was fed black barley, making up 75% of the concentrate feed. The overall fattening duration was 84 days, including a 14-day adaptation phase. In addition, the concentrate feed of each group was prepared to contain 19.1% cottonseed meal, 2.5% wheat bran, 1.6% $CaCO_3$, 0.30% DCP, 0.5% salt, 1% mineral and vitamin mixture. Concentrate diets and water were available on an ad libitum basis during fattening trial. The lambs were given two meals daily, served at consistent times: 8:00 AM and 6:00 PM. The compositions and nutrient ingredients of the rations used in the experiment are shown in Table 1. Throughout the trial, weight measurements were made every two weeks. Measurements from two days in a row were averaged to determine the initial and final weights.

Table 1. Ingredient and chemical composition of diets fed to lambs

Diets (% as fed basis)			
Item (%)	Hooded Barley	Black Barley	White Barley
Barley	75	75	75
Cotton seed meal	19.1	19.1	19.1
Wheat bran	2.5	2.5	2.5
$CaCO_3$	1.6	1.6	1.6
DCP	0.30	0.30	0.30
Salt	0.5	0.5	0.5
Mineral and vitamin mix	1	1	1
Chemical composition, (%)			
DM	93.78	93.96	93.37
OM*	93.35	92.06	93.44
CP*	14.13	14.77	14.46
ADF*	15.25	13.80	11.35
NDF*	35.56	30.29	28.48
Crude Fiber*	8.41	7.64	8.07
Crude Ash*	6.65	7.94	6.56

*Percent of dry matter, DM: Dry matter, OM: Organic Matter, CP: Crude protein, ADF: Acid detergent fiber, NDF: Neutral detergent fiber, $CaCO_3$: Calcium carbonate, DCP: Di calcium phosphate.
Source: Authors' own elaboration

Apparent digestion trial: Male yearlings were used in the digestion trial. A total of 16 male yearlings (48.93 ± 1.429), 4 from each fattening trial group, with similar live weights, were placed in conventional digestion pens. Intramuscular vitamins (vitamins A, D3 and E) were applied to the animals at the beginning of the trial. The animals used in the conventional digestion trial were given 85% hooded barley + 15% alfalfa for the 1st group; 85% white barley + 15% alfalfa for the 2nd group; 85% black barley + 15% alfalfa for the 3rd group and 100% alfalfa for the 4th group. Nutrient composition of diets and barley varieties are shown in Table 2. The lambs were kept in individual pens throughout the digestion trial. The digestion trial period lasted 21 days, including diet adaptation, feed intake determination and feces collection. Feces collection lasted 7 days.

Daily clean water was provided ad libitum in each trial compartment. In the digestion trial, the difference between the amount of feed eaten by the yearlings and the chemical components of the amount of feces excreted through feces revealed the degree of digestion. Specialized harnesses and bags were attached to the animals to facilitate fecal collection. After excretion, the feces were gathered and combined daily to determine the total weight. A 10% representative sample was then extracted to create ongoing composite samples for each animal. All dietary and fecal samples were stored in sealed polyethylene bags and kept in freezers until

Table 2. Nutrient composition of diet and barley varieties used in digestion trial

	Chemical Composition					
*Diets**	DM	OM***	CP***	ADF***	NDF***	CF***
Hooded Barley	94.02	95.63	10.25	15.82	37.26	8.75
Black Barley	93.85	96.25	12.31	13.75	31.29	7.87
White Barley	93.53	96.22	10.92	14.29	28.89	8.36
Alfalfa Hay	95.59	90.17	12.62	46.96	52.47	27.79
Grains**						
Hooded Barley	93.46	96.23	9.83	10.32	34.57	5.39
Black Barley	93.82	96.83	12.26	7.89	27.55	4.36
White Barley	93.58	96.64	10.42	8.52	24.74	4.94

*Contains 15% alfalfa and 85% one of the barley variety
**100% one of the barley variety
***Percent of dry matter, DM: Dry matter, OM: Organic Matter, CP: Crude protein, ADF: Acid detergent fiber, NDF: Neutral detergent fiber
Source: Authors' own elaboration

they underwent chemical analysis. Digestibility of the diets and barley's nutrients calculated by employing the following equation reported by Merchen (1993):

$$\text{Digestibility of nutrients in diet (\%)} = = \frac{\text{Nutrient consumed (g/d)-Fecal nutrient (g/d)}}{\text{Nutrient consumed (g/d)}} \times 100$$

$$\text{Digestibility of nutrient in barley variety (\%)} = = \frac{(A) - (B)(C)}{(D)} \times 100$$

where: A = digestibility of nutrient in whole diet; B = digestibility of nutrient in alfalfa hay; C = portion of total nutrient in the given alfalfa hay; D = part of total nutrient in the diet supplied by the barley variety.

Ethical clearance (2022/008/01) for this study was granted by the HRU-HADYEK (Harran University Animal Experiment Local Ethical Committee).

Chemical analyses: Fecal samples were dried in an oven at 65 °C for 48 h. Fecal and diet samples were ground to pass 1 mm screen for chemical analysis. AOAC (1990) methodologies were used to determine DM, OM, and crude ash content of ration and feces samples. The acid detergent fiber (ADF) and neutral detergent fiber (NDF) were determined as previously described (Goering and Van Soest, 1970). Crude fiber (CF) content of diets and feces were performed in accordance with the methods described by Crampton and Maynard (1938). The protein content in the samples was determined as a percentage (%) in the calibrated NIT (Near-Infrared Transmittance) spectroscopy device (Anonymous, 1990).

Statistical analyses: Data on live weight gain, feed conversion, and feed intake from the fattening trial, as well as nutrient digestion values from the apparent digestion trial, were analyzed using a completely randomized design, and differences between group means were determined using the LSD test in the SAS (1989) software package.

Results and Discussion

Lamb fattening trial: The effects of diets containing different barley varieties on average daily gain (ADG), dry matter intake (DMI) and feed efficiency are shown in Table 3. Differences in ADG and feed efficiency were detected between diets over the first two weeks of the fattening trial. The black barley diet group had greater ADG and feed efficiency values compared to white barley diet group ($P < 0.05$). However, similar effects were not detected throughout the fattening trial, and ADG, DMI, and Feed efficiency values were not changed by the use of different barley varieties. At the end of the 70-day trial, the ADG values obtained from Awassi lambs were found to be between 237 and 249 g/day. The ADG levels obtained in fattening experiments on Awassi lambs with various concentrated meals were found to be similar to those reported in this study (Can et al., 2004; 2005; Demir and Can, 2019). Ozbey et al. (2000) found ADG in Awassi yearlings fed a ration containing barley between 235.77 g/day and 256.02 g/day. In the light of these data, ADG values of Awassi lambs were compatible with the above-mentioned previous studies. In this study, the dietary inclusion of various barley grain varieties had no effect on DMI. At the end of the fattening study, The average DMI was 1338 g in the hooded barley group, 1392 g in the black barley group, and 1301 g in the white barley group, and no statistically significant difference was observed ($P > 0.05$). The DMI of the experimental groups was greater than in previous studies by Can et al. (2004) and Can et al. (2005), which used the same breed, barley-based diets, and similar

circumstances. This difference can be explained by the fact that the beginning (22 kg vs 27 kg) and the end body BW (36 kg vs 44 kg) of Awassi lambs were lower than those in the current research. In contrast, Demir and Can (2019) observed slightly higher DMI values for fattening Awassi lambs, which had a greater initial body weight (29 kg) and the same final body weight (44 kg) and a shorter fattening period (56-d vs 70-d). Differences in feed efficiency were detected between diets throughout the first two weeks of the fattening trial. The black barley containing diet had better feed efficiency value (5.06) than white barley diet (6.27) ($P < 0.05$). However, feed efficiency values were not affected due to usage of different barley variety during whole fattening trial. The feed efficiency values obtained in the fattening studies conducted on Awassi lambs with different concentrated feeds were found to be similar to the values obtained in this study (Demir and Can, 2019). In contrast, some previous studies reported slightly better feed efficiency values for fattening Awassi lambs due to lower initial body and final body weights (Can et al., 2004; 2005).

Apparent digestion trial: Nutrient digestibility of the diet and barley varieties is set out in Table 4. DM and OM digestibility of barley variety including diets were found similar ($P > 0.05$), however alfalfa hay had a lower DM and OM digestibility ($P < 0.05$). Also, DM and OM digestibility of diets containing barley varieties were found to be similar and ranged from 74.95 to 81.76%. Ramsey et al. (2001) reported that apparent in vivo digestibility of DM with 95% barley varieties containing diets were ranged from 80.5 to 87.4% and hulless variety had the highest value. In a study conducted by Denek and Deniz (2004), the DM digestibility values of barley grain determined by *in vivo* and *in vitro* methods were found to be between 77.55–82.18%. The percentages found in this study are consistent with earlier findings. Former studies also did not detect a difference in OM digestibility of barley varieties (Ovenell-Roy et al., 1998b; Ramsey et al., 2001). In contrast, Ovenell-Roy et al. (1998b) found that two rows barley had 7% greater OM digestibility than six row barley variants. Denek and Deniz (2004) showed that the OM digestibility values of barley grain evaluated by *in vivo* and *in vitro* techniques ranged from 79.14 to 83.87%, which is consistent with this study.

The CP digestibility of barley varieties and diets was similar ($P > 0.05$), whereas alfalfa hay had a greater CP digest-

Table 3. Effect of different barley varieties on fattening performance of Awassi lamb

	Diets*				
Item	Hooded Barley	Black Barley	White Barley	*SEM*	*P-values*
Number of lambs	12	12	12		
Initial body weight (BW, kg)	27.21	27.24	27.77	*0.678*	*0.81*
Final BW (kg)	44.26	44.66	44.34	*1.113*	*0.96*
ADG (0–14 d) (g)	207^{ab}	218^{a}	167^{b}	*14.5*	*0.05*
ADG (15–28 d) (g)	175	246	236	35.7	0.35
ADG (29–42 d) (g)	290	235	216	*46.6*	*0.54*
ADG (43–56 d) (g)	260	255	251	*24.1*	*0.97*
ADG (57–70 d) (g)	287	290	313	*42.0*	*0.87*
ADG (0–70 d) (g)	244	249	237	*13.2*	*0.82*
DMI (0–14 d) (g)	1059	1081	1035	*35.41*	*0.665*
DMI (15–28 d) (g)	1173	1270	1189	*43.81*	*0.293*
DMI (29–42 d) (g)	1416	1506	1404	*77.68*	*0.615*
DMI (43–56 d) (g)	1515	1526	1417	*98.53*	*0.701*
DMI (57–70 d) (g)	1530	1578	1457	*87.93*	*0.634*
DMI (0–70 d) (g)	1338	1392	1300	60.12	0.575
Efficiency (0–14 d)	5.18^{ab}	5.06^{b}	6.27^{a}	*0.332*	*0.05*
Efficiency (15–28 d)	6.97	6.55	5.15	*1.31*	*0.61*
Efficiency (29–42 d) (g)	5.14	7.90	6.57	*1.15*	*0.29*
Efficiency (43–56 d) (g)	6.04	5.96	5.68	*0.34*	*0.74*
Efficiency (57–70 d) (g)	5.64	6.09	4.77	*0.86*	*0.57*
Efficiency (0–70 d) (g)	5.79	6.31	5.69	*0.36*	*0.45*

*Each diets contains 75% of barley variety; ADG, average daily gain (g/day); DMI dry matter intake g/day; Efficiency (g DMI/g ADG).

abc: Different superscript letters represent means with a row for each diet. Unlike superscripts differ ($P \leq 0.05$).

Source: Authors' own elaboration

Table 4. Nutrient digestibility of diet and barley varieties

*Diets**	Digestibility, %							
	BW, kg	DMI, % of BW	DM	OM	CP	ADF	NDF	CF
Hooded Barley	49.88	2.33	77.36[a]	79.25[a]	68.24[ab]	56.20[ab]	63.74	23.64[b]
Black Barley	47.48	2.56	74.98[a]	77.09[a]	62.68[b]	41.94[c]	50.22	19.52[b]
White Barley	49.25	1.94	78.28[a]	79.86[a]	67.40[ab]	47.30[bc]	55.92	17.32[b]
Alfalfa Hay	49.10	2.53	67.92[b]	68.67[b]	71.88[a]	68.20[a]	62.45	61.04[a]
SEM	*3.13*	*0.19*	*1.24*	*1.16*	*2.11*	*4.09*	*4.91*	*4.90*
P value	*0.95*	*0.14*	*0.0003*	*0.0001*	*0.0500*	*0.0040*	*0.240*	*0.0001*
Grains**	Digestibility, %							
Hooded Barley			80.62	77.68	67.52	47.38[a]	64.09	19.04
Black Barley			78.04	74.95	60.96	22.61[b]	54.23	13.81
White Barley			81.76	78.98	66.43	27.95[ab]	53.48	12.69
SEM			*1.47*	*1.64*	*2.76*	*7.12*	*4.15*	*6.64*
P value			*0.240*	*0.258*	*0.250*	*0.050*	*0.186*	*0.776*

*Contains 15% alfalfa and 85% one of the barley variety

**100% one of the barley variety

DMI: dry matter intake (kg), BW: body weight (kg), DM: dry matter, OM: organic matter, CP: crude protein, ADF: Acid detergent fiber, NDF: Neutral detergent fiber, CF: crude fiber, SEM: standard error of mean

[abc]: Different superscript letters represent means with a column for each diet and grains. Unlike superscripts differ ($P \leq 0.05$).

Source: Authors' own elaboration

ibility than diet containing black barley ($P < 0.05$). Also, the CP digestibility of barley varieties was similar, ranging from 60.96 to 67.52%. Denek and Deniz (2004) reported that CP digestibility values of barley grain determined by *in vivo* and *in vitro* methods was found to be between 62.11–64.35%. In the previous study, the CP digestibility of barley grain was assessed in a manner comparable to the current study. However, Ramsey et al. (2001) reported that apparent *in vivo* digestibility of DM with diets containing 95% barley varieties ranged from 79.7 to 87.0%, and two-row barley and six-row varieties had the same CP digestibility values. These differences can be explained with using different animals (ram lambs vs. steers) in *in vivo* studies, and as well as chemical characteristic of different varieties. Denek et al. (2006) found that heat stress, roughage concentrate feed ratio, and roughage type all had an influence on CP digestion in Awassi lambs. They also indicated that CP digestion of a diet including 70% concentrate feed and 30% alfalfa was 74.6% in summer and 68.41% in winter season. The summer season value they reported is similar to the CP digestion results in this work.

The ADF digestibility of diets containing barley varieties and of the barley varieties themselves was found to be different ($P \leq 0.05$), while alfalfa hay had greater ADF digestibility than diets containing black and white barley ($P \leq 0.05$). In addition, the ADF digestibility of the hooded barley variety was shown to be greater than that of the black variety. Akcay (2006) observed that yearling lambs fed barley-based feeds had an ADF digestibility rate ranging from 46.11% to 48.60%. Demir and Can (2019) found that the ADF digestibility values in Awassi lambs ranged from 24.83 to 32.88%. The ADF digestibility of barley grain was evaluated in both studies, which is comparable to the current study. In contrast, NDF and CF digestibility of barley variety including diets and barley grains were found similar ($P>0.05$).

Conclusion

When the potential of hooded barley grain, a new variety, was examined by comparing it with white barley and black barley, it was determined that there was no difference in terms of nutrient digestibility and its effect on the fattening performance of Awassi lambs compared to other barley varieties. Additionally, hooded barley grain's numerically superior NDF, ADF, and CF digestibility values as compared to other barley types were a positive result. Another benefit is that, compared to other barley varieties in this research area, the hooded barley is an important alternative to other barley varieties. Therefore, hooded barley is important an alternative substitute to other barley varieties for sheep nutrition.

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Conflict of interest

The authors have declared no conflict of interest.

Author's contribution

All the authors have contributed to the study.

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