Turkish Journal of Veterinary & Animal Sciences

Volume 37 | Number 6 | Article 19

1-1-2013

The effects of barley/triticale silage on performance, carcass characteristics, and meat quality of lambs

GÜLCAN DEMİREL

AHMET YAVUZ PEKEL

BÜLENT EKİZ

HAKAN BİRİCİK

NEŞE KOCABAĞLI

See next page for additional authors

Turkish Journal of Veterinary and Animal Sciences

http://journals.tubitak.gov.tr/veterinary/

Research Article

Turk J Vet Anim Sci
(2013) 37: 727-733
© TÜBİTAK
doi:10.3906/vet-1303-53

The effects of barley/triticale silage on performance, carcass characteristics, and meat quality of lambs

Gülcan DEMİREL[1,*], Ahmet Yavuz PEKEL[1], Bülent EKİZ[2], Hakan BİRİCİK[3], Neşe KOCABAĞLI[1], Müjdat ALP[1]
[1]Department of Animal Nutrition and Nutritional Disease, Faculty of Veterinary Medicine, İstanbul University, Avcılar, İstanbul, Turkey
[2]Department of Animal Breeding and Husbandry, Faculty of Veterinary Medicine, İstanbul University, Avcılar, İstanbul, Turkey
[3]Department of Animal Nutrition and Nutritional Disease, Faculty of Veterinary Medicine, Uludağ University, Görükle, Bursa, Turkey

Received: 22.03.2013 • **Accepted:** 07.06.2013 • **Published Online:** 13.11.2013 • **Printed:** 06.12.2013

Abstract: This study was conducted to investigate the performance, carcass characteristics, and meat quality of lambs fed barley/triticale silage treated with/without inoculant and enzyme mixture-based diets with similar barley supplementation. Thirty Tahirova × Sakız crossbred weaned ram lambs (mean body weight: 34 ± 0.5 kg) were used in this study. Lambs were randomly divided into groups of 3 and fed the respective diets. These 3 diets were: 1) hay grass + barley, 2) triticale/barley silage + barley, and 3) triticale/barley silage with inoculants and enzyme mixture + barley. There were significant differences among groups in daily live weight gain ($P < 0.001$). Cold carcass weight and dressing percentage based on empty body weight and carcass conformation scores were not significantly different among groups, but fatness scores and proportion of omental and mesenteric fat were significantly affected by diet ($P < 0.05$). No differences were found in terms of meat lightness (L*), redness (a*), and yellowness (b*) values for *M. longissimus thoracis* muscle. However, silage-fed lambs in both groups had higher shear force values than hay-fed lambs in the current study ($P < 0.05$). It can be concluded that barley/triticale silages offered with concentrate had no unfavorable effect on lamb performance, carcass characteristics, and meat quality.

Key words: Lamb, triticale, barley, silage, meat quality

1. Introduction

Silages can be used for lamb production together with grain when the pasture quality is low. Live weight gains were low in lambs fed only silage diets and inclusion of grain to the diet led to good responses in production parameters (1). The cereals are of certain interest because of extensive use for hay production. Feeding value of cereal silages is much higher than hays of cereals (2). However, production response to silage, such as fermentation quality and dry matter (DM) content, is an important point and needs more consideration (3). Silage inoculants are important for unstable silages. Feeding lambs with ryegrass ensiled with bacterial inoculant treatment increased silage consumption and caused more carcass growth (4) compared to the silage without inoculant treatment. In some studies, no improvement was observed in lamb performance even there was an improvement in silage quality (5). There are many research papers published on the effects of feeding on sheep performance and meat quality, but limited data are available on information comparing grass, hay, and cereal silage feeding of lambs fed similar concentrate levels. Therefore, the objective of this study was to present the effect of feeding lambs with triticale/barley silage treated with or without inoculants on lamb performance, carcass characteristics, and meat quality.

2. Materials and methods

2.1. Animals, diets, and experimental procedure

Thirty Tahirova × Sakız crossbred weaned ram lambs (mean body weight: 34 ± 0.5 kg) were used in this study. Lambs were divided into 3 groups and fed 1 of 3 dietary treatments. These 3 diets were: 1) hay grass + barley (G), 2) triticale/barley silage + barley (S), and 3) triticale/barley silage with inoculants and enzyme mixture + barley (SM). The lambs were kept in straw-bedded group pens during 57 days of trial period. After 2 weeks of environmental and dietary adaptation, silage was offered ad libitum with a barley equivalent to 1% of the live weights of lambs in the experimental period and daily refusals were recorded. Vitamin and mineral premix was used at 3 parts barley to 1 part supplement. The quantity of silages given was adjusted each day according to feed consumed the

* Correspondence: gdemirel@istanbul.edu.tr

previous day. Animals first received half of the amount of hay and silages at 0800 hours and then 1 h later barley was given. The remaining hay or silages were distributed at 1500 hours. Lambs were weighed in fortnightly intervals before feeding throughout the trial and live weights were recorded. Average daily gain, dry matter intake, and feed conversion ratio were determined for all groups.

The silage materials (triticale/barley) were harvested at an early heading stage in the early spring. After wilting, the forage was chopped to a length of 2.5 cm and treated with an inoculant (Sil-All^{4x4}, Alltech, USA) at a rate of 10 mg/kg of forage prior to ensiling. Inoculant was of powder form, dissolved in water and pulverized on forage, and was stored in plastic bags for 70 days. The pH of silages was measured after water extraction with a pH-meter (Hanna Instruments pH 211 Microprocessor pH Meter, Romania). Water extracts were put together with 25% meta-phosphoric acid and volatile fatty acids in the silage were determined by gas chromatography (CP-Sil 5CB column, 10 m × 0.25 mm ID, Chrompact, UK). The spectrophotometry method was used to determine lactic acid by using an enzymatic procedure (6). Nutrient compositions of feeds were determined according to the Weende analysis system but neutral detergent fiber (NDF) fraction was determined using the procedure described by Van Soest et al. (7) and acid detergent fiber (ADF) was determined using the method of Goering and Van Soest (8) as adapted for the Ankom200 Fiber Analyzer (Ankom Technology, USA).

2.2. Slaughter procedures and carcass measurements

Animals were slaughtered at İstanbul University Faculty of Veterinary Medicine abattoir. For 12 h before slaughter animals had access to water, but not to feed. After recording of live weights and electrical stunning, lambs were slaughtered. Hot carcass weight was recorded after removal of head, skin, feet, lungs, trachea, liver, heart, spleen, pancreas, gastrointestinal tract, diaphragm, and testicles. Hot carcass weight comprised kidneys and perinephric-pelvic fat. The empty body weight was determined by excluding contents of the gastrointestinal tract. Carcasses were classified for fatness and conformation (9) after they were chilled at 4 °C for 24 h. Leg lengths, internal carcass length, thoracic depth, and hind limb lengths were measured and estimated according to Fisher and de Boer (10).

2.3. Meat instrumental quality and laboratory analyses

Carcass pH levels were measured from the longissimus thoracis muscle between the 12th and 13th thoracic vertebrae by digital pH-meter (Testo 205, Testo AG, Germany) immediately after dressing (pH_0), at 45 min after slaughter ($pH_{45\ min}$), and at 24 h after slaughter ($pH_{24\ h}$). Meat color, drip and cooking loss (%), and Warner-Bratzler (WB) shear force (kg) were assessed from the *M. longissimus thoracis* removed from the left side of carcass at 24 h postmortem. Drip loss was determined according to the method described by Honikel (11) and cooking loss (%) was measured in samples as described by Hoffman et al. (12). Water holding capacity (WHC) was expressed as percentage of weight loss of 5-g meat samples (13). Caudal subcutaneous fat color values were taken from the tail root.

2.4. Statistical analysis

In order to determine the effect of feeding 2 silages and grass hay on performance, carcass, and meat quality characteristics, 1-way ANOVA was performed using SPSS 10.0 (14). Duncan's multiple-range test was used to evaluate the significance of the difference. Kruskal–Wallis and Mann–Whitney U tests were used to evaluate conformation and fatness scores.

3. Results

The chemical composition of the barley/triticale silages after 70 days of fermentation process is presented in Table 1. Dry matter content of silages treated with inoculant/enzyme mixture was higher than that of untreated silages. Crude protein, ether extract, and crude ash contents were similar, but ADF and NDF values of silages with inoculant/enzyme mixture were lower compared with the untreated silages. Feeding lambs dry grass or silages had an effect on daily live gain ($P < 0.001$) in the present study (Table 2). Grass hay feeding resulted in numerically higher DM intake and lower feed efficiency rates.

The effects of feeding grass hay and triticale/barley silage with or without inoculant and enzyme mixture on slaughter characteristics and carcass quality are presented in Table 3. There were no significant differences for slaughter weight ($P > 0.05$) among groups. Furthermore, hot carcass weight and dressing percentages based on empty body weight did not differ. However, dressing percentages based on slaughter weight for lambs fed grass hay were higher than those of silage-fed lambs ($P < 0.05$). Cold carcass weight and dressing percentage based on empty body weight and carcass conformation were not significantly different among groups, but fatness scores and proportion of omental and mesenteric fat were significantly affected by silage feeding ($P < 0.05$). Lambs of both silage groups showed significantly lower carcass fatness scores compared with the grass hay group. Initial pH was not significantly different among the groups (Table 4). Despite the differences in ultimate pH, no differences were observed for pH decline during 24 h postmortem, but silage-fed groups showed numerically lower values than lambs fed hay. Silage-fed lambs in both groups had higher shear force values than hay-fed lambs in the current study (Table 4). Cooking loss values were not affected by the dietary treatments ($P > 0.05$). No differences were observed in terms of meat lightness (L*), redness (a*), and

Table 1. Chemical composition of the feeds (%, in DM basis).

	Dry grass	Silage	Silage + inoculant/enzyme	Barley
Dry matter	84.7	34.7	38.8	88.4
Crude protein	10.8	11.3	11.2	11.5
Crude ash	7.0	6.5	6.4	3.2
Ether extract	2.0	2.2	2.5	2.2
ADF	41.6	38.3	36.9	7.67
NDF	69.1	58.3	54.5	21.6
Silage pH		4.7	4.1	
Lactic acid		5.36	10.1	
Acetic acid		1.22	1.80	
Propionic acid		0.05	0.73	
Butyric acid		0.61	0.06	

Table 2. Live weights, feed intake, and feed conversion efficiency of experimental groups.

	G		S		SM		Sig.
	Mean	SE	Mean	SE	Mean	SE	
Initial weight of lambs, kg	35.2	0.46	35.3	0.54	34.4	0.44	NS
Final weight of lambs, kg	42.57	1.32	46.21	1.78	44.13	1.66	NS
Live weight gain, g/day	130^{b}	7.51	191^{a}	7.39	170^{a}	9.82	***
Daily feed intake, kg DM	1.27	-	1.18	-	1.14	-	-
FCR	9.78	-	6.17	-	6.69	-	-

NS: Not significant (P > 0.05), ***: P < 0.001.
FCR: Feed conversion ratio (kg DM / kg body weight gain).
$^{a, b}$: Means in the same row with different superscripts are significantly different.

yellowness (b*) values for *M. longissimus thoracis* muscle (Table 5). However, silage diets caused a decrease in fat yellowness of lambs (Table 6).

4. Discussion

There is no information on the fermentation characteristics of barley/triticale silage and responses to inoculant/enzyme mixture in the literature. Few studies have been conducted to compare the efficiency of inoculant/enzyme in silages from barley and other cereal crops, and improved fermentation quality has been observed in barley silage treated with a multistrain inoculant containing *L. plantarum* and enzyme (15). Addah et al. (16) reported that inoculation of whole-crop barley silage with a mixed culture of homolactic lactic acid bacteria (LAB) and *L. buchneri* at ensiling improved aerobic stability and resulted in a higher lactic-to-acetic acid ratio than untreated silage. On the other hand, Keles and Demirci (17) found little impact of homofermentative LAB plus enzyme on fermentation parameters of triticale-Hungarian vetch silage after 3 months of fermentation process. Despite the use of an inoculant in triticale-lupin silage, the fermentation resulted in high pH and acetic acid and in low lactic acid concentrations in a study by Dawson (18). DM content and fermentation characteristics of silages affected dry matter intake in studies examining the effect of crop silages on beef and lamb (19). Bolsen et al. (2) found that the effects of barley dough-stage silages were superior to those in lambs fed wheat dough-stage silages and resulted in greater gain, DM intake, and feed efficiency. However, Keles and Demirci (17) reported no significant effects of triticale-Hungarian vetch silages with homofermentative LAB + enzyme mixture on intake of lamb, similar to the current study. Dawson (18) also found no differences for intake of beef cattle fed with grass, maize, or triticale/lupin silages despite the poor quality of silage produced from lupin/triticale forages. In a study by Jones and Woolford (5), lambs consumed more

Table 3. Means and standard errors (SEs) for certain slaughtering and carcass quality characteristics of experimental groups.

	G		S		SM		Sig.
	Mean	SE	Mean	SE	Mean	SE	
Preslaughter live weight, kg	41.81	1.30	46.24	1.82	43.94	1.55	NS
Empty body weight, kg	35.16	1.11	36.72	1.48	34.61	1.25	NS
Hot carcass weight, kg	19.48	0.72	20.20	0.97	19.16	0.91	NS
Hot dressing percentage 1[d], %	46.54[a]	0.55	43.60[b]	0.68	43.49[b]	0.95	*
Hot dressing percentage 2[e], %	55.34	0.67	54.89	0.63	55.18	0.93	NS
Omental and mes. fat, %	1.95[a]	0.30	1.13[b]	0.32	0.83[b]	0.17	*
Empty stomach, %	2.56	0.13	2.71	0.13	2.82	0.11	NS
Empty intestines, %	5.51	0.26	5.04	0.23	5.65	0.31	NS
Cold carcass weight, kg	19.00	0.71	19.72	0.96	18.68	0.90	NS
Carcass quality characteristics							
Cold dressing percentage 1, %	45.39[a]	0.51	42.56[b]	0.68	42.40[b]	0.97	*
Cold dressing percentage 2, %	53.98	0.59	53.58	0.64	53.79	0.95	NS
Carcass length, cm	72.82[b]	1.13	78.33[a]	1.84	79.30[a]	1.53	*
Thoracic depth, cm	27.63	0.35	28.54	0.53	28.64	0.54	NS
Leg length, cm	22.25	0.31	22.80	0.34	23.26	0.25	NS
Hind limb length, cm	30.46[b]	0.79	30.61[b]	0.68	33.72[a]	0.61	**
Internal carcass length, cm	60.49	1.11	62.03	1.38	61.98	0.86	NS
Conformation score	6.60	0.43	7.00	0.63	6.80	0.63	NS
Fatness score	8.30[a]	0.40	6.90[b]	0.48	6.70[b]	0.75	*

NS: Not significant (P > 0.05), *: P < 0.05, **: P < 0.01
[a, b]: Means in the same row with different superscripts are significantly different.
[d]: Dressing percentage based on slaughter weight, [e]: dressing percentage based on empty body weight.

Table 4. Means and standard errors (SEs) for pH, WHC, cooking loss, and WB shear force values of experimental groups.

	G		S		SM		Sig.
	Mean	SE	Mean	SE	Mean	SE	
pH_0	6.56	0.06	6.63	0.05	6.61	0.04	NS
$pH_{45\ min}$	6.54	0.06	6.57	0.05	6.57	0.06	NS
$pH_{24\ h}$	5.62[b]	0.02	5.73[a]	0.03	5.71[a]	0.02	*
pH decline (0–24 h)	0.94	0.04	0.90	0.05	0.90	0.04	NS
WHC, %	7.92	0.56	6.63	0.61	8.14	0.51	NS
Cooking loss, %	33.04	0.63	32.78	0.71	33.96	0.88	NS
WB shear force values, kg	5.83[b]	0.33	7.08[a]	0.50	7.67[a]	0.40	*

NS: Not significant (P > 0.05), *: P < 0.05.
WHC: Water holding capacity.
[a, b]: Means in the same row with different superscripts are significantly different.

of the inoculated ryegrass silage. Differences in dressing percentage can be attributed to differences in gut-fill, since lambs in each group had similar carcass conformation scores. Similarly, Scerra et al. (20) observed a similar pattern for slaughter weight and dressing percentage in male lambs fed silage compared to oat hay as a forage source. Petit and Castonguay (21) also reported that high levels of concentrate supplementation increased slaughter

Table 5. Means and standard errors (SEs) for meat color characteristics of experimental groups.

	G		S		SM		Sig.
	Mean	SE	Mean	SE	SE	Mean	
L_0	37.13	0.45	35.37	0.86	38.11	1.06	NS
$L_{1\ h}$	38.48	0.32	36.91	0.84	38.99	0.84	NS
$L_{1\ day}$	41.10	0.40	40.15	0.71	41.89	0.68	NS
$L_{2\ days}$	40.58	0.35	39.42	0.63	41.01	0.71	NS
$L_{3\ days}$	39.01	0.48	38.31	0.57	39.89	0.87	NS
$(a^*)_0$	15.18	0.28	15.10	0.34	15.23	0.29	NS
$(a^*)_{1\ h}$	16.70	0.38	16.57	0.41	17.01	0.34	NS
$(a^*)_{1\ day}$	17.21	0.30	17.13	0.36	17.29	0.45	NS
$(a^*)_{2\ days}$	16.68	0.35	16.56	0.42	17.22	0.49	NS
$(a^*)_{3\ days}$	16.40	0.44	15.87	0.48	16.70	0.45	NS
$(b^*)_0$	1.53	0.26	1.09	0.32	2.12	0.41	NS
$(b^*)_{1\ h}$	3.44	0.33	2.59	0.28	4.02	0.54	NS
$(b^*)_{1\ day}$	7.07	0.27	6.72	0.28	6.39	0.75	NS
$(b^*)_{2\ days}$	6.96	0.31	6.47	0.17	7.19	0.42	NS
$(b^*)_{3\ days}$	7.69	0.23	7.02	0.28	7.90	0.33	NS

NS: Not significant.
(L*): lightness, (a*): redness, (b*): yellowness.

Table 6. Means and standard errors (SEs) for fat color characteristics of carcass of experimental groups.

	G		S		SM		Sig.
	Mean	SE	Mean	SE	Mean	SE	
(L*)	66.56	1.08	66.59	1.612	69.40	1.38	NS
(a*)	6.57^a	0.57	4.86^b	0.41	4.60^b	0.72	*
(b*)	7.99	0.49	8.49	0.59	7.69	0.84	NS

NS: Not significant ($P > 0.05$), *: $P < 0.05$.
(L*): lightness, (a*): redness, (b*): yellowness.
$^{a, b}$: Means in the same row with different superscripts are significantly different.

weight and dressing percentage of lambs and, thus, similar slaughter weights and dressing percentage based on empty body weight in the current study could be explained by similar inclusion of concentrate to lamb diets. Scerra et al. (20) reported that carcass fatness is affected markedly by silage diets and silage-fed lambs had lower carcass fatness scores. However, Keady et al. (22) reported the effect of inclusion of whole-crop wheat silages on dressing percentage, carcass conformation, fat classification, and weight of internal fat depths of beef carcasses. Ultimate pH values were not higher than pH 5.8–5.9, which indicated dark, firm, and dry meat. Grass-hay groups were significantly lower in ultimate pH values than were silage-fed lamb carcasses. This may be because of the considerably low fat level of carcasses of lambs fed silages and, therefore, the carcass may have cooled faster, leading to a slow rate of pH decline. Otherwise, the pH decline would be faster and would result in much lower pH values. There have been variable reports in the literature on the effect of silages on tenderness of lamb meat. Shear force values in silage-fed groups were higher than 6 kg, which was noted as tough, in a study by Webb et al. (23). Despite similar growth rates prior to slaughter at the same weight and age, differences in tenderness in the current study arose from differences in fatness levels (24). A high amount of fat causes a decrease in the rate of temperature decline, which increases the activity of autolytic enzymes in muscle, lessens the extent of myofibrillar shortening, and, therefore, increases tenderness of meat from a fatter carcass (25). The opposite was happening in our case, which led to our conclusion that differences in cooling rate were responsible for the differences in tenderness in the current study. Differences in cooking loss arise from intramuscular fat content (26). Intramuscular fat content was not measured in the current study, but probably similar intramuscular fat content led to similar cooking loss values. May et al. (27) also found that intramuscular fat content increased with increasing carcass weight. Therefore, in the present experiment it appears that similar growth rate and energy intake led to similar cooking loss values. As indicated above, results related to meat color were similar among groups. Scerra et al. (20) reported that color parameters (L^*, a^*, b^*) were unaffected by dietary treatment after feeding lambs either oat-hay or wheat-straw silage. French et al. (28) found no effect of grass, grass silage, and concentrate-based diets on color of the longissimus thoracis muscle; in our findings, we are in agreement with those of French et al. (28). Published results to the present show that many factors like animal age, fatness, ultimate pH, and carcass weight affect the color of meat (29), but the level and content of concentrate in feeding ruminants may be the most important factor determining the color of meat (30). No data are available from research that evaluated triticale/barley silage-based rations on fat color of lamb. In a cattle study, feeding steers with whole-crop silages resulted in lower b^* values in fat than in those fed grass silage. French et al. (28) showed that carcass fat yellowness was inversely and linearly related to the proportion of concentrate in the diet. These results may explain the absence of differences in yellowness in the current study, which used a similar concentrate level. However, results related to fat redness are not constant, even in grazing and indoor counterparts.

The results of silage fermentation parameters demonstrate that adding inoculant/enzyme mixture to barley/triticale silage had positive effects on silage fermentation parameters but had no effect on lamb carcass characteristics and meat quality. It is concluded that barley/triticale silages offered with concentrate had no unfavorable effect on lamb performance, carcass characteristics, and meat quality.

Acknowledgment
The authors would like to thank Dr Hülya Yalçıntan and DVM Dilek Akçin for their assistance in the slaughtering process. The present study was supported by the Research Fund of İstanbul University (Project No: 574-14082006).

References

1. Khan SH, Shahzad MA, Nisa M, Sarwar M. Nutrients intake, digestibility, nitrogen balance and growth performance of sheep fed different silages with or without concentrate. Trop Anim Health Prod 2011; 43: 795–801.
2. Bolsen, KK, Berger LL, Conway KL, Riley G. Wheat, barley and corn silages for growing steers and lambs. J Anim Sci 1976; 42: 185–191.
3. Filya I, Ashbell G, Hen Y, Wienberg ZG. The effect of bacterial inoculants on the fermentation and aerobic stability of whole-crop wheat silage. Anim Feed Sci Technol 2000; 88: 39–46.
4. Jones R, Woolford MK. Technology of forage preservation. In: Proceedings of the 11th Interntional Silage Conference, Aberystwyth, Wales, UK; 1996; pp. 232–233.
5. Rooke JA, Kafilzadeh F. The effect upon fermentation and nutritive-value of silages produced after treatment by 3 different inoculants of lactic-acid bacteria applied alone or in combination. Grass Forage Sci 1994; 49: 324–333.
6. Barker SB, Summerson WH. The colorimetric method for determination of lactic acid in biological material J Biol Chem 1941; 138: 535–554.
7. Van Soest PJ, Robertson JB, Lewis BA. Method for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. J Dairy Sci 1991; 74: 3583–3597.
8. Goering HK, VanSoest PJ. Forage Fiber Analysis. USDA-ARS Agriculture Handbook No. 379. Washington, DC, USA: Government Printing Office; 1970.
9. Ruiz de Huidobro F, Miguel E, Díaz MT, Velasco S, Lauzurica S, Pérez C, Onega E, Blazquez B, Caneque V. Carcass classification in suckling lambs. II. Comparison among subjective carcass classification methods: Fatness scales and conformation scales with 0.25 point-intervals. Meat Sci 2004; 66: 135–142.
10. Fisher AV, de Boer H. The EAAP standard method of sheep carcass assessment. Carcass measurements and dissection procedures. Livest Prod Sci 1994; 38: 149–159.
11. Honikel KO. Reference methods for the assessment of physical characteristics of meat. Meat Sci 1998; 49: 447–457.
12. Hoffman LC, Muller M, Cloete SWP, Schmidt D. Comparison of six crossbred lamb types: Sensory, physical and nutritional meat quality characteristics. Meat Sci 2003; 65: 1265–1274.
13. Ekiz B, Ekiz EE, Kocak O, Yalcintan H, Yilmaz A. Effect of pre-slaughter management regarding transportation and time in lairage on certain stress parameters, carcass and meat quality characteristics in Kivircik lambs. Meat Sci 2012; 90: 967–976.
14. SPSS, Inc. Statistical Package for the Social Sciences, Release 10.0. Chicago, IL, USA: SPSS; 1999.
15. Kung L, Ranjit NK. The effect of *Lactobacillus buchneri* and other additives on the fermentation and aerobic stability of barley silage. J Dairy Sci 2001; 84: 1149–1185.

16. Addah W, Baah J, Groenewegen P, Okine E, McAllister T. Comparison of the fermentation characteristics, aerobic stability and nutritive value of barley and corn silages ensiled with or without a mixed bacterial inoculant. Can J Anim Sci 2011; 91: 133–146.

17. Keles G, Demirci U. The effect of homofermentative and heterofermentative lactic acid bacteria on conservation characteristics of baled triticale–Hungarian vetch silage and lamb performance. Anim Feed Sci Technol 2011; 164: 21–28.

18. Dawson LER. The effect of inclusion of lupins/triticale whole crop silage in the diet of winter finishing beef cattle on their performance and meat quality at two levels of concentrates. Anim Feed Sci Technol 2012; 171: 75–84.

19. Huhtanen P, Rinne M, Nousiainen J. Evaluation of the factors affecting silage intake of dairy cows; a revision of the relative silage dry matter intake index. Animal 2007 1: 758–770.

20. Scerra V, Caparra P, Foti F, Lanza M, Priolo A. Citrus pulp and wheat straw silage as an ingredient in lamb diets: effects on growth and carcass and meat quality. Small Rum Res 2001; 40: 51–56.

21. Petit HV, Castonguay F. Growth and carcass quality of prolific crossbred lambs fed silage with fish meal or different amounts of concentrate. J Anim Sci 1994; 72: 1849–1856.

22. Keady TWJ, Lively FO, Kilpatrick DJ, Moss BW. Effects of replacing grass silage with either maize or whole-crop wheat silages on the performance and meat quality of beef cattle offered two levels of concentrates. Animal 2007; 1: 613–623.

23. Webb EC, Casey NH, Simela L. Goat meat quality. Small Rum Res 2005; 60: 153–166.

24. Muir PD, Smith NB, Wallace GJ, Cruickshnk GJ, Smith DR. The effect of short term grain feeding on live weight gain and beef quality. New Zeal J Agr Res 1998; 41: 517–526.

25. Santos VAC, Silva SR, Azevedo JMT. Carcass composition and meat quality of equally mature kids and lambs. J Anim Sci 2008; 86: 1943–1950.

26. Solomon MB, Kemp JD, Moody WG, Ely DG, Fox JD. Effect of breed and slaughter weight on physical, chemical and organoleptic properties of lamb carcasses. J Anim Sci 1980; 51: 1102–1107.

27. May SG, Dolezal HG, Gill DR, Ray FK, Buchanan DS. Effects of days fed, carcass grade traits and subcutaneous fat removal on postmortem muscle characteristics and beef palatability. J Anim Sci 1992; 70: 444–453.

28. French P, O'Riordan EG, Monahan FJ, Caffrey PJ, Vidal M, Mooney MT, Troy DJ, Moloney, AP. Meat quality of steers finished on autumn grass, grass silage or concentrate based diets. Meat Sci 2000; 56: 173–180.

29. Priolo A, Micol D, Agabriel J. Effects of grass feeding systems on ruminant meat colour and flavor. A review. Anim Res 2001; 50: 185–200.

30. Huuskonen A, Jansson S, Honkavaara M, Tuomisto L, Kauppinen R. Performance, meat fatty acid profile and meat colour of dairy bulls finished on grazed pasture or grass silage-based diets with similar concentrate allowances Acta Agr Scand A-An 2010; 60: 104–111.