Effects of pre-slaughter diet/management system and fasting period on physiological indicators and meat quality traits of lambs

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ABSTRACT

This study determined the effects of pre-slaughter diet/management system on blood and rumen parameters and meat-quality traits of Norduz lambs. Eighty lambs were divided into two groups according to diet (AH: alfalfa hay; BAH: alfalfa supplemented with 500 g/head barley) for 21 days. Following this period, lambs from each group were distributed among four groups according to pre-slaughter fasting period as 0, 12, 24 or 48 h. Cortisol concentrations were found to be significantly higher in the 24 h and 48 h groups when compared to the 0 h group ($p < 0.01$). Diet and fasting period had limited effect on muscle glycogen content and ultimate pH·L*, WHC and moisture decreased in line with increases in the fasting period ($p < 0.01$). In conclusion, carcass conformation and some meat quality traits were better in BAH lambs. Fasting had a negative effect on some meat quality parameters, with significant increases in some physiological stress indicators after fasting periods of 24 h or longer.

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1. Introduction

Farm animals are exposed to various levels of stress during certain periods of the production process, such as the short period of time in which they are transferred to the slaughterhouse. Stress factors related to certain management practices during this time can have a considerable effect on both animal welfare and meat quality.

Feeding management is one of the most important factors to affect animal welfare and meat quality prior to slaughter. Animals are sometimes fasted for over 48 h between transport and slaughter. The combined effect of pre-slaughter diet, fasting and additional stress factors may considerably reduce muscle glycogen reserves. Pre-slaughter factors such as feeding system and fasting period have also been found to negatively affect meat quality by increasing serum cortisol and ultimate meat pH levels (Kannan et al., 2014; Zimerman, Domingo, Grigioni, Taddeo, & Willems, 2013). A linear relationship has been found between muscle glycogen levels and metabolic energy levels of rations (Jacob, Pethick, & Chapman, 2005; Pethick & Rowe, 1996), with a number of studies reporting that feeding high-energy rations for several weeks in cattle (Gallo, Apaoblaza, Pulidoa, & Jerez-Timaurec, 2013; Immonen, Ruusunen, Hissa, & Puolanne, 2000) and high level feed intake in longer periods in sheep (Pethick & Rowe, 1996) before slaughter may help prevent stress-related problems such as dark cutting meat. However, the majority of research on this subject has involved yearling or older sheep, with few comprehensive studies conducted with young animals (Edwards & Babiszewski, 2013).

Therefore, this study evaluated the effects of pre-slaughter fasting period on blood, rumen, slaughter and carcass characteristics and meat-quality parameters in male lambs fed with only roughage and those fed a barley-supplemented diet for 21 days prior to slaughter. The effects of pre-slaughter fasting periods of different lengths were also examined. The findings of this study may be used in the development of pre-slaughter management practices aimed at reducing animal stress and economic loss.

2. Materials and methods

2.1. Animal material and feeding management

Animal research procedures were conducted with the approval of the Local Animal Ethics Committee of Yuzuncu Yıl University in Van, Turkey (Decision No. 2015/03). The animal material used in the study consisted of 80 7-month-old male Norduz lambs. Lambs were kept in the pens (1.6 m² per lamb) in the outdoor sheepfold until slaughter. Following a 15-day period during which lambs were fed ad-libitum alfalfa hay in order to determine average feed consumption values, they were divided into two groups (n = 40) according to feed content based on NRC (1985) during finishing, as follows: AH: alfalfa hay (1750 g/lamb/day); BAH: barley-supplemented alfalfa hay (1250 g alfalfa hay + 500 g barley/lamb/day). Nutrient contents of alfalfa hay and barley used in the experiment are presented in Table 1. The difference in energy intake between diets was intended to be minimal, so as to avoid any effect of diet on carcass characteristics and meat quality being confounded by differences between treatments for live weight at the commencement of fasting. Lambs were fed according to these

Table 1
Nutrient contents (%) of feed.

Nutrient matter	Alfalfa hay	Barley
Dry matter (DM)	95.88	97.19
Crude ash	11.87	2.61
Crude protein	13.51	11.68
Ether extract	0.44	1.74
Crude cellulose	28.03	5.71
Neutral detergent fiber (NDF)	43.82	27.69
Acid detergent fiber (ADF)	31.67	6.38
Energy, kcal/kg DM	2486.13	2895.67

regimes for a 15-day adjustment period that allowed the animals in the BAH group to adjust to the barley supplementation, followed by a 21-day finishing period. At the end of the finishing period, feed was removed for 12 h then lambs were weighed to determine final body weight. To determine weight loss during fasting all lambs' full weighs and their fasted weigh were recorded prior to slaughter. After weighing, equal numbers of lambs from both groups were randomly placed into 1 of 4 groups (0, 12, 24 and 48 h) according to the length of pre-slaughter fasting period. However, three animals were removed due to reasons unrelated to treatment. Lambs were housed in the same pens which used for the finishing period until slaughter. Animals were allowed ad-libitum water during fasting.

2.2. Feed analyses

Dry matter, crude ash, crude protein and ether extract analyses of hay and barley were performed based on the AOAC (2000). NDF and ADF contents were determined according to Van Soest and Robertson (1979).

2.3. Blood sampling and analyses

Blood samples were taken from the vena jugularis of 20 lambs from each group at days 0, 11 and 21 of the finishing period and from all lambs immediately before slaughter. Samples were centrifuged at 5000 rpm for 10 min within 1 h of collection, and serum was stored for further analysis at −80 °C. Serum glucose (glucose oxidase method), triglyceride (glycerol phosphate dehydrogenase test method), blood urea nitrogen (BUN) (urease test method), lactate dehydrogenase (LDH) (IFCC method), total protein (biuret method) and creatine kinase (CK) (adenosine triphosphate method) levels were measured using Bioanalitik™ kits with an Olympus AU400 chemical analyzer. Serum cortisol, insulin, T3, and T4 levels were measured by chemiluminescence microparticle immunological analysis using Abbott™ kits with an Architect c8000 (Burtis, Ashwood, & Bruns, 2013).

2.4. Rumen fluid sampling and analyses

In addition to blood samples, approximately 250 mL of rumen fluid was collected by oral probe from 20 randomly selected lambs in each group 5 h after feeding (Nordlund & Garrett, 1994) on days 0, 11 and 21 of the finishing period and from all lambs before slaughter. Rumen pH was measured using an Orion 720 digital pH meter accurate to 0.01. Ammonia content in rumen fluid was determined according to Akkan (1983). Rumen volatile fatty acids (VFA) analysis was conducted using a high-pressure liquid chromatography (HPLC) with a Schimazdzu UV detector and an Alltech IOA-1000 HPLC column (column length: 3000 mm; inner dia.: 7.8 mm) using 0.004 M sulfuric acid 50 °C as an isocratic mobile phase. Total HPLC working time was 50 min (Peu, Béline, & Martinez, 2004).

2.5. Carcass characteristics and meat quality analysis

Lambs were slaughtered at the experimental abattoir unit in research farm without transportation. Hot carcass and offal weights were determined at slaughter. Following slaughter, carcasses were stored at 4 °C for 24 h, after which carcasses were measured based on Bonvillani et al. (2010) and cut into pieces according to Colomer-Rocher, Morand-Fehr, & Kirton (1987). Meat quality characteristics were assessed using samples taken from the *m. longissimus* thoracis [LT] (between the 6th and 13th ribs). Color and water-holding capacity were analyzed within 2 h after sampling, and the samples were then placed on polystyrene trays, overwrapped with an oxygen-permeable PVC film and stored at 4 °C for 72 h. Samples were then placed in vacuum bags to be kept until texture analysis and stored at −18 °C for a month.

Meat pH measurements were obtained at 45 min ($pH_{45\ min}$), 8 h ($pH_{8\ h}$) and 24 h ($pH_{24\ h}$) from left half-carcasses and at 72 h ($pH_{72\ h}$) from LT samples (the 12th–13th ribs) using a pH meter (Hanna HI 99163) with the probe inserted into the muscle to a depth of approximately 3 cm.

Meat color was evaluated with a CIELAB-illuminant D65/10° movable spectrophotometer (Lovibond RT-300) using samples taken from the left half-carcass (the 11th–12th ribs). The measurements were performed on a freshly cut surface of 2.5 cm thick samples after allowing the muscle surface to bloom in the chiller at 4 °C for 30 min L*(luminosity), a*(redness), and b*(yellowness) were measured at 3 fat-free areas on the surface of each sample, and the average measurements were calculated and recorded. Chroma value and hue angle were calculated using the equations $C* = [(a*)^2 + (b*)^2]^{1/2}$ and $h* = \tan^{-1}(b*/a*)$, respectively. Meat water-holding capacity was determined using the filter-paper press method (Wierbicki & Deatherage, 1958).

Texture analysis was performed on samples (aging for 72 h at 4 °C after slaughter) taken from the left half-carcass LT (the 6th–11th ribs) that had been stored at −18 °C for 1 month and then allowed to thaw overnight (~12 h) at 4 °C. Samples were weighed and placed in thin, heat-resistant plastic bags that were then sealed and placed in a water bath at 75 °C for 1 h (Hoffman, Muller, Cloete, & Schmidt, 2003). After cooking, the bags were cooled under running tap water for 1 h. Samples were removed from the bags, the meat surfaces were dried with paper towels, and the meat samples were reweighed in order to calculate cooking losses (%). Following weighing, the cooked meats were again stored overnight (~12 h) at 4 °C until texture analysis. A coring device was used to obtain 3 cores per sample (1-cm dia. × 1.5 cm) taken parallel to the direction of the muscle fibers. Shear force values were analyzed using a texture analyzer (TA. XT plus) equipped with a Warner Bratzler V-slot blade. Shear testing was performed with a 50-kg load cell, a cross-head speed of 200 mm/min and a blade-penetration depth of 20 mm (Kannan, Kouakou, Terrill, & Gelaye, 2003), with the average of the 3 core values calculated and recorded for each sample.

Nutrient analysis was performed on LT samples taken from the right half-carcass (the 6th–12th ribs) that had been stored at −18 °C for 1 month and then thawed overnight (~12 h) at 4 °C. Thawed samples were homogenized, and dry matter (950.46), ash (920.153), fat (960.39-ether extract) and protein (928.08-Kjeldahl) contents were measured according to AOAC (2000).

2.6. Glycogen concentrations

Glycogen concentrations were evaluated from samples taken from the right half-carcass LT (the 12th–13th ribs) and the middle of the central liver lobe during the first 30 min post-slaughter and immediately transferred to a liquid nitrogen tank for storage at −80 °C until glycogen analysis (~1 month). The amounts of glycogen in muscle and liver tissue were quantitatively assessed (Carroll, Longley, & Roe, 1956; Roe, Bailey, Gray, & Robinson, 1961).