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Effect of energy source and level, and animal age and sex on meat characteristics of sheep

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ABSTRACT

Trial 1 was designed to identify meat quality differences due to sheep age (n = 16 ewe lambs, n = 16 yearling ewes, and n = 16 mature ewes) and diet (ad libitum alfalfa pellets (AP), and ad libitum whole shelled corn (WSC100)). Mature ewes had greater ($P \leq 0.02$) lean CIELAB a^* values when compared with yearling ewes and ewe lambs. Offering WSC100 resulted in a greater ($P \leq 0.05$) CIELAB a^* value from the fat of sheep carcasses. *Longissimus thoracis* (LT) cook loss and slice shear force (SSF) values decreased ($P \leq 0.01$) with postmortem aging from 1 d to 14 d. Trial 2 was designed to identify meat quality differences due to diet (AP, WSC100, and 85% restricted intake of WSC; WSC85), lamb sex (n = 48 ewes and n = 48 wethers), and lamb age (n = 48 short-fed and n = 48 long-fed). Short-fed lambs had greater LT ultimate pH ($P \leq 0.05$) and lean CIELAB L^* values ($P \leq 0.01$) when compared with long-fed lambs. Long-fed lambs had greater ($P \leq 0.05$) CIELAB L^* values from the fat of the carcass when compared with short-fed lambs. Lambs offered WSC100 produced carcass fat with greater ($P \leq 0.03$) CIELAB a^* values when compared with lambs offered AP. Long-fed lambs had a greater percentage of lipid in the LT ($P \leq 0.01$) and the whole, boneless ground shoulder ($P \leq 0.01$) and greater shoulder patty cook loss ($P \leq 0.01$) when compared with samples from shorter-fed lambs. Offering WSC100 resulted in a greater ($P \leq 0.01$) percentage of lipid in the shoulder patty when compared with offering AP and WSC85. Percent cook loss and SSF values decreased ($P \leq 0.05$) in the LT when aged for 14 days when compared with 1 day. Across the two trials, indicators of sheep meat quality were not largely influenced by diet, age of the sheep, or sex of the sheep.

1. Introduction

In the United States, sheep are marketed on a live weight basis; therefore, sheep producers and feeders are able to increase the amount of revenue and potential profit when they market heavier sheep. However, as body weight increases, the body composition of lambs begin to change, with a shift from lean muscle growth to greater fat deposition (Ferrell et al., 1979). The current quality grading system used in the United States (USDA, 1992) is heavily influenced by carcass fatness and physiological maturity (break joint status). Therefore, the American sheep industry currently has no system that accurately measures quality characteristics indicative of eating satisfaction. Implementing a marketing system that will reward producers for marketing high quality lamb with added premiums and discounts for low quality lamb would help improve lamb quality and be a great benefit to the American sheep industry.

The American Lamb Industry Roadmap Project (2013) states that the focus of the American sheep industry should be directed towards product characteristics in order to improve the consumer's eating experience by providing them with a consistent and premier lamb product every time. The 2015 National Lamb Quality Audit (Hoffman et al., 2016) identified eating satisfaction as the most important quality attribute for lamb consumers when deciding to purchase lamb products. Therefore, the present trials investigated functional meat quality characteristics that are indicators of eating quality as influenced by energy source, lamb sex, and sheep age. While a large amount of research investigating meat quality characteristics has been done in leading lamb producing countries such as Australia and New Zealand,

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current data is lacking in the United States with the use of today's current diets, genetics, and management practices (slaughter weights).

The demand for sheep meat in the United States is seasonal, meaning the demand for lamb typically occurs around the time of religious holidays (Byrne et al., 1993; Ward et al., 1995). Due to the seasonal demand for lamb, many lamb producers attempt to capitalize on the increased market price just before religious holidays. However, retaining market ready lambs in the feedlot for additional days on feed produces "long-fed" lambs that are excessively fat (Field and Whipple, 1998; Jaborek et al., 2018; Southam and Field, 1969). There is concern that these long-fed lambs may have a poorer eating quality compared to younger, lighter, short-fed lambs such as those investigated by Jaborek et al. (2017), which may be a contributing factor to the inconsistent quality of American lamb.

The hypotheses for this study are based on previous literature, such that: *longissimus thoracis* (LT) color would become darker as age at harvest increased, LT slice shear force would be more desirable from younger sheep when compared with older sheep, there are no expected differences between ewe and wether lambs, and offering sheep a high energy diet would increase the intramuscular fat content, and as a result, increase lean color and tenderness. As previously mentioned, much of the sheep meat quality research has been conducted in other countries, however current data is lacking in the United States with today's diets, genetics, and management practices that may lead to differences in sheep meat quality. Therefore, the objectives of the present trials were to determine the effects of energy source, lamb sex, and sheep age on meat quality attributes.

2. Materials and methods

Animal procedures were approved by the Institutional Animal Care and Use Committee (IACUC protocol number 2015A00000023) of The Ohio State University and animal care followed guidelines recommended in the Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching.

2.1. Experimental design and treatments

Forty-eight short-fed lambs, 48 long-fed lambs, 16 yearling ewe lambs, and 16 mature ewes of Dorset × Hampshire breed composition were used in two experimental trials. Trial 1 utilized 16 ewe lambs (174 ± 20.0 days of age at harvest (DOA)), 16 yearling ewes (421 ± 11.6 DOA), and 16 mature ewes (3+ years old) offered either ad libitum whole shelled corn (WSC100) or ad libitum alfalfa pellets (AP) to determine the effects of energy source and sheep age on meat quality characteristics. Trial 2 utilized 48 short-fed (177 ± 16.6 DOA and 93 ± 20.5 days on feed (DOF)) and 48 long-fed (294 ± 7.0 DOA and 219 ± 3.8 DOF) ewe and wether lambs from experiments conducted by Jaborek et al. (2017, 2018) and offered one of three diets (AP, WSC100, or whole shelled corn at 85% of ad libitum intake (WSC85)) to determine the effects of energy source and level, lamb sex, and lamb age on meat quality characteristics. All sheep were housed at the Ohio Agriculture Research and Development Center's sheep research feedlot inside a covered barn in Wooster, OH throughout the duration of this experiment, from April, 2015 through December, 2015. Sheep were allotted to 32 pens, four sheep per pen, blocked by sex and age, and stratified by initial body weight (BW), and randomly assigned a dietary treatment. All pens were constructed on either expanded metal or hard plastic flooring with three metal gates and a wooden fence line feed bunk on the fourth side. Pen dimensions were 1.49 × 4.88 m with 1.49 m of bunk space. Each pen was equipped with an automatic watering cup to provide sheep with ad libitum access to water at all times.

2.2. Feeding and performance data collection

Feeding and performance data information were presented previously for short-fed lambs (Jaborek et al., 2017) and long-fed lambs (Jaborek et al., 2018). Short-fed lambs from Jaborek et al. (2017) were removed from the feedlot for slaughter on a pen basis when ewe and wether lambs reached an average BW of 59.0 kg and 63.5 kg, respectively. Long-fed lambs from Jaborek et al. (2018) were removed from the feedlot for slaughter on a pen basis with similar number of DOF for each of the three diets. Yearling and mature ewes were randomly assigned WSC100 or AP diets and feeding procedures were the same as previously reported (Jaborek et al., 2017, 2018). Yearling and mature ewes were fed to simulate a 60 day 'white fat' cow finishing strategy or to emulate mature cull ewes that may be fed for a short period of time before being slaughtered. Therefore, yearling and mature ewes were removed from the feedlot for slaughter at the Ohio State University abattoir after being fed for an average of 63.5 and 71.5 days, respectively.

2.3. Carcass data collection

All animals were harvested and carcasses were fabricated at the Ohio State University meat science laboratory. Carcass data and collection procedures performed for all sheep carcasses was mentioned previously in Jaborek et al. (2017, 2018). CIELAB color (L^*, a^*, and b^*) was measured once on each carcass using a Konica Minolta color CR-410, with a 50 mm diameter aperture and D_{65} illuminant, to determine fat color over the rack (free of lean) of the carcass and lean muscle color on a butterflied loin chop from the LT, after allowing 20 min to bloom at 4 °C. After lean muscle color was collected, the butterflied loin chop was vacuum sealed, frozen at -25 °C, and stored to be used on a later date to assess ultimate pH at 24 h and extractable lipid percentage of the LT. One LT from the rack was cut in half, vacuum sealed, and each half of the LT was randomly assigned to a postmortem aging treatment of either 1 or 14 days at 4 °C and subsequently frozen at -25 °C. The boneless square cut shoulder (IMPS No. 207) was vacuum sealed and wet-aged for 13 additional days (14 d total) at 4 °C before being ground through a 3/8 inch (0.95 cm) plate. The ground shoulder was mixed by hand and 908 g was vacuum sealed and frozen at -25 °C for later use to determine the extractable lipid percentage.

2.4. Laboratory procedures

Butterflied loin chops were powdered with a liquid nitrogen cooled mortar and pestle, weighed, and stored in a microcentrifuge tube from each butterflied loin chop to determine ultimate pH. Each sample for pH analysis was homogenized after the addition a solution containing 5 mM sodium iodoacetate and 150 mM KCL (pH 7.0) at a 1:8 (wt/vol) ratio (Bendall, 1973). Samples for pH were then, centrifuged for 5 min at 12,000 *g* and placed in the heating block at 25 °C until pH analysis was conducted using a bench top pH meter with a Accumet Basic semi-micro pH glass electrode (Fisher Scientific, Waltham, MA). The pH meter was calibrated daily prior to analysis of all samples.

Total lipid extraction from the butterflied lamb chop followed the methods of Fisher et al. (2013). Two replicates of 2 g of ground tissue from butterflied loin chops were placed inside 2 sheets of folded filter paper for total lipid extraction analysis. Upon analysis, sample packets were lyophilized using a Labconco Freezedryer-6 (Labconco, Kansas City, MO) for 22–24 hours to remove the moisture from the ground tissue samples. Packets were removed from the freeze dryer and weighed to determine moisture content (%). Next, samples were placed into Soxhlet glassware for extractable lipid determination. Briefly, a 87:13 solution of chloroform:methanol was used and samples were extracted for 12 h. After, samples were allowed to vent in the fume hood before being placed into the oven at 100 °C for 60 min to evaporate the organic solvent. Samples were weighed again and total