



Extra dietary vitamin E – selenium as a mitigation strategy against housing-induced stress in Dohne Merino lambs: Effect on growth performance, stress biomarkers, and meat quality

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ABSTRACT

Deprivation of social contact through solitary confinement has the potential to induce stress in farm animals. Current evidence that housing-induced stress contributes to suboptimal welfare, growth performance and meat quality in sheep is neither ubiquitous nor convincing. This study, therefore, investigated the effect of social stress, as induced by single-pen (isolated) and paired-pen (socially interacting) housing, and extra dietary antioxidants (vitamin E – selenium) on growth performance, oxidative stress biomarkers, carcass characteristics and meat quality of 24 male Dohne Merino lambs (25.8 ± 2.7 kg). Lambs were randomly assigned to four treatment combinations in a completely randomized design: 1. single-pen housing (solitary confinement) with no extra vitamin E – selenium supplementation, 2. single-pen housing (solitary confinement) with extra vitamin E – selenium supplementation, 3. paired-pen housing with no extra vitamin E – selenium supplementation, and 4. paired-pen housing with extra vitamin E – selenium supplementation. Solitary confinement significantly ($P < 0.05$) reduced the superoxide dismutase and glucose levels but had no effect on glutathione peroxidase. Supplementation with vitamin E – selenium increased ($P < 0.05$) feed intake, weight gain, metabolic weight gain, packed cell volume (PCV), red blood cells (RBC), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC). At the end of the 60-day feeding trial, paired lambs had higher ($P < 0.05$) slaughter weight compared to those housed individually. However, housing had no effect ($P > 0.05$) on hot carcass weight, cold carcass weight, carcass conformation, fat score, carcass length, and temperature, water holding capacity, meat colour (L, a*, and b*), shelf life colour (L, a*, and b*), ultimate pH (pHu), and fatty acid profiles. Vitamin E – selenium supplementation increased slaughter weight, dressing percentage, and pHu. It was concluded that solitary confinement reduced the oxidative status of lambs but vitamin E – selenium supplementation reduced the impact of the stress by increasing feed intake and growth performance. However, housing had no influence on the carcass and meat quality traits in Dohne Merino sheep.

1. Introduction

Intensive sheep production systems are known to induce stress that may impact on the animals' physiological and production responses (Miranda-De la Lama et al., 2010). It has been reported that individually-housed animals experience more stress than animals that are reared under group housing conditions (Rushen and de Passill, 1992; Xiccato et al., 2002; Lee et al., 2012). Individual housing is frequently used to control the environment, facilitate biological sampling and

early fattening of lambs. However, this type of housing also prevents social interaction and reduces exploratory behaviours resulting in the induction of stereotypes that are non-compliant with welfare and associated with a state of being stressed (Chulayo and Muchenje, 2015). Stress can also be induced by suboptimal nutritional or environmental conditions leading to the production of large quantities of free radicals resulting in oxidative stress, whereby free radicals induce oxidative damage and reduce the antioxidant defences in biological systems (Saleh, 2008). Oxidative stress thus arises due to a reduction in

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enzymatic and non-enzymatic antioxidants causing a disruption in normal function of biomolecules like nucleic acids, proteins, and cell membrane phospholipids (Singh et al., 1999). These disruptions may negatively affect long-term physiological functions and consequently, growth performance (Rushen and de Passill, 1992) and possibly meat quality in animals as comprehensively reviewed by Chulayo and Muchenje (2015). Indeed, oxidation is thought to be an important determinant of quality loss in meat (Falowo et al., 2014).

Optimal welfare standards for farm animals worldwide are enforced via a two-pronged strategy: legislatively (legally enforceable minimum standards) and via market incentives (welfare-friendly products at premium prices) (Thorslunda et al., 2016). Meeting the minimum standards of animal welfare criteria, such as increased space allowance, avoiding restrictive housing systems, and environmental enrichment, require greater capital and time investment (Webster, 2005). Establishing a positive association between optimal welfare and desirable animal product quality, with the potential to fetch premium prices, is crucial if producers are to be motivated to maintain or even exceed the minimum welfare standards. Unfortunately, very little empirical research has been carried out to unravel the links between long-term social stress and meat quality in sheep, despite the existence of some evidence that stress does affect meat quality parameters in sheep (Aguayo-Ulloa et al., 2014). High levels of stress can lead to increased lipid oxidation in meat of stressed lambs. These changes often lead to meat discoloration, lipid oxidation and increased drip loss (Faustman et al., 1998; Wulf et al., 1995). Meat colour stability, reduced lipid oxidation and drip loss can be enhanced by dietary supplementation with antioxidants like vitamin E and selenium (Ponnampalam et al., 2012; Suman et al., 2014). Vitamin E has been shown to delay the conversion of oxymyoglobin into metmyoglobin and increase the shelf life of lamb meat (Ripoll et al., 2013). Vitamin E and selenium have been shown to play a role in growth, immune function enhancement, tissue integrity, reproduction, disease prevention, and as biological antioxidants (Dalle Zotte and Szendrő, 2011; Rooke et al., 2004). There is, therefore, a possibility that supplementing sheep with vitamin E – selenium may mitigate against housing-induced social stress that may, otherwise negatively affect growth performance, physiological parameters and quality of meat.

To our knowledge, no attempt has been made to investigate the effects of housing on stress induction in intensive lamb production systems and the potential of dietary antioxidant supplements as a mitigation strategy. Therefore, we hypothesized that providing extra dietary vitamin E – selenium to lambs subjected to housing stress (single-pen housing (visual and physical isolation)) would improve growth performance, meat quality, aid physiological responses to stress as measured by haematological indices, serum biochemistry, and stress biomarkers. Thus, the present study was designed to assess the effectiveness of extra dietary vitamin E – selenium supplementation in mitigating against housing-induced social stress in Mutton Merino lambs as measured by haematology, serum biochemistry, growth performance, and meat quality.

2. Material and methods

2.1. Study site

The study was carried out at North-West University Experimental Farm, South Africa, from September to December 2016. The farm is situated between latitude 25° S and longitude 25° E. The ambient temperatures in this area range from 25 to 37 °C during summer and between 10–20 °C during winter. It receives less than 300 mm of rainfall per annum. It has a uniform terrain with an altitude of 1 400 m above sea level. During the study, temperatures ranged from 30 to 40 °C.

2.2. Management of experimental animals

A total of 24 male Dohne Merino lambs aged between 9–12 weeks, with an average weight of 25.8 ± 2.7 kg, were purchased from a farm in Bloemfontein (Free State province, South Africa). The animals were injected sub-cutaneously with oxytetracycline LA (1 ml/10 kg) and Ivermectin LA (1 ml/50 kg) for prophylactic intervention against bacterial disease cum internal and external parasite infestation. The lambs were then allocated to two types of housing. In the first group, a single animal was allocated to a 1.4 m² pen with no view/sight of any other animal and thus ensuring no social interactions or contact with other animals occurred (single-pen housing). In the second group, two lambs were allocated to a 2.8 m² pen that allowed social interaction between the two animals at all times except during feeding times (paired-pen housing). Paired lambs were separated by removable barriers, which were only used during feeding to facilitate individual feeding. All experimental and animal management procedures were approved by the University Animal Research Ethics Committee, North-West University, South Africa (Ethical clearance: NWU-00100-14-S9). The welfare of the lambs was regularly monitored by the National Society for the Prevention of Cruelty to Animals (NSPCA) in South Africa throughout the experimental period.

2.3. Dietary treatments

Lambs were fed a finishing commercial ration (NutriFeeds, Lichtenburg) at 4% of their body weight, twice daily at 0800 h and in the afternoon at 1400 h. The diet was modified for the animals receiving extra vitamin E – selenium by adding 200 mg/kg Vitamin E/0.2 mg selenium premix to the finishing commercial ration. Each of the 24 experimental wether lambs were allocated to the following four, diet × housing treatment combinations in a 60-day feeding trial:

1. Single-pen housing with no extra vitamin E – selenium supplementation
2. Single-pen housing with extra vitamin E – selenium supplementation
3. Paired-pen housing with no extra vitamin E – selenium supplementation
4. Paired-pen housing with extra vitamin E – selenium supplementation

Thus, the study was executed using a 2 × 2 factorial treatment arrangement in a completely randomized design with 6 experimental replicates per treatment. Lambs were afforded 2 h at each feeding time before collection and quantification of refusals. The animals were quarantined for three weeks and afforded a 7-day adaptation period before data collection commenced.

2.4. Growth performance and physiological parameters

Feed offered to the lambs and the refusals were weighed daily using digital scale. Feed intake was calculated on a daily basis as feed offered less feed refused. Lambs were weighed at the beginning of the experiment and, thereafter, on weekly basis till the end of the experiment. The weights were taken in the morning before feeding in order to avoid measuring gut-filled weight. Weight gain (WG) was calculated as the interim weight (final weight – initial weight) divided by time taken to accumulate the weight. Feed conversion efficiency (FCE) was calculated by dividing body weight gain by feed intake (FI).

2.5. Blood analyses

A total of 10 ml of blood was collected from each lamb at 07:00 h at the end of the experiment (60 days). Blood was drawn via jugular venepuncture using vacutainer holder and vacutainer needle and stored in

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