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The impact of gender and age on the nutritional parameters of alpaca (*Vicugna pacos*) meat, colour stability and fat traits

M.A. Smith [a,*], R.D. Bush [a], R.J. van de Ven [b], E.J.S. Hall [a], P.L. Greenwood [c], D.L. Hopkins [d]

[a] The University of Sydney, Faculty of Veterinary Science, 425 Werombi Road, Camden, NSW 2570, Australia
[b] NSW Department of Primary Industries, Orange Agricultural Institute, Forest Road, Orange, NSW 2800, Australia
[c] NSW Department of Primary Industries, Beef Industry Centre, University of New England, Armidale, NSW 2351, Australia
[d] NSW Department of Primary Industries, Centre for Red Meat and Sheep Development, Cowra, NSW 2794, Australia

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ABSTRACT

Meat quality parameters for 50 huacaya alpacas, representing three age groups (18, 24 and 36 months) and two genders (females and castrated males) were studied. Prior to chilling, samples of *m. longissimus thoracis et lumborum* (LL) were taken to determine isocitrate dehydrogenase activity and glycogen concentration, and further meat quality samples were taken after 24 h. Alpaca meat has low levels (<1%) of intramuscular fat in the LL, *m. semimembranosus* and *m. biceps femoris*, but the level in the LL increases with animal age, with levels of desirable polyunsaturated fatty acids (PUFA) ranging from 96.3 to 136.4 mg/100 g. Lipid oxidisation post retail display ranged from 1.27 to 1.96 MDA/kg meat. Colour stability testing indicated alpaca meat was relatively stable during retail display with day of display having no significant effect on lightness (L*), or the 630 nm/580 nm ratio. These results may relate to the high proportion (76%) of glycolytic and type IIX muscle fibres in LL.

1. Introduction

Understanding alpaca meat quality parameters is important for acceptance within the competitive red meat market. Meat quality parameters such as intra-muscular fat (IMF), fatty acid (FA) profiles, retail colour stability, lipid oxidisation, muscle fibre composition, and glycogen content have been well defined and can be influenced by nutrition, age, gender, and inter-species differences (Lefaucheur, 2010; Pannier et al., 2010). However, to the authors' knowledge there is no information available on how these traits vary in alpaca meat, especially across different age groups and genders and this warrants further investigation.

The percentage of IMF can vary depending on muscle type, nutritional intake of the animal prior to slaughter, and genetics (Pethick, Harper, & Oddy, 2004). Increased IMF content has been linked with positive eating quality experiences due to its ability to act as a buffer during cooking by helping improve the juiciness of cooked product and enhance eating quality (Scollan et al., 2006). Studies in Peru reported that alpaca *m. longissimus thoracis et lumborum* (LL) had an IMF content of on average 0.49% (±0.01: s.d.) in 25 month old male grass-fed animals (Cristofanelli, Antonini, Torres, Polidori, & Renieri, 2004) and on average 2.2% (±0.85) in 18–24 month old alpacas raised on pasture and finished for two weeks by forage and grain feeding (Salvá, Zumalacárregui, Figueira, Osorio, & Mateo, 2009). These results potentially reflect feeding system variation impacting on IMF concentrations of alpaca meat, but are not informative for understanding the effect of animal age on IMF which also warrants further investigation.

Understanding the proportion of FA in IMF is important as they are correlated to other meat and eating quality factors that are important for consumers (Wood et al., 2008). It is accepted that polyunsaturated fatty acids (PUFA), in particular omega 3's (n-3), have advantageous health benefits, especially in comparison to saturated fatty acids (SFA) (Scollan et al., 2006). A previous investigation into alpaca meat has found that the n-6/n-3 and PUFA/SFA ratios for muscle from 18 to 24 month Peruvian alpacas raised on pasture and finished for two weeks on forage and grain were comparable to pasture fed beef and lamb (Salvá et al., 2009). However, it is uncertain if these FA profiles differ between genders or age groups as, to our knowledge, there is no published data on the effects of these factors.

Micro and macro elements are also important for a healthy diet and meat is a common source of minerals, including iron and zinc, which are required for a healthy balanced diet aiding in healthy brain development, immune function and reducing nutritional disorders such as anaemia (Mulvihill, 2014). Previous work conducted by Salvá et al. (2009) reported potassium, phosphorous, sodium, and magnesium as the major minerals found within alpaca LL. In addition, Polidori, Antonini, Torres, Beghelli, and Renieri (2007a) reported similar results in male alpacas with potassium being the major mineral found, and levels of iron and zinc were reported to be similar to values found in beef. However, it is unknown how the mineral composition of alpaca

* Corresponding author.
E-mail address: melanie.smith@sydney.edu.au (M.A. Smith).

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meat changes with animal age or gender and this information is important when understanding the health benefits for human consumption in relation to recommended animal slaughter ages.

Meat quality (MQ) traits including muscle fibre type composition, IMF and FA content can play an important role in colour stability of retail cuts during commercial display (Lefaucheur, 2010) and the oxidative capacity of the muscle. Meat colour during retail display is a major factor influencing purchasing decisions. Browning of product during retail display is a common occurrence and is seen as less desirable by the consumer. This browning is due to the oxidisation and the formation of metmyoglobin (Mancini & Hunt, 2005). In other species of meat (e.g. lamb) the level of oxidisation and rate of browning on the surface of the meat increases as retail display continues. This change in colour caused by the formation of metmyoglobin can be indirectly indicated by the ratio of reflectance for light wavelengths 630 and 580 nm (oxy/met ratio; Khliji, van de Ven, Lamb, Lanza, & Hopkins, 2010), but there is no data available on alpaca meat. Lipids within the meat also undergo oxidisation during display and high levels of lipid oxidisation can lead to undesirable odours and rancid smells which can be influenced by the types of FA within the fat itself (Scollan et al., 2006). Currently, only fresh colour parameters have been reported for alpaca meat, indicating their unique colour characteristics (Smith, Bush, van de Ven, & Hopkins, 2016). Therefore, further research is required on colour stability and the rate of lipid oxidisation to provide recommendations to the processing and retailing sectors on likely shelf life and potential variation due to animal age and gender.

Muscle fibre composition not only influences meat colour, but also impacts on meat and eating quality traits. Each muscle is composed of a variety of muscle fibre types based on contractile speed and oxidative and glycolytic capacity, which relate to myofibre size, colour, glycogen and lipid content (Lee, Joo, & Ryu, 2010). This ultimately impacts upon meat quality traits such as the rate of pH decline, ultimate pH, toughness and overall eating quality (Lee et al., 2010). There are three major muscle fibre types, slow oxidative (type I), fast oxidative-glycolytic (type IIA), and fast glycolytic (IIX or IIB), and two intermediate or transitional fibre types, type I – type IIA intermediate (type IIC) and type IIA – type II X or IIB intermediate (type IIAX or IIAB; Lee et al., 2010). The myofibre composition of muscles can be influenced by muscle use (i.e. postural or locomotive), animal age, species and breed, and can also manipulated by genetic selection, hormones, and amount of physical activity (Lee et al., 2010). To complement our understanding of the factors influencing meat quality, colour and nutritional parameters, investigation of factors including fibre type composition and oxidative capacity of alpaca muscle is required. Furthermore, the use of oxidative enzymatic markers such as isocitrate dehydrogenase (ICDH), which have been used in relation to meat quality characteristics in other species such as sheep and cattle, should be investigated in alpaca meat to determine activity levels and suitability as oxidative markers in alpaca meat.

This paper describes an experiment that was designed to determine the biochemical and meat quality factors influencing alpaca meat quality across two genders (females and castrated males) and three age groups (18, 24 and 36 months) by providing information on fibre types, glycogen, IMF, FA composition, colour stability, lipid oxidisation, and mineral traits.

2. Materials and methods

2.1. Experimental design

For the study a commercial flock of huacaya alpacas was used to randomly select nine alpacas from each of six groups, comprising three ages (14, 20, 32 months at the commencement of the study) by two genders (females and castrated males). These animals were grazed together on coastal summer pastures on the south coast of New South Wales, Australia (34°45′7.1316″S, 150°43′9.0186″W) for four months. The age groups selected reflect current industry processing ages. The animals were randomly assigned to one of two slaughter dates (n = 25/group) two weeks apart with treatments balanced across the two days. Further detail on experimental design, grazing conditions, processing and meat quality traits is provided in Smith, Bush, Thomson, and Hopkins (2015) and Smith et al. (2016). Samples examined in this paper were sourced from the carcasses either prior to chilling or during boning out (24 h after slaughter) as discussed below. In addition, samples were taken across three age groups and two genders to determine the variation and impact of these factors.

2.2. Carcass processing

The animals were slaughtered using a conventional captive bolt and immediately after exsanguination were immobilised (2000 mA peak current at 500 μs pulse interval (2000 Hz) and 100 μs pulse width for 10 s) to prevent excess kicking during carcass dressing. Once dressed, the neck was removed at the junction of the 5th and 6th cervical vertebrae prior to the carcass being split in half down the vertebral column using a cattle brisket saw. Before entering the chillers a 1 g sample of the LL was taken with a drill corer between the 12th and 13th rib on the left side of each carcass for subsequent measurement of glycogen concentration and isocitrate dehydrogenase (ICDH) activity. These samples were snap frozen in liquid nitrogen and held at −80 °C until analysis. After the core samples were taken the right side of each carcass was electrically stimulated (ES; 600 mA peak at 68 ms pulse interval (15 Hz) and a 1000 μs pulse width for 40 s). The ES only occurred for animals slaughtered on the first day (n = 25), as the stimulation unit failed on the second slaughter day preventing stimulation. Further detail on animal processing is provided by Smith et al. (2016).

2.3. Sample preparation

After chilling for 24 h (average chiller temperature 4.3 °C and 90.3% humidity) the carcasses were prepared into retail cuts (average boning room temperature 5.0 °C and humidity 90.5%). Each carcass side was marked at the 12th/ 13th rib prior to the removal of the LL (HAM 5101). The LL was cut at the 12th/13th rib mark to produce the eye of rack (HAM 5153) and eye of shortloin (HAM 5150).

The medial section of the eye of rack (LL; HAM 5153) was divided into a 35 g mineral sample (taken from the caudal end), a 4 cm colour stability block (taken from the medial section) and a $2 \times 2 \times 2$ cm^3 fibre typing block (taken at the caudal end of each carcass at the site of cutting of the 12/13th rib). The mineral sample was frozen at −20 °C until analysis, whilst the colour block was chilled at 4 °C and aged vacuum packed for 5 days prior to colour analysis and post display testing for lipid oxidisation. After ageing a 1 g ultimate pH sample was taken, homogenized and measured as outlined by Dransfield, Etherington, and Taylor (1992). The fibre typing block of LL was prepared using methods outlined in Greenwood, Davis, Gaunt, and Ferrier (2006a) and stored at −80 °C until slide preparation. A 40 g FA and IMF block was taken from the caudal end of the eye of shortloin (LL; HAM 5150) from each carcass and frozen (−20 °C) until analysis.

The *m. semimembranosus* (SM) and *m. biceps femoris* (BF) were removed from the hindquarter of each carcass and trimmed of any subcutaneous fat prior to a 40 g block being taken and frozen (−20 °C) for FA and IMF analysis. The *m. adductor femoris* (AF) was also removed from the hindquarter and denuded of any fat prior to a 4 cm thick sample being taken, vacuum packed, chilled at 4 °C and aged for 5 days prior to being used for colour analysis and testing of lipid oxidisation. After 5 days an ultimate pH sample (1 g) was taken from the AF and measured using methods outlined previously.

2.4. IMF and FA analysis

The IMF and FA analysis was conducted using methods described previously by Hopkins et al. (2014). Prior to analysis samples were