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Effects of supplementary feeding on carcass and meat quality traits of young llamas (*Lama glama*)

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ABSTRACT

Sixty llamas were used to study the effect of a 90 days feed supplementation on performance, carcass traits and meat quality. Treatments were: GR = llama on native pasture until slaughter; GR + SH = like GR, but llama had overnight access to barley/alfalfa hay (0.30 kg/animal/day), GR + SC = like GR, but llama had overnight access to wheat bran/sorghum grain concentrate (0.30 kg/animal/day). The characteristics of daily weight gain, final live weight, hot and cold carcass weight, perirenal fat weight, loin eye muscle area and marbling score were significantly increased by concentrate supplementation ($P < 0.05$). Concentrate supplementation of grazing llamas also provided animals with greater morphometric measures *in vivo* and in carcass (thoracic perimeter, leg perimeter, hindquarter perimeter). Carcass dressing percentage was improved by both hay and concentrate supplementation compared to grazing only ($P < 0.01$). Perirenal fat had a higher mean b^* value (was yellower) and a lower mean L^* value in GR + SH fed llamas compared to GR + SC ($P < 0.05$), but did not differ from controls. In conclusion, supplementation of young llamas grazing native pasture with concentrate led to greater live weight, greater carcass weight, greater fat deposits and improved carcass characteristics, supporting the idea that it is a good alternative in the production of llama meat, especially in the dry season where there is poor pasture availability.

1. Introduction

The breeding areas of llamas in South America are located 3800 m above sea level, at the Andean Altiplanos, which are characterized by very low temperatures and intense solar radiation during almost all year round. About 75% of the rainfall in the Altiplano of Bolivia, Perú and Chile concentrates between December and April, a period where plant growth is rapid, offering medium to high quality grass to animals. However during a short period of the year (December–April), it becomes green, flowers and starts to form seeds. The rest of the year, the dry season (May–November), there is no change at all in forage growth, plants are mature and of very low quality. The dominant vegetation is coarse bunchgrasses, mainly of the genera *Stipa*, *Festuca* and *Calamagrostis*. With these two opposite plant growing seasons, llamas are exposed to abundant forage of high quality during the rainy season but to minimal low quality forage during the long period of the dry season (Sumar, 2010).

The breeding systems of South American camelids are not specialized, and for this reason we can find a low reproductive efficiency, a high mortality rate, and consequently reduced meat production in all the farms of the Andean countries in which llamas and alpacas are reared (Flores Ochoa, 1982).

The conventional llama production system is based on native grazing feeding. Lack of nutritional forage during the

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dry season limits llama (*Lama glama*) production on the Bolivian Altiplano. Protein may be deficient in llama and alpaca diets throughout the dry season (May–November, fall–spring), while energy may also be deficient towards the end of the dry season (Reiner and Bryant, 1986). Providing supplement to grazing animals is another way of compensating for the absence of good-quality forage (Van Soest, 1994); it can improve performance and carcass quality, but its high cost can limit its usage. Supplements with great potential in the region are barley hay and wheat bran, which by cost and ease of availability are recommended for use. Therefore, the aim of this study was to determine the effect of a feed supplementation on performance, carcass characteristics and meat quality of young llamas on pasture at finishing stage.

2. Materials and methods

2.1. Animal management and diets

The experiment was conducted on a farm located in the municipality of Comanche (latitude 16°45′49″ and longitude 68°2′27″), province of Pacajes, La Paz-Bolivia, between September and November 2011. The average daily temperature was 8.6 °C and the average maximum and minimum temperatures were 17.3 and 1.1 °C, respectively, with a mean monthly rainfall of 13.1 mm.

A total of 60 intact male llamas of the Kh'ara genotype, 18–24 months old according to dental chronometry (milk teeth), were used in this experiment. Llamas were sampled randomly from breeders in the Bolivian Altiplano, where they had been fed on native grass pasture.

At the beginning of the adaptation period, the animals were weighed after fasting for 16 h and treated against external and internal parasites. During the adaptation period, which lasted 30 days, they were fed without restriction with the same diet of the experimental period.

At the beginning of the experiment, the animals had an average live weight of 43.2 ± 3.3 kg. Llamas were individually identified with numbered ear tags and assigned randomly to one of three treatments (20 llamas each): pure native grass pasture (GR), native grass pasture plus hay (barley-alfalfa, in proportion: 65/35) (GR + SH) and native grass pasture plus concentrate (sorghum-Wheat bran, in proportion: 30/70) (GR + SC). The barley and alfalfa hay were harvested in late summer (March in Bolivia). The amount of supplement offered (0.30 kg/animal/day of hay and 0.30 kg/animal/day of concentrate) was calculated from the ME requirements for gaining about 200 g/day (NRC, 2007) considering the anticipated contribution of pasture. The llamas of the three treatments grazed together 8 h per day on the same native grass pasture characterized by: *Festuca dolichophylla*, *Stipa ichu*, *Muhlenbergia* spp., *Bromus unioloides*, *Calamagrostis* spp., *Festuca orthophylla.* The supplements were offered daily at 18:00 h in one collective pen per treatment, once llamas were gathered from the daily grazing period for overnight maintenance (a common procedure in Bolivia). A mineral mix (Salmin Engorde, Praxis Química: Ca 15.0%, P 7.0%, Na 35.8%, S 0.15%, Zn 12.1 mg/100 g, Cu 6.14 mg/100 g, Mg 35.7 mg/100 g, Mn 12.6 mg/100 g, K 480 mg/100 g, Fe 114 mg/100 g, I 0.3 mg/100 g) was offered daily *ad libitum* to all animals in the pens in order to avoid mineral deficiency. The experiment was carried out over 90 days. Every 30 days, llamas were individually weighed.

2.2. Pasture characteristics

The pasture consisted of 20 ha with a stocking density of approximately 1.5 animal unit equiv. ha^{-1} (AU = Adult llama of 80 kg/BW); llamas had permanent fresh water availability. Detailed sward measurements were carried out prior to grazing by the experimental animals. Plant cover and species composition were estimated using the point-quadrant method (Daget and Poissonet, 1971) along 30-m transects per site, located on each site following a stratified randomized design according to types of vegetation. Plant species were grouped into four categories according to their broader group forms: grasses, graminoids, shrubs and forbs. Plant reference material from the study site was collected and taxonomically identified according to the taxonomic keys described by Rossel et al. (1992). Herbage mass (kg DM/ha) was measured the day the trial started (1 September 2011) by cutting five quadrants to ground level and drying for 48 h at 60 °C. Measurements were made on-site representative of the prairie and this was repeated at the end of the trial.

The harvested material of the pasture was pooled according to species in order to obtain one composite and representative sample. Samples were sent to the Forage Laboratory of the Animal Production Department at Universidad Austral de Chile, Valdivia to be analyzed. Supplements and pasture were ground through a 1-mm screen (Wiley Mill, Arthur H. Thomas Co., Philadelphia, PA, USA) and analyzed for DM, CP, acid detergent fibre and ash (according to Association of Official Analytical Chemical, 1996), and neutral detergent fibre (NDF) (according to Van Soest et al., 1991). Metabolizable energy of the pasture was estimated by regression using a 'D' value (digestible organic matter/DM x_100) and was determined *in vitro* (Tilley and Terry, 1963) according to Goering and Van Soest (1970).

2.3. Morphometric measurements

The body measurements were carried out at the beginning and end of the trial. Height at withers (cm) was measured from the highest point of the processus spinalis of the thoracic vertebrae to the floor. Body length (cm) was measured as the distance between the cervical-thoracic articulation and the tail base in the first inter-coccygeal articulation. Thoracic perimeter (cm) was taken behind the forelegs. Thoracic depth (cm) was measured from the highest point of the processus spinalis of the thoracic vertebrae to the sternum. Rump width (cm) was the distance between the largest trochanters of both femurs. Metacarpus perimeter (cm) was taken around the middle part of the metacarpus. Body linear measurements were taken with a tape and weights (BW) were recorded with an electronic balance.

2.4. Carcass traits

At the end of the trial, a random sample of 10 llamas per treatment were weighed and transported together to a commercial slaughterhouse, where they were fasted (only water was available) for 12 h prior to slaughter. The llamas were slaughtered according to the standard procedures in Bolivia (Limon et al., 2009). The carcasses were obtained after bleeding, cutting the head at the occipital–atlantoidal articulation and the feet at the tarsal–metatarsal and carpal–metacarpal articulations, dehiding and eviscerating (except for the kidney and perirenal fat) following the procedures described by Salvá et al. (2009). Immediately after slaughter, the carcasses were weighed (hot carcass weight, HCW), and the dressing percentage was calculated as the ratio of hot carcass weight to live weight on farm (dressing percentage = HCW × 100/slaughter weight). Empty body weight was calculated as the slaughter weight minus the weight of the digestive tract (stomach and intestine) contents. Cold carcass was weighed (CCW) and chilling loss calculated as the ratio of cold carcass weight to hot carcass weight ([HCW − CCW]/HCW × 100).

On the carcasses the following characteristics were assessed: carcass conformation grade (based on a five-point muscling score: 5 = very convex, 4 = convex, 3 = rectilinear, 2 = concave, 1 = very concave), external fat finishing score (5 = extremely abundant, 4 = abundant, 3 = medium 2 = slight, 1 = scarce.), and perirenal fat (1 = no perirenal fat, 2 = little perirenal fat coverage, 3 = 2/3 of the kidney covered, 4 = kidney completely covered, 5 = kidney covered with very thick fat). The following measurements were carried out on the carcasses: thoracic perimeter was measured behind the shoulder, thorax width was measured at the level of the 3rd and 4th ribs, rump width was obtained as the maximum width between the trochanters of both femurs, rump perimeter, based on the trochanters of the femur. After 24 h of refrigeration (0–9 °C), carcasses were cut sagitally in two halves and the resulting half-carcasses were weighed. In the left half-carcass, the following measurements were obtained: carcass internal length (CIL): distance between the anterior edge of the pubic bone and anterior edge of the first rib at its midpoint; thoracic depth: distance between the sternum and withers. Leg length was measured from the border of the perineum bottom to the proximal surface of the tarso-metatarsian joint. Leg perimeter was obtained at the base of the leg. The carcass compactness index (CCI) was determined by the following formula: carcass compactness index (kg/cm) = carcass weight/internal carcass length. In order to calculate the loin eye area at the 12th rib, the