Available online at www.sciencedirect.com
ScienceDirect
Small Ruminant Research 67 (2007) 285–290
Small Ruminant Research
www.elsevier.com/locate/smallrumres

Lipogenic activity in goats (*Blanca celtibérica*) with different body condition scores

J.A. Mendizabal [a,*], R. Delfa [b], A. Arana [a], P. Eguinoa [a], A. Purroy [a]

[a] *Departamento de Producción Agraria, Universidad Pública de Navarra, 31006 Pamplona, Spain*
[b] *Centro de Investigación y Tecnología Agroalimentaria, Gobierno de Aragón, Apartado 727, 50080 Zaragoza, Spain*

Received 9 May 2005; received in revised form 8 November 2005; accepted 25 November 2005
Available online 10 January 2006

Abstract

The aim was to study the variation in the amount of adipose tissue, size and number of adipocytes and lipogenic enzyme activities in does with different body condition scores (BCS). These parameters were studied in the omental (OM), mesenteric (MES), perirenal (PR), subcutaneous (SC) and intermuscular (IM) fat depots of 22 adult, non-pregnant and non-lactating *Blanca celtibérica* does, with a BCS ranging from 1.5 to 4.5 (scale 0–5). SC adipose tissue showed the highest deposition-mobilization phase (highest fat relative to the variation per BCS unit of 74%), followed by OM (65%), PR (63%), MES (48%) and IM (46%) adipose depots. Adipocyte size varied with the amount of fat ($P < 0.001$), while the SC depot was the only depot that showed a positive correlation between adipocyte number and BCS ($r^2 = 0.20$; $P < 0.05$). The activities of glycerol 3-phosphate dehydrogenase (G3PDH) and fatty acid synthetase (FAS) enzymes were not generally affected by BCS, due to the fact that animals were on a maintenance diet prior to slaughter. The findings obtained in this work indicate that the processes of storage and mobilization of fat reserves in adult goats are principally due to variation in the size of the adipocyte cells. Therefore, the use of BCS could be a good method for predicting nutritional status in goats.

Keywords: Fat reserves; Adipocytes; Lipogenic enzymes; Goats

1. Introduction

In extensive ruminant production systems the animal's nutrient requirements do not generally coincide with the dietary intake. This leads to the storage or mobilization of body energy reserves, principally in the form of fat. These changes in fat depots are mediated by specific enzymes that result in important variation in the size of adipocyte cells (Vernon, 1980; Chilliard, 1987).

In sheep, breed, physiological state and energy intake can have an important effect on the abundance and distribution of body fat reserves (Hood and Thornton, 1979; Sebastián et al., 1989, 1993; Susmel et al., 1995; Bocquier et al., 1999). Recently, body condition score (BCS), measured on a scale of 0–5 (Russel et al., 1969), was reported to be a result of fat accumulation and mobilization with concurrent changes observed in adipocyte size, while adipocyte numbers remained unchanged, in sheep with varying body condition (Arana et al., 2005). The activity of certain lipogenic enzymes, particularly the fatty acid synthetase, was also observed to vary with BCS ($P < 0.05$). Subcutaneous fat proved to be the depot with the greatest capacity for the storage and mobilization of body fat (Arana et al., 2005).

Unlike the numerous studies on the dynamics of fat depots in sheep, similar studies in goats are remark-

* Corresponding author. Tel.: +34 948 169117; fax: +34 948 169732.
E-mail address: jamendi@unavarra.es (J.A. Mendizabal).

0921-4488/$ – see front matter © 2005 Elsevier B.V. All rights reserved.
doi:10.1016/j.smallrumres.2005.11.006

ably sparse. Current studies indicate that the distribution of fat depots in goats differ from that in sheep, mainly because intermuscular fat depots are favored over subcutaneous depots in goats (Morand-Fehr, 1981; Colomer et al., 1987; Teixeira et al., 1995). Such differences in the distribution of body fat may also reflect species-specific variation in cellular and histological characteristics and the activity of enzymes involved in fat metabolism. The present study was thus aimed to determine the quantities of fat, size and number of adipocytes and the activity of selected lipogenic enzymes in adult *Blanca celtibérica* goats as related to different BCS, as this could be a useful system of scoring to be developed for being applied as an indicator of nutritional status in goats.

2. Material and methods

2.1. Animals

Twenty-two (3–6-yr-old) non-lactating, non-pregnant *Blanca celtibérica* does were selected according to BCS, determined by examination of the sternal area (Hervieu et al., 1989). Animals were alloted across a range 1.5–4.5 BCS values (approximately 3 goats/score) from the experimental herd at the *Centro de Investigación y Tecnología Agroalimentaria* experimental station, Zaragoza, Spain. Live body weights varied between 33.0 and 80.5 kg (mean 55.3 ± 12.6 kg). Seven days prior to slaughter, each goat was fed maintenance nutrient requirements according to body weight and condition (INRA, 1988). Diets included barley grain (between 225 and 725 g/day) and barley straw (average 650 g/day). The care and use of goats followed European guidelines (1999/575/CE; OJEC, 1999).

Immediately following slaughter (Delfa et al., 1995), the omental (OM) and mesenteric (MES) fat depots were removed and weighed. For analysis of adipocyte and enzyme activity, samples were taken from the OM (middle region of the mayor epiploon), MES (middle region of rectum), perirenal (PR, cephalic region of left kidney), subcutaneous (SC, base of tail) and intermuscular (IM, right branchial plexus) fat depots.

The following day perirenal fat was removed and weighed. To determine the quantity of the subcutaneous and intermuscular fat standardized quartering was performed to allow the dissection of the left side of the carcass (Colomer et al., 1988).

2.2. Adipocyte size and number

Samples of 0.5 g fatty tissue were taken from the slaughtered animal and placed in a Tirode solution (150 mM) and immediately transported to the laboratory. Samples were fixed with osmium tetroxide and adipocyte size was measured in ∼200 cells/sample using a compound microscope connected to an image analysis program (Mendizabal et al., 2003). Adipocyte numbers were calculated, based on the weight of fat in each depot, the chemical fat content (Soxhlet method, ISO-1433-1973; ISO, 1973), the density of the chemical fat ($d = 0.915$ g/ml), and the mean adipocyte volume, assuming that cells are spherical in shape (weight of fat × chemical fat content/0.915 × mean adipocyte volume) (Keys and Brozek, 1953).

2.3. Activity of lipogenic enzymes

Frozen samples of 1 g fatty tissue were homogenized in 4 ml ice-cold STEG buffer (sucrose 300 mM, Trizma base 30 mM, EDTA 1 mM, glutathione 1 mM; pH 7.4), using a Sorvall Omni-Mixer at 50000 rpm for 3 cycles of 10 s each. Homogenates were passed through a 20 μm pore filter and centrifuged at 6000 rpm (4 °C), for 10 m. The supernatant was filtered again, centrifuged at 11,000 rpm (4 °C) for 10 m, and finally passed through a 0.45 μm filter and used for enzymatic analysis.

The activity of glycerol 3-phosphate dehydrogenase (G3PDH; EC 1.1.1.8) was determined by the method of Wisse and Green (1979) and that of the fatty acid synthetase (FAS; EC 2.3.1.85), using the method of Halestrap and Denton (1973). The absorbance of enzymatic reaction products was measured in a spectrophotometer at 340 nm and standardized to $\times 10^6$ adipocytes. Reactions were linear over time during the assay period and proportional to the quantity of substrate present.

2.4. Statistical analyses

Quantities of fat tissue, adipocyte volumes and estimated numbers, and enzymatic activities were subjected to an analysis of variance (ANOVA), with mean separation by Fisher's PLSD-test for comparing the different fat depots. The relationships between the variables and BCS were examined by linear regression. To satisfy the conditions of normality and homogeneous variants, it was necessary to logarithmically transform all the variables before applying the statistical analysis. Analyses were performed in SPSS 8.0 (SPSS, 1998).

3. Results

The mean (±S.D.) BCS value was determined as 2.9 ± 0.97 (Table 1). The largest fat depots were OM