



# Energy partitioning and substrate oxidation by Guirra ewes fed soy hulls and corn gluten feed blend as a replacement for barley grain



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## ABSTRACT

The aim of this experiment was to study the effect of substituting barley grain by soy hulls and corn gluten feed blend on energy partitioning, substrate oxidation, carbon and nitrogen balance in sheep. The experiment was conducted in a crossover design with 12 dry and non-pregnant adult Guirra ewes ( $57.5 \pm 1.9$  kg of BW) in each group, and sheep were fed two dairy treatments in two 27 d periods. The ewes were fed with two different mixed diets; one group was fed a mixed diet with 365 g/kg of dry matter (DM) of barley grain (BRL diet) and the other diet (SHGF diet) replaced barley with soy hulls (271 g/kg DM) and gluten feed (93 g/kg DM). Six sheep per group were used to determine apparent total tract digestibility (10 d adaptation plus 5 digestibility and balance of nutrients), gas exchange (12 d), oxidation of nutrients and carbon and nitrogen balance. The average values of metabolisable energy (ME) intake, heat production (HP) and retention of energy (RE) were 498, 436 and 62 kJ/kg 0.75 of body weight (BW), respectively, with no differences between diets. The estimated value of ME for maintenance was 391 kJ/kg 0.75 BW. The efficiency of use of ME for maintenance ( $k_m$ ) was 0.64 and the nutritive value of the diets was 7.6 MJ of net energy/kg DM, on average. Most of the HP derived from oxidation of fat (0.48) for the fibrous diet, and from oxidation of carbohydrates (0.63) for the starchy diet, with no differences in total tissue energy recovered (67 kJ/kg 0.75 BW). This fibrous by-product was utilised by the ewes with no detrimental effect on energy metabolism and resulted in a similar positive energy balance to that of a traditional cereal based diet. The economic advantages and sustainability of this choice should be evaluated.

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## 1. Introduction

The Spanish ruminant production system (Interal, 2008; FEDNA, 2009) is based on high use of concentrate, with mixed diets instead of whole forage rations. By-product feeds have been used extensively in ruminant diets in many parts of the world as economical substitutes for cereals and soybean meal. The partial replacement of cereal grain with low starch by-product feeds represents a potential alternative to reduce the cost of feeding. Soy hulls and corn gluten feed are typically used as grain replacers. According to NRC (2001), soy hulls and corn gluten feed are two by-product feeds that are highly digestible but low in non fibrous carbohydrates (NFC); soy hulls are high in neutral detergent fibre (NDF) with 670 g/kg of dry matter (DM) and acid detergent fibre (ADF), but are low in lignin and NFC (140 g/kg DM). Ludden et al. (1995) considered soy hulls to be a bulky concentrate similar to beet pulp rather than roughage, despite the higher fibre content of soy hulls.

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**Table 1**

Ingredients and chemical composition of diets (dry matter (DM) basis: g/kg DM): barley grain diet (BRL) and, soy hulls and corn gluten feed blend diet (SHGF).

Ingredients	Diets <sup>a</sup>	
	BRL	SHGF
Alfalfa hay	513.2	514.9
Barley	365.0	–
Soy meal 44% CP	102.1	79.8
Soy hulls	–	271.3
Gluten feed 18% CP	–	92.7
Lard <sup>b</sup>	–	19.4
By-pass fat <sup>c</sup>	–	11.7
Calcium carbonate	8.2	5.7
Bicalcium phosphate	6.3	–
Sodium chloride	2.6	1.9
Premix <sup>d</sup>	2.6	2.6
Chemical composition		
Dry matter	878	888
Organic matter	924	920
CP	185	174
Ether extract	20.5	62.5
aNDF	368	439
ADF	150	245
NFC <sup>e</sup>	309	233
Starch	264	83.2
Gross energy, MJ/kg DM	18.9	19.2

<sup>a</sup> BRL = barley diet; SHGF = soy hulls and gluten feed diet.

<sup>b</sup> Fused lard provided by VALGESS S.L., Carpesa, Valencia, Spain.

<sup>c</sup> Provided by NACOOP S.A. (Spain). Premix composition: Se 40 mg/kg; I 250 mg/kg; Co 80 mg/kg; Cu 3000 mg/kg; Fe 6000 mg/kg; Zn 23,400 mg/kg; Mn 29,000 mg/kg; S 60,000 mg/kg; Mg 60,000 mg/kg; vitamin A 2,000,000 IU/kg; vitamin D3 400,000 IU/kg; vitamin E 2000 mg/kg; nicotinic acid 10,000 mg/kg; choline 20,300 mg/kg.

<sup>d</sup> By-pass fat of palm fatty acid distillate. Provided by Norel Animal Nutrition, Norel S.A., Spain.

<sup>e</sup> NFC = 100 – (NDF + ash + CP + EE).

According to [NRC \(2001\)](#), corn gluten feed is good source of crude protein (CP, 240 g/kg DM), high in hemicellulose (360 g NDF/kg DM) and moderate in NFC (300 g/kg DM). These by-products are widely available and an affordable source of energy supply for the animal.

Dietary composition influences the efficiency of energy metabolism. The respiration quotient method (RQ) was used to determine the associated heat production (HP), and the carbon (C) and nitrogen (N) balance (CN method) was used to calculate the recovered energy (RE), assuming that all energy is retained either as fat or protein. The aim of this experiment was to study the effect of substitution of barley grain by soy hulls and corn gluten feed blend on energy partitioning, substrate oxidation and CN balance in sheep.

## 2. Materials and methods

The experimental procedure was approved by the Animal Use and Care Committee of the Polytechnic University of Valencia (Spain) and followed the codes of practice for animals used in experimental works proposed by the [European Union \(2003\)](#).

### 2.1. Animals and feeding

The experiment was conducted with 12 dry and non-pregnant adult Guirra breed ewes kept in two groups and fed 1 of 2 diets in two 27 d periods in crossover design. The 12 ewes had similar body weight (BW):  $57.5 \pm 1.9$  kg of BW. Ewes were fed with two different mixed diets; one group was fed a mixed diet with 365 g/kg DM of barley grain (BRL diet) and the other diet substituted barley with 364 g/kg DM of by-products (SHGF diet) in the following proportion: 271 soy hulls and 93 gluten feed, both expressed in g/kg DM. Six ewes per group were used to determine apparent total tract digestibility, gas exchange, oxidation of nutrients and CN balance; this process was repeated, crossing the animals. Alfalfa hay was cut into 2.5 cm pieces (Skjold Saby A/S, Kjeldgaardsvej, DK 9300) and the concentrate was mixed and pelleted along with the premix ([Table 1](#)). Mixed diets contained similar amounts of gross energy (GE, 19 MJ/kg DM) and CP (180 g/kg DM). Fat was included in the SHGF diet to increase the energy content of the fibrous diet (19.4 g/kg DM of lard and 11.7 g/kg DM of by-pass fat of palm FA distillate). Starch levels were 264 and 83 g/kg DM for BRL and SHGF diets, respectively. Nutrient requirements followed the FEDNA recommendation (2009) for sheep. Intake was *ad libitum* with diets offered at 110% of consumption on the preceding few days. Half of the daily ration was offered at 08:00 and another half at 16:00 h, respectively. Ewes had free access to water.

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