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Energy partitioning and substrate oxidation by Murciano-Granadina goats during mid lactation fed soy hulls and corn gluten feed blend as a replacement for corn grain

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ABSTRACT

The aim of this experiment was to study the effect of substituting corn grain by soy hulls and corn gluten feed blend on energy partitioning, substrate oxidation, and milk performance in dairy goats during mid lactation. Ten multiparous Murciano-Granadina goats in mid lactation were fed 2 isoenergetic and isoproteic diets [19.08 MJ/kg of dry matter (DM) and 18.7% of CP, DM basis] in a crossover design. One group of 5 goats was fed a mixed ration with 373 g of corn grain/kg of DM (CRN diet) and the other diet replaced corn grain with 373 g/kg DM of fibrous by-products [soy hulls and gluten feed (SHGF) diet]: 227 g of soy hulls/kg of DM and 146 g of gluten feed blend/kg DM. Fat was added to the SHGF diet to make it isoenergetic. After 10 d of adaptation, the feed intake, refusal, total fecal and urine output, and milk yield were recorded daily over a 5-d period. Then, gas exchange measurements were recorded by a mobile open-circuit respirometry system using a head box for 10 d. Dry matter intake was similar for both diets (2.07 kg/d, on average). Greater and significant values were found in the SHGF diet for ammonia N, energy in urine, and oxidation of protein. Values were significantly lower for heat production of fermentation, indicating a decrease in rumen fermentation with this diet, probably due to an excess of crude protein in the diet and lack of synchronization of the nonfiber carbohydrates with rumen-degraded protein. The metabolizable energy intake was no different between CRN and SHGF treatments, with an average value of 1,444 kJ/kg of $BW^{0.75}$. Due to the positive energy balance during mid lactation in this trial, most of the heat production from oxidation of nutrients derived from carbohydrate oxidation (55%, on average), followed by oxidation of fat (29%, on average). No significant differences were observed for milk production, although milk fat was significantly greater for the SHGF diet than the CRN diet (7.0 vs. 5.4%, respectively). Despite the different starch levels and fibrous content used in these mixed diets, no significant differences for the efficiency of use of metabolizable energy for late lactation were observed (0.63, on average). An average nutritive value of 7.52 MJ of net energy of lactation/kg of DM was obtained. This fibrous by-product was utilized by lactating goats without detrimental effect on energy metabolism and resulted in similar performance to grain bases diet. The economic advantages and sustainability of this choice should be evaluated.

Key words: Murciano-Granadina goat, corn substitution, heat production, substrate oxidation

INTRODUCTION

To achieve maximum milk production potential by means acceptable to consumers, feeding systems for dairy ruminants need to ensure high intake of energy, among other factors. This might be accomplished by raising the dietary concentration of rapidly degraded NFC, such as starch from cereal grain. Increasing the concentration of NFC in diets for dairy cows, however, can lead to undesirable ruminal fermentation, compromising the nutrient supply for production of milk and milk components. To prevent ruminal upsets and health problems, the NRC (2001) recommended that the maximum NFC in diets for high-producing dairy cows should range from 36 to 44%, depending on the total and forage NDF content of the ration. The partial replacement of cereal grain with low starch by-product feeds represents a potential alternative to overcome this limitation. By-product feeds have been used extensively in dairy cattle diets in many parts of the world as economical substitutes for corn and soybean meal. There is increasing interest in the nutritive value of by-product feeds as nutritionists seek to manipulate NFC concentrations and undegraded intake protein of dairy ruminant diets. Soy hulls and corn gluten feed are typically used as grain replacers. According to NRC (2001), soy hulls and corn gluten feed are 2 by-product feeds that are highly digestible but low in NFC; soy hulls are high in NDF (67%, high in cellulose) and ADF, but are low in lignin and NFC (14%). Ludden et al.

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(1995) considered soy hulls to be a bulky concentrate similar to beet pulp, rather than roughage, in spite of the higher fiber content of soy hulls. According to NRC (2001), corn gluten feed is a good source of CP (24%), much of which is ruminally degraded. Corn gluten feed (36% NDF) is high in hemicellulose and moderate in NFC (30%). Therefore, these by-products are widely available and an affordable source to supply energy for production.

The Spanish ruminant production system (Interal, 2008; FEDNA, 2009) is based on high use of concentrate (40 to 70%), with mixed diets instead of whole-forage rations. Consuming high levels of concentrate in the diet is common practice in Spain due to the lack of pasture; nutritionists are aware of the importance of ruminants in converting fibrous feeds, unsuitable for direct human consumption, into high-quality protein sources such as milk and meat. Goat livestock in Spain occupies the second position after France in the European Union, with 30% of the milk production (MAAMA, 2012). The aim of this experiment was to study the effect of substitution of corn grain by soy hulls and corn gluten feed blend on energy partitioning, substrate oxidation, and milk performance in dairy goats during mid lactation.

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 (European Council, 2003).

Animals and Feeding

The experiment was conducted in a crossover design with 10 lactating dairy goats kept in 2 groups and fed 1 of 2 diets in two 25-d periods. The 10 multiparous mature Murciano-Granadina goats in mid lactation had similar BW (43.07 ± 2.5 kg of BW). Goats were fed 2 different mixed diets; one group was fed a mixed diet with 373 g of corn grain/kg of DM (**CRN** diet) and the other on diet substituted corn with 373 g of by-products/kg DM [soy hulls and gluten feed (**SHGF**) diet] in the following proportion: 227 soy hulls and 146 gluten feed, both expressed in g/kg of DM. Five goats per group were used to determine apparent total-tract digestibility, gas exchange, oxidation of nutrients, and milk yield. Ruminal fermentation parameters were determined in the first period of the experiment. Alfalfa hay was cut into 2.5-cm pieces (Skiold Sæby A/S, Kjeldgaardsvej, Denmark) and the concentrate was mixed and pelleted along with the premix (Table 1). Mixed diets were isoenergetic, with an average value of 19.08 MJ/kg of DM for gross energy (**GE**), and isoproteic 18.7% of CP (DM basis). Fat was included in the SHGF diet to make it isoenergetic (2.3% lard and 1.3% bypass fat). Besides, the SHGF diet had 2.3% molasses compared with 0.1% in the CRN diet. Starch levels were 27.99 and 6.57% of DM for the CRN and SHGF diets, respectively. Nutrient requirements followed the recommendation of Lachica and Aguilera (2003) and Fundación Española para el Desarrollo de la Nutrición Animal (FEDNA, 2009) for goats in lactation. Intake was ad libitum, with diets offered at 110% of consumption on the preceding few days. Half of the daily ration was offered at 0800 h and half at 1600 h, respectively. Goats had free access to water.

Experimental Schedule and Measurements

Goats were fed with experimental diets in pens for 10 d and then allocated to individual metabolism cages in thermoneutral conditions (20 to 23°C determined by

Table 1. Ingredients (g/kg of DM) and chemical composition of the diets (% of DM): corn grain (CRN) and soy hulls and corn gluten feed blend (SHGF)

	Diet	
Item	CRN	SHGF
Ingredient, g/kg of DM		
Alfalfa hay	445.9	445.2
Corn	372.8	—
Soybean meal (44% CP)	165.7	113.4
Soy hulls	—	226.8
Gluten feed (18% CP)	—	145.7
Lard[1]	—	22.7
Bypass fat[2]	—	13.0
Molasses	1.2	23.3
Calcium carbonate	9.7	4.7
Premix[3]	2.6	2.6
Sodium chloride	2.1	2.6
Chemical composition, % of DM		
DM, %	87.60	88.20
OM	92.51	91.27
CP	18.60	18.80
Ether extract	2.13	5.04
NDF	34.82	47.45
ADF	19.06	27.79
NFC[4]	36.96	19.98
Starch	27.99	6.57
Gross energy, MJ/kg of DM	18.76	19.40

[1]Fused lard provided by Valgess S.L. (Carpesa, Valencia, Spain).

[2]Bypass fat of palm FA distillate. Provided by Norel Animal Nutrition (Norel S.A., Madrid, Spain).

[3]Provided by Nacoop S.A. (Madrid, Spain). Premix composition: 40 mg of Se/kg, 250 mg of I/kg, 80 mg of Co/kg, 3,000 mg of Cu/kg, 6,000 mg of Fe/kg, 23,400 mg of Zn/kg, 29,000 mg of Mn/kg, 60,000 mg of S/kg, 60,000 mg of Mg/kg, 2,000,000 IU of vitamin A/kg, 400,000 IU of vitamin D_3/kg, 2,000 mg of vitamin E/kg, 10,000 mg of nicotinic acid/kg, and 20,300 mg of choline/kg.

[4]NFC = 100 − (NDF + ash + CP + ether extract).