Small Ruminant Research 114 (2013) 152–160

Contents lists available at SciVerse ScienceDirect

Small Ruminant Research

journal homepage: www.elsevier.com/locate/smallrumres

Milk fatty acids profile and arterial blood milk fat precursors concentration of dairy goats fed increasing doses of soybean oil

O.C. Almeida[a], A.V. Pires[b,*], I. Susin[b], R.S. Gentil[b], C.Q. Mendes[d], M.A.A. Queiroz[e], E.M. Ferreira[c], M.L. Eastridge[f]

[a] Departamento de Zootecnia, Universidade Federal Rural de Pernambuco, Unidade Acadêmica de Garanhuns, Garanhuns, Pernambuco 55296-901, Brazil
[b] Departamento de Zootecnia, Escola Superior de Agricultura "Luiz de Queiroz", Universidade de São Paulo, Piracicaba, PO Box 09, São Paulo 13418-900, Brazil
[c] Departamento de Zootecnia, Universidade Estadual de Ponta Grossa, Ponta Grossa, Paraná 84.030-900, Brazil
[d] Faculdade de Agronomia e Medicina Veterinária, Universidade de Brasília, PO Box 4508, 70.910-970 Brasília, DF, Brazil
[e] Colegiado de Zootecnia, Fundação Universidade Federal do Vale do São Francisco, Petrolina, Pernambuco 56310-770, Brazil
[f] Department of Animal Sciences, The Ohio State University, Columbus 43210, United States

ARTICLE INFO

Article history:
Received 10 August 2012
Received in revised form 29 April 2013
Accepted 30 April 2013
Available online 2 June 2013

Keywords:
CLA
Fatty acids
Mammary metabolism
Milk fat precursors

ABSTRACT

The provision of fatty acid sources in ruminant diets allows the manipulation of fatty acid profiles in milk and meat, permitting to increase the fatty acids of interest, such as conjugated linoleic acid. The objectives of this experiment were to evaluate the inclusion of increasing doses of soybean oil (30, 60 or 90 g/d) on intake, total tract digestibility of nutrients, milk production and composition, arterial and milk fatty acid profiles, and arterial concentrations of glucose, acetate, and β-hydroxybutyrate in dairy goats. Four multiparous Saanen goats with mean initial DIM 32 ± 6 and mean initial BW 63 ± 7 kg were assigned in a 4 × 4 Latin square. Does were housed in tie stalls and fed a 40% of corn silage and 60% concentrate diet. Experimental treatments consisted of: (1) basal diet without soybean oil infusion (control); (2) basal diet plus an oral infusion of 30 mL soybean oil; (3) basal diet plus an oral infusion of 60 mL soybean oil; and (4) basal diet plus an oral infusion of 90 mL soybean oil. The DM and OM intakes decreased linearly ($P < 0.05$) with increasing soybean oil supply. Dry matter digestibility was negatively influenced by oil ($P < 0.01$); however, the OM digestibility was not affected by soybean oil doses. Milk production tended to decrease ($P = 0.07$) by soybean oil supply, although when this was corrected to 3.5% fat, it decreased linearly ($P < 0.01$) as a result of the decreasing ($P < 0.05$) milk fat content. Vaccenic acid concentration in arterial blood increased ($P < 0.01$) 127% with 90 g/d of soybean oil addition. Appearance of C18:2 t10, c12 in milk caused a reduction ($P < 0.01$) in milk fat and reached a 31% reduction when 90 g/d of soybean oil was offered compared to the control diet, while the opposite occurred with C18:2 c9, t11, which decreased ($P < 0.05$) with increasing doses of soybean oil. Increasing soybean oil had no effect on arterial blood concentrations of glucose, acetate and β-hydroxybutyrate. Therefore, the decrease in milk fat concentration was due to the inhibition of mammary synthesis of fatty acids, but not by a limitation of its precursors for fatty acid synthesis.

1. Introduction

Lipid sources have been the object of many studies on ruminant nutrition, especially those focused on the

* Corresponding author.
E-mail address: pires.1@usp.br (A.V. Pires).

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http://dx.doi.org/10.1016/j.smallrumres.2013.04.014

assessment of energy needs, reduction of methane production, and manipulation of fatty acid (FA) profile in milk and meat. When ingested by lactating animals, the FA can be targeted to 3 metabolic purposes: incorporation into the fat tissue, oxidation to energy supply, and direct secretion in milk (Palmquist, 1994). The last one can request up to 75% of absorbed FA (Palmquist and Mattos, 1978). Sources of FA have been shown to be a very promising tool to meet current market demands, once the manipulation of FA profile in milk and in meat occur through the incorporation of compounds of interest, such as conjugated linoleic acid (CLA). This group of isomers is derived from the activity of rumen bacteria on dietary linolenic and linoleic acid (Bauman and Griinari, 2003) and has aroused interest in the scientific community due to its ability to perform various metabolic functions in the human body, particularly the ability to inhibit lipogenesis and some types of carcinomas (Bhattacharya et al., 2006).

Dairy products account for about 75% of CLA ingested by humans (Bauman et al., 2006), where the isomer C18:2 c9, t11 (rumenic acid) represents over 75% of CLA present in these products (Sieber et al., 2004). Although this isomer is also produced in the rumen, the main source of rumenic acid present in milk derived from intramammary synthesis is via Δ9-desaturase enzyme activity on vaccenic acid (C18:1 t11). The C18:1 t11 is one of the intermediates of ruminal biohydrogenation of linoleic and linolenic acids, being transported to the mammary gland via bloodstream. Another CLA isomer that has attracted attention is the C18:2 t10, c12; its relationship with milk fat depression in cows has already been defined (Bauman et al., 2006). However, its effects on lactating goats are controversial (Andrade and Schmidely, 2006; Erasmus et al., 2004; Lock et al., 2008).

The present study aimed to evaluate the effects of increasing doses of soybean oil (30, 60 or 90 g/d) on intake, nutrient total tract digestibility, milk production and composition, milk and arterial FA profiles, and concentrations of glucose, acetate, and β-hydroxybutyrate in the arterial blood of lactating goats.

2. Materials and methods

The research protocol and all animal care followed the guidelines recommended in the Guide for the Care and Use of Agricultural Research and Teaching (FASS, 1998). All procedures were approved by "Luiz de Queiroz" College of Agriculture Animal Ethics Committee.

2.1. Animal, treatments and experimental design

Four lactating Saanen goats with mean initial DIM 32 ± 6 and mean initial BW 63 ± 7 kg were allotted in individual tie-stall pens (0.50 m × 1.2 m), provided with a feed bunk and water. Animals were assigned to a 4 × 4 Latin square design. Experimental periods consisted of 28 d; d 1 through 24 served as an adjustment period and d 25 to 28 were for data collection. Two months before start of the experiment, the animals were surgically prepared for subcutaneous exteriorization of both carotid arteries to facilitate the collection of arterial blood.

All animals were fed ad libitum a total mixed diet (basal diet, Table 1). The basal diet was formulated to meet the requirements for lactating goats (AFRC, 1998). Experimental treatments consisted of: (1) basal diet without soybean oil infusion (control); (2) basal diet plus an oral infusion of 30 mL soybean oil; (3) basal diet plus an oral infusion of 60 mL soybean oil; and (4) basal diet plus an oral infusion of 90 mL soybean oil. Soybean oil was provided by oral infusion to have an exact control of the amount consumed, and thereby investigate the effects of increasing amounts of soybean oil on dairy goat performance, milk fatty acid composition and some metabolic parameters.

Table 1
Ingredient and chemical composition of experimental basal diet (% of DM).

Item	Basal diet
Ingredients	
Corn silage	40.0
Ground corn	42.5
Soybean meal, 48% CP	13.7
Urea	0.90
Mineral mixture[a]	2.90
Chemical analysis	
Dry matter, as-fed basis	70.3
Crude protein	17.8
Ether extract	3.2
Neutral detergent fiber	34.0
Ash	7.1

[a] Composition: Ca, 24.1%; P, 7.5%; Mg, 1.0%; S, 7.0%; Cl, 21.8%; Na, 14.5%; Mn, 1100 mg/kg; Fe, 500 mg/kg; Zn, 4600 mg/kg; Cu, 300 mg/kg; Co, 40 mg/kg; I, 80 mg/kg; and Se, 15 mg/kg.

2.2. Feeding management

Concentrate ingredients were mixed previously in a horizontal mixer with a 500 kg capacity. Experimental diets were fed at 0800 and 1600 h daily as TMR (except for soybean oil) for ad libitum intake. Animals were allowed free access to fresh water. Silage and concentrate were individually weighed in an electronic scale for each pen and manually mixed in the feed bunks. The amounts of TMR offered and refused for each animal were recorded daily to maintain feed refusals less than 10%. Soybean oil was administrated orally with the aid of a syringe twice a day (50% of daily dose each time) at the same time as feeding the TMR (0800 and 1600 h). The oral administration of the oil was used to ensure the increasing oil doses ingestion independently of the other ingredients of the diet.

2.3. Sample and data collection

Digestibility was measured on d 25–28 of each period. A capsule containing 1.5 g of chromic oxide was dosed orally on d 14–28. Fecal grab samples were taken on d 27–28 of each period to represent every 2 h in a 12-h period. Samples were frozen during collection, dried in a forced-air oven at 60 °C for 72 h and composited for each animal by equal sample weight at the end of each period.

Goats were milked at 0730 and 1600 h daily. Milk yield was recorded from the d 21 to 27 of each period using a Tru-Test (Tru-Test®, Manukau, New Zealand) milk meter. Two consecutive milk samples were taken at a.m. and p.m. milkings on d 27–28 of each period, and each sample was split into 2 aliquots. The a.m. and p.m. milk samples were composited, and the first aliquot was stored at 4 °C with bronopol Broad Spectrum Microtubs II (2-bromo-2-nitropropane-1-3-diol, D&F Control Systems Inc., Dublin, CA), and sent to Clínica do Leite (ESALQ/USP, Piracicaba, São Paulo, Brazil) to determine milk composition. The second aliquot of milk was stored at −18 °C until it was analyzed for FA profile by GLC analysis.

Arterial blood samples were collected from d 21 to 27 of each period at 0, 2, 4 and 6 h after offering the diets at the a.m. feeding, taken by carotid arteries using BD Vacutainer® tubes containing EDTA (BD-Brazil, Juiz de Fora, Minas Gerais). Plasma was immediately separated by centrifugation at 3000 × *g* for 20 min and stored at −18 °C for later laboratorial determination of FA profile, glucose, β-hydroxybutyrate, and acetate.

2.4. Chemical analysis and calculations

The samples of feed offered, orts, and fecal contents were dried in a forced air oven at 60 °C for 72 h, ground to pass through a 1-mm screen (Marconi, Piracicaba, São Paulo, Brazil), and were analyzed for DM, OM, N and EE (AOAC, 1990). The NDF and ADF contents of feed, orts, and fecal samples (correted for ash and protein) were determined according