Small Ruminant Research 137 (2016) 151–156

Contents lists available at ScienceDirect

Small Ruminant Research

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

Feeding behavior, nutrient digestibility, feedlot performance, carcass traits, and meat characteristics of crossbred lambs fed high levels of yellow grease or soybean oil

Flavia de Oliveira Scarpino van Cleef*, Jane Maria Bertocco Ezequiel, Andre Pastori D'Aurea, Marco Túlio Costa Almeida, Henrique Leal Perez, Eric Haydt Castello Branco van Cleef

Department of Animal Science, São Paulo State University, Jaboticabal, São Paulo 14884-900, Brazil

ARTICLE INFO

Article history:
Received 24 October 2015
Received in revised form 10 March 2016
Accepted 15 March 2016
Available online 19 March 2016

Keywords:
By-products
Digestion
Frying oil
Performance
Sheep
Soybean oil

ABSTRACT

Twenty-four crossbred (Santa Inês × Dorper) non-castrated male lambs (initial body weigh 24.9 kg ± 2.4 kg), were used to evaluate the effects of lipid sources (soybean oil or frying soybean oil) on feeding behavior, feedlot performance, digestibility of dry matter and nutrients of finishing lamb diets. The animals were distributed in a randomized block design and assigned to one of the isonitrogenous (18.4% CP, DM basis) diets which were formulated in forage:concentrate ratio of 40:60. The control treatment (CTL) was composed of corn silage, corn grain, sunflower meal, soybean hulls, urea, limestone and minerals. The other two treatments contained 6% soybean oil (SO) or 6% residual soybean frying oil (YG) on DM basis, mainly replacing corn grain and soybean hulls. Animals were offered total mixed rations twice daily *ad libitum*. Animals were harvested at 35 kg BW, and carcass characteristics data were recorded. Samples of *Longissimus* muscle were collected for centesimal composition analysis. The feeding behavior was observed for 3 consecutive days (12 h period each). The apparent digestibility of DM and nutrients of experimental diets were estimated using the internal marker indigestible acid detergent fiber. The oil supplementation, regardless of the source, did not change feeding behavior and carcass characteristics. Dry matter and nutrient intake and digestibility were decreased when animals were fed oil, except for ether extract, which increased. Animals fed YG presented lesser average daily weight gain (177.7 g) than SO-fed lambs (205.3 g). In conclusion, the addition of soybean oil or yellow grease at 6% in diet DM for feedlot crossbred lambs has minimal effects on feeding behavior and increases feed efficiency, however decreases digestibility of DM, NDF and ADF, and tends to increase intramuscular fat. The use of yellow grease as an alternative energy source increases lambs' days on feed.

1. Introduction

Costs of feeding limit the feedlot activity in many countries around the world (*i.e.* Brazil). The use of alternative feed ingredients aims to minimize production costs without altering the production of animal products such as meat, milk or wool. Food industry residues may be economical alternative energy sources in ruminant diets, especially when the prices of conventional ingredients, such as corn and soybean hulls, are high. In addition to economic constraints, competition between humans and animals for grains limits the level of grain inclusion, and negatively affects the sheep industry (Awawdeh et al., 2009a).

Vegetable oils and animal fat are used in animal feed to increase energy density of the diets (NRC, 2007), as well as to serve as carriers of fat-soluble ingredients (vitamins and essential fatty acids), to facilitate the digestion process of these ingredients, and to improve the physical nature of the ration (Palmquist, 1987).

According to OCDE/FAO (2015), vegetable oil production in Brazil is approximately 8 Mt l, and the demand for human consumption is about 5 Mt l, with perspective to expand the oil production by up to 31% by 2024. Also, according to the PNBE (National Thought of Entrepreneurs Bases) only 2.5–3.5% of disposed edible oil is recycled (Yoshida and Morcatti, 2010).

Because of the benefits of using oil in animals' diets coupled with the possibility of decreasing feeding costs, previous researchers

* Corresponding author.
E-mail address: flascarpino@hotmail.com (F.d.O.S. van Cleef).

http://dx.doi.org/10.1016/j.smallrumres.2016.03.012
0921-4488/

investigated the inclusion of residual frying oil (yellow grease) in diets for beef cattle (Plascencia et al., 1999), dairy cattle (Chow et al., 1990), and sheep (Awawdeh et al., 2009b) with promising results. This by-product is most commonly used in biodiesel, soap, or ink production, but it still requires a quality standardization and specific regulation of using it as an animal feed ingredient.

Moreover, data from studies using yellow grease as an energy source in ruminants' diets are still rare in the literature. Thus, the objectives of this study were to evaluate the effects of yellow grease or soybean oil on feeding behavior, feedlot performance, nutrient digestibility, and meat quality of crossbred lambs.

2. Materials and methods

The study was carried out at the Animal Unit of Digestive and Metabolic Studies from the Department of Animal Science of São Paulo State University (Unesp), Jaboticabal, São Paulo, Brazil. The São Paulo State University Institutional Animal Care and Use Committee approved all experimental protocols adopted in the current study (approval number: 00719711).

2.1. Animals, diets and management

Twenty-four Santa Inês × Dorper male lambs (initial BW = 25 ± 2.4 kg) were housed in individual shaded pens (1.2 m^2), and used in a complete randomized block design. Upon arrival, all lambs were offered *ad libitum* access to corn silage and water before processing. Animals were blocked by initial BW and randomly assigned, within block, to one of the three treatments (n = 8), for a total of 24 pens. Animals were tagged, vaccinated for clostridiosis (Sintoxan Polivalente T, Merial Saúde Animal Ltda, Paulínia, Brazil), and supplemented with vitamins A, D, and E (Valléevita ADE, Vallée S/A Produtos Veterinários, Montes Claros, Brazil).

Lambs were transitioned from a 70:30 roughage:concentrate diet to a 40:60 finishing diet over a period of 21 days, using three step-up diets. Three Isonitrogenous (18.4% CP) finishing diets were formulated according to NRC (2007) for a minimum average daily weight gain of 0.250 kg (Table 1). The control treatment (CTL) was composed of corn silage, corn grain, sunflower meal, soybean hulls, urea, limestone and mineral-vitamin premix. In yellow grease (YG) and soybean oil (SO) treatments, corn grain and soybean hulls were partially replaced, and antioxidant butylated hydroxytoluene (BHT) was added. Yellow grease was obtained from restaurants of Jaboticabal City, Brazil, and soybean oil was obtained from commercial sources. Diets were mixed weekly to avoid oil rancidity. Feed samples were collected weekly for determination of DM, OM, CP (AOAC, 2005), ADF and NDF (Goering and Van Soest, 1970), using thermostable α-amylase and an autoclave [0.5 kgf/cm^2, 110 °C, for 40 min], according to Senger et al. (2008).

Animals were fed total mixed rations (TMR) twice daily (0700 and 1700 h) *ad libitum*, and before access to the morning feed was allowed, the feed was spread out in the bunk according to Pritchard (1993), to present feed bunk with score 1 (thin uniform layer of feed across bottom of bunk). Samples of refused feed were collected weekly from each bunk, and composited for each animal to calculate DM and nutrient intakes.

Lambs were weighed upon arrival, at the end of adaptation period, and every seven days of the experimental period, for monitoring weight gain. At the end of the experimental period, the average daily gain (ADG) as well as feed efficiency (F:G) were calculated. When animals reached 35 kg BW, they were harvested at São Paulo State University Goat Unit experimental abattoir, where carcass data were collected.

Table 1
Ingredient and chemical composition of experimental diets.

Item	Treatments		
	Control (CTL)	Soybean oil (SO)	Yellow grease (YG)
Ingredient composition (%)			
Corn Silage	40.0	40.0	40.0
Corn cracked grain	10.8	7.5	7.5
Sunflower meal	37.5	40.9	40.9
Soybean hulls	9.8	3.6	3.6
Soybean oil	–	6.0	–
Frying residual oil	–	–	6.0
Urea	0.5	0.5	0.5
Limestone	0.4	0.5	0.5
Butylated hydroxytoluene	–	0.02	0.02
Mineral-vitamin premix[a]	1.0	1.0	1.0
Nutrient composition			
Dry matter, %	66.7	67.4	67.4
Crude protein, % DM	18.4	18.4	18.4
Ether extract, % DM	2.4	8.2	8.2
Neutral detergent fiber, % DM	46.2	43.0	43.0
Acid detergent fiber, % DM	30.7	28.6	28.6
Non-fibrous carbohydrates[b], % DM	29.2	26.5	26.5
Calcium, % DM	0.8	0.9	0.9
Phosphorus, % DM	0.6	0.6	0.6
Metabolizable energy[c], kcal/kg	2.5	2.5	2.5

[a] Composition per 1 kg contained (vitamin A, 2,000,000 IU; vitamin D3, 35,000 IU; vitamin E, 300 mg; Ca, 100 g; P, 60 g; Mg, 10 g; S, 25 g; Na, 195 g; Cl, 300 g; Co, 100 mg; Fe, 1.2 g; Se, 12 mg; Zn, 4 g; F, 600 mg; Cu, 600 mg.
[b] NFC = 100 − (% CP + % NDF + % ash + % EE).
[c] Calculated based on TDN contents, considering TDN = %DCP + %DNDF + %DEE × 2.25 + %DNFC; 1 kg TDN = 4409 kcal DE; ME = DE × 0.82.

2.2. Feeding behavior

To evaluate feeding behavior, animals were observed for 3 consecutive days (day 30 to day 32) in a 12 h period (0700 to 1900 h). Data collection was performed by two trained observers, which observed 12 animals each, and recorded, each 5 min, the following activities: interaction with feed bunk (IF), when animal positioned the head toward the feed bunk, without specifying whether ingested, smelled or played with the feed; interaction with waterer (IW), when animal positioned the head toward the waterer, without specifying whether ingested, or played with the water; standing still (SS), when the animal was with four feet in contact with pen's floor without moving the body; stand ruminating (SR); laid ruminating (LR); laid (LD); stereotypes (ST—when the animal was chewing pen's wood, biting, repetitively licking or butting), and other activities (OA). Time (expressed in minutes) expended in each activity was calculated by the number of observations recorded multiplied by 5.

2.3. Total tract apparent digestibility

The apparent digestibility of dry matter and nutrients of experimental diets were estimated by using the internal marker indigestible acid detergent fiber (iADF). Diets and refused feed were sampled daily during the feedlot period, and fecal samples were collected each 4 h during 3 consecutive days (day 40 to day 42) in order to obtain representative fecal samples of 24 h periods. Subsequently, samples were composited by animal, pre-dried in a 55 °C oven for 72 h, ground (2 mm) using a Wiley-type mill, and approximately 4 g of each sample were placed into pre-weighed nylon bags (7 × 14 cm), and incubated in a bovine rumen for 264 h (Casali et al., 2008). After incubation period, bags were dried at 55 °C in a forced air-circulation oven for 72 h, and samples were ground (1 mm) using a Wiley-type mill and analyzed for ADF contents. ADF analysis was performed according to Goering and Van Soest