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Oilseeds in feeding for growing and finishing ¾ Boer + ¼ Saanen goat kids[1]

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ABSTRACT - In order to evaluate the use of oilseeds in the diet of goat kids, two experiments were performed. Experimental treatments consisted of four different total mixed diets, all containing oat hay, ground corn, soybean meal and mineral supplement, and differing in oilseeds inclusion (dry matter basis), according to the treatments: 1) control (without oilseeds), 2) diet containing 7.87% flaxseed, 3) diet with 7.30% sunflower seed, and 4) diet containing 8.00% canola. In the first experiment (to evaluate the performance), 28 ¾ Boer + ¼ Saanen castrated goat kids (22.66 kg to 30.88 kg BW) were allotted in a randomized design in feedlot. There was no difference between treatments for intake of dry matter, organic matter, crude protein and ether extract, total weight gain, average daily gain, feed conversion or days in feedlot (61 days). In the second experiment (to evaluate the digestibility), four goats (47.42 ± 1.83 kg BW) were allotted in a 4 × 4 Latin square. The inclusion of sunflower seeds in the diet increased the intake of neutral detergent fiber. The digestibility of dry matter, organic matter, crude protein, neutral detergent fiber, total carbohydrate and total digestible nutrients were not influenced by the addition of oilseeds in the diets. There was higher ether extract digestibility for goats receiving dietary canola. The inclusion of flaxseed (7.30%), sunflower (7.87%) and canola (8.00%) seeds in the diets of ¾ Boer + ¼ Saanen goats does not improve performance, but can be used without changing intake, digestibility and energy value of diets.

Key Words: digestion, gain, goats, intake, lipid

Introduction

In Brazil, the herd of goats is composed mainly of animals of unknown genetic composition that are characterized by low weight and the limited capacity of meat and milk production. Recently, herds have been improved by the introduction of the Boer breed, which has the aptitude to meat production. Moreover, the use of intensive production systems has improved the animal performance. The feedlot, for example, allows reducing the age at slaughter and having greater control of diet to be provided.

Researches have been conducted to study the addition of fat to the diet with the objective of improving the fatty acid profile of animal products for human consumption (NRC, 2007). However, the use of lipid sources in diets of ruminants is still the source of many contradictions.

Compared with other nutrients, lipids have a higher energy value with a digestibility in the small intestine of ruminants ranging from 80 to 90% (Kozloski, 2002). However, the inclusion of lipid sources in ruminant diet must be done considering the safety limits, especially for the unsaturated fatty acids sources, which can cause problems in the rumen fermentation, such as the inhibition of cellulolytic and methanogenic bacteria that can decrease the fiber degradation (Van Soest, 1994; Swenson & Reece, 1996). Among the lipids, the polyunsaturated fatty acids and those in non-esterified form seem to be more potent inhibitors of consumption and digestion (Benson et al., 2001).

Lipids may come from animal or vegetable sources, and the levels and ways of inclusion can also be quite variable. Among the plant sources are the oilseeds, especially flaxseed, canola and sunflower. These oilseeds provide a mix of protein, fiber and fat (Romans et al., 1995), as well as an excellent fatty acid composition such as oleic acid (C18:1 n-9) and linoleic acid (C18:2 n-6) and α-linolenic acid (C18:3 n-3).

Providing animals with dietary whole oilseeds can reduce the negative effects of lipids on fermentation. It is possible because of the carbohydrate and protein matrix that reduces the direct contact of microorganisms with the lipids (Byers & Schelling, 1999).

This study was conducted to evaluate performance, digestibility of dry matter and nutrients, and energy value of diets with oilseeds for ¾ Boer + ¼ Saanen goat kids.

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Material and Methods

This experiment was conducted at Fazenda Experimental de Iguatemi, from the Universidade Estadual de Maringá, southern Brazil. Twenty-eight non-castrated ¾ Boer + ¼ Saanen (22.66 ± 2.23 kg; 90 days old) goat kids were used. Animals were distributed in a completely randomized design and were housed in single pens.

Throughout the experimental period, due to varying climatic conditions, four animals suffered respiratory diseases and died. Then, evaluation of data was performed with different number of repetitions.

The experimental diets (Tables 1 and 2) consisted of four different total mixed diets, all containing oat hay, ground corn, soybean meal and mineral supplement, and differing in oilseeds inclusion (on dry matter basis), according to the treatments: 1) control (without oilseeds; n = 6), 2) diet containing 7.87% flaxseed (n = 7), 3) diet with 7.30% sunflower seed (n = 5), and 4) diet containing 8.00% canola (n = 6). Diets were formulated to meet the energy and protein requirements from AFRC (1995) and were offered to animals as total mixed diets (pelleted) once a day (8:00 a.m.) based on 3.5% DM of the body weight in order to provide 10% of orts.

Animals were weighed during fasting period (16 h) at the beginning of the experiment and every two weeks to be adjusted to the offered feeding and to determine average daily gain. Days in feedlot were also evaluated, which consisted of the time required to reach slaughter weight (± 30.0 kg), which started to be counted from the beginning of the trial.

To determine the digestibility of dry matter and nutrients, four non-castrated goats (47.42 ± 1.83 kg) were assigned to four treatments in a 4 × 4 Latin square design. Animals were kept in individual metabolic cages and had free access to water.

Each experimental period consisted of 15 days, of which adaptation to experimental treatments was from the 1st to the 10th day. Dry matter intake was calculated using the dry matter (DM) from total mixed diet and the DM refused in orts. Samples of the total mixed diets were taken

Table 1 - Chemical composition of ingredients

Item	Ingredient					
	Oat hay	Soybean meal	Ground corn	Flaxseed	Sunflower seed	Canola
Dry matter (%)	88.12	89.40	86.93	92.96	92.66	93.60
Organic matter (% DM)	93.03	93.33	98.73	96.69	97.42	96.69
Ash (%DM)	6.97	6.67	1.27	3.31	2.58	3.31
Crude protein (% DM)	13.53	49.56	8.63	14.46	15.70	20.74
Ether extract (% DM)	1.11	2.10	3.59	25.06	40.95	37.28
Neutral detergent fiber (% DM)	51.09	14.85	16.34	41.32	30.27	28.99
Acid detergent fiber (% DM)	43.30	8.81	4.26	27.25	21.60	21.67

Table 2 - Ingredients and chemical composition of experimental diets

Item	Diet			
	Control	Flaxseed	Sunflower seed	Canola
Oat hay (%)	30.00	32.95	33.08	30.76
Soybean meal	19.65	15.75	17.76	16.88
Ground corn	47.37	40.42	38.85	41.33
Flaxseed	-	7.87	-	-
Sunflower seed	-	-	7.30	-
Canola seed	-	-	-	8.00
Mineral supplement[1]	3.00	3.00	3.00	3.00
Dry matter (%)	90.16	89.14	88.95	90.10
Organic matter (% DM)	94.62	93.97	98.85	94.89
Ash (% DM)	5.38	6.03	6.15	5.11
Crude protein (% DM)	19.09	18.59	21.07	20.07
Ether extract (% DM)	1.28	3.15	3.62	4.02
Neutral detergent fiber (% DM)	33.00	34.26	35.12	33.41
Total carbohydrates (% DM)	73.95	73.12	70.21	70.84
Total digestible nutrient (% DM)[2]	73.28	72.45	74.94	74.66
Metabolizable energy (Mcal/kg DM)[2]	2.65	2.62	2.71	2.70

[1] Chemical composition (per kg of product): vitamin A - 135,000.00 UI; vitamin D3- 68,000.00 UI; vitamin E - 450.00 UI; Ca - 240.00 g; P - 71.00 g; K - 28.20 g; S -20.00 g; Mg - 20.00g; Cu - 400.00 mg; Co - 30.00 mg; Cr - 10.00 mg; Fe - 2,500.00 mg; I - 40.00 mg; Mn - 1,350.00 mg; Se - 15,00 mg; Zn - 1,700.00 mg; F - 710.00 mg(max); Citric acid (2%) solubility of phosphorus 95% (min) (Commercial product).
[2] Calculated using published values of feed ingredients (NRC, 2001).

daily from day 11 to 15 and pooled within a period for each goat. Total feces were weighted daily from day 11 to 15 (8 a.m.) using canvas bags. Samples of feces (10% on a fresh basis) were taken after weighing and then pooled. All samples were frozen at –20 ºC for subsequent analysis.

Samples of diets and feces were oven-dried (55°C; 72 h), then ground through a 1-mm screen. Dry matter was determined according to method nº 934.01 of AOAC (1998). Organic matter was determined by combustion in a muffle furnace according to method nº 942.05 of AOAC (1998). Total nitrogen (TN) determination used a Tecnal TE-036/1 (Tecnal, Piracicaba, São Paulo, Brazil) following method nº 988.05 of AOAC (1998) and crude protein (CP) was estimated as TN × 6.25. Ether extraction in diets was conducted with Tecnal TE-044/1 according to the method n° 920.39 of AOAC (1998). The concentrate diet of NDF was determined as described by Van Soest et al. (1991). Procedures for NDF determination were adapted for use in an Ankom[200] Fiber Analyzer (Ankom Technology Corp., Fairport, NY). ADF content was determined according to AOAC (1998) method nº 973.18.

Total carbohydrates (TC) and total digestible nutrients (TDN) were estimated according to equations described by Sniffen et al. (1992): TC (%) = 100 - (%CP + %EE + %ash) and TDN = DCP + (2.25 x DEE) + DTC, where DCP = digestible crude protein, DEE = digestible ether extract and DTC = digestible total carbohydrates.

Data from performance experiment were analyzed according to the following model:

$$Y_{ij} = \mu + T_i + e_{ij}$$

where: Y_{ij} = the dependent variable, μ = overall mean, T_i = effect of the treatment (i = control, flaxseed, sunflower or canola), e_{ij} = random residual error.

Data of digestibility were analyzed using analysis of variance with the following general model:

$$Y_{ijk} = \mu + G_i + P_j + T_k + e_{ijk}$$

where: Y_{ijk} = the dependent variable, μ = overall mean; G_i = effect of goat (i = 1 to 4), P_j = effect of period (j = 1 to 4), T_k = effect of treatment (k = control, flaxseed, sunflower or canola), e_{ijk} = random residual error.

The obtained data were analyzed using analyses of variance of the SAEG system developed at Universidade Federal de Viçosa (2007).

Results and Discussion

Oilseeds did not alter (P>0.05) the intakes of dry matter, organic matter, crude protein or ether extract (Table 3). Considering the presented data and mean values reported in studies (Hashimoto et al., 2007; Lima et al., 2011) on nutrient intake (Boer + Saanen goat kids fed on diets with 30% of hay and 70% of concentrate), we can say that feeding flaxseed, sunflower or canola to goat kids did not restrict the nutrient intake. However, sunflower increased (P<0.05) the NDF intake, which would be an intake limiting factor, but it was not.

There were no effects (P>0.05) of dietary oilseeds on total body weight gain, average daily gain, feed conversion and days in feedlot (Table 3). These performance results agree with those reported by Cameron et al. (2001), who observed 0.14 kg of average daily gain and 4.38 of feed conversion for Boer + Spanish and Boer + Angora goat kids fed on diets with high level of concentrate. However, Lima et al. (2011) evaluated the performance of ¾ Boer + ¼ Saanen goat kids fed on pelleted diets containing hay (30% on DM basis) and reported better values (0.25 kg

Table 3 - Intake of dry matter and of nutrients in ¾ Boer + ¼ Saanen goat kids fed on diets with oilseeds

Item	Diet				Mean	CV
	Control	Flaxseed	Sunflower	Canola		
Initial body weight (kg)	22.45	22.83	22.76	22.56	22.66	-
Final body weight (kg)	31.71	30.89	30.63	30.33	30.88	-
			Intake (kg/day)			
Dry matter (%)	0.95	0.91	0.86	0.86	0.90	7.97
Organic matter (%DM)	3.51	3.38	3.22	3.25	3.34	9.10
Ash (%DM)	1.00	0.96	0.90	0.91	0.95	7.66
Crude protein (%DM)	0.16	0.15	0.15	0.15	0.15	7.19
Ether extract (%DM)	0.01	0.03	0.03	0.03	0.03	16.89
Neutral detergent fiber (%DM)	0.46b	0.44b	0.52a	0.44b	-	20.25
			Performance			
Total body weight gain (kg)	9.26	8.1	7.86	7.73	8.22	29.61
Average daily gain (kg)	0.17	0.11	0.14	0.12	0.13	29.88
Feed conversion (kg DM/kg gain)	5.80	7.36	6.06	7.10	6.58	27.47
Days in feedlot	57.0	67.0	57.66	62.33	61.0	24.41

Means with different superscripts in a row differ (P<0.05) by Tukey test.

and 3.31) of average daily gain and feed conversion, respectively.

Differences between previous studies on the performance of goat kids and results from the current study suggest that it can be related to factors such as genetic group, initial and final body weight, diet composition and feed characteristics, since the energy and protein levels contribute to improving the expression of the animal genetic potential. Feeding pelleted diets also must be considered, because this makes feed selection difficult, and assures nutrient intake. Furthermore, performance and feed conversion are better when animals are fed on pelleted diets (Machmüller et al., 2000).

In the digestibility experiment, there were no effects of dietary oilseeds (P>0.05) on intakes of dry matter, organic matter, crude protein, neutral detergent fiber, total carbohydrates or total digestible nutrients (Table 4). Dry matter intake was 1.3 kg/day, which corresponds to 2.74% of body weight.

Ether extract intake was higher (P<0.05) for goats fed on canola diet. There were no differences between flaxseed and sunflower diets, but both showed ether extract intake higher than control diet, which can be explained by the ether extract content of diets (Table 2).

Dietary oilseeds did not affect (P>0.05) digestibility of dry matter, organic matter, crude protein, total carbohydrates, or, especially, neutral detergent fiber (Table 4). However, Machmüller et al. (2000) evaluated the supplementation with squeezed canola, sunflower or flaxseed in growing lambs fed on corn silage, grass hay and concentrate (5.6% EE *vs.* 3.1% control) and observed that dietary sunflower seed reduced the digestibility of neutral detergent fiber, acid detergent fiber and organic matter.

Differences between results from studies are probably related to the different forms of oilseeds supplementation (whole *vs.* squeezed). Thus, in the current experiment where lipids were offered in a protected form, fatty acids did not affect rumen fermentation.

Moreover, ether extract content of diets with oilseeds (3.6% on average) is not considered a level high enough to damage nutrient digestibility, mainly neutral detergent fiber digestibility.

Diets were formulated to provide similar total digestible nutrients and crude protein contents in order to avoid composition variations and rumen environment changes. Then, the major variation was observed in the ether extract content, which showed highest digestibility for diets with oilseeds (Table 4); and these values are within the range of lipid digestibility (80 to 90%), usually observed in ruminants (Kozloski, 2002).

The increase in digestibility of ether extract, caused by dietary oilseeds inclusion, can be related to the improvement in the intake of this nutrient. Moreover, the lipid sources used in this experiment are rich in polyunsaturated fatty acids (canola: 60% oleic acid; flaxseed: 45% linolenic acid; and sunflower: 65.2% linoleic acid). In general, these fatty acids show better digestibility than saturated fatty acids and are more harmful to rumen fermentation (Palmquist & Mattos, 2006).

Oilseeds did not alter (P>0.05) the energetic values of diets (Table 5), even with the average increase of 2.32% of ether extract compared with the control diet.

Chilliard (1993) reported that diets with 3.9% of lipids show higher (9%) energetic values than control diets. Among the nutrients, lipids have the highest energetic value (NRC, 2007). Therefore, the highest intake and

Table 4 - Intake, digestibility and total digestible nutrients of diets with different oilseed meals for goat kids

Item	Diet				CV
	Control	Flaxseed	Sunflower	Canola	
		Intake (kg/day)			
Dry matter	1.31	1.29	1.31	1.29	5.03
Organic matter	1.23	1.21	1.22	1.21	8.06
Crude protein	0.25	0.24	0.27	0.25	6.31
Ether extract	0.02c	0.04b	0.04b	0.05a	34.43
Neutral detergent fiber	0.41	0.43	0.44	0.42	8.98
Total carbohydrates	0.96	0.93	0.91	0.91	10.51
Total digestible nutrients	0.95	0.95	0.96	0.97	15.16
		Digestibility (%)			
Dry matter	75.45	75.72	74.10	74.63	3.50
Organic matter	75.90	75.91	74.43	75.23	7.96
Crude protein	83.55	84.35	84.40	84.45	2.73
Ether extract	69.13c	89.26b	89.31b	92.90a	20.45
Neutral detergent fiber	53.33	59.78	56.10	57.70	6.24
Total carbohydrates	74.03	73.36	70.71	71.61	9.25

Means with different superscripts in a row differ (P<0.05) by Tukey's test.

Table 5 - Energetic value of experimental diets

Item	Diet				Mean	CV
	Control	Flaxseed	Sunflower	Canola		
Total digestible nutrients (%DM)[1]	72.43	74.24	73.31	75.86	73.96	7.62
Digestible energy (Mcal/kg DM)[2]	3.19	3.27	3.23	3.34	3.26	7.62
Metabolizable energy (Mcal/kg DM)[3]	2.62	2.68	2.65	2.74	2.67	7.62

[1] TDN = DCP + 2.25 × DEE +DTC (Sniffen et al., 1992).
[2] DE = %TDN × 0.04409 (NRC, 1996).
[3] ME = DE × 0.82 (NRC, 1996).

digestibility for ether extract provided by oilseeds could alter the energy value of diets, but this was not observed in this experiment. This may be related to levels of inclusion of oilseeds, and also to the balancing of the diets which presented similar values of metabolizable energy in their final composition.

Furthermore, the control diet had higher corn content and, consequently, a higher level of nonfiber carbohydrates, which probably offset the additional energy contained in oilseeds diets. Values of calculated total digestible nutrients were also similar to estimated values (Table 2), and it confirms that animals responded to the energetic value predicted in diets.

Conclusions

Feeding diets with flaxseed, sunflower seed and canola seed to ¾ Boer + ¼ Saanen goat kids is not beneficial enough to performance; however, these ingredients can be used without changing intake, digestibility or energetic values of diets.

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