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Palm kernel cake from the biodiesel industry in diets for goat kids. Part 1: nutrient intake and utilization, growth performance and carcass traits

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ABSTRACT

This study was conducted to test the hypothesis that palm kernel cake could be included in diets for goat kids without reducing their growth rate and carcass traits. Forty non-castrated crossbred Boer × indigenous goat kids were supplemented with palm kernel cake at levels of 0, 7, 14 and 21% of the total dry matter (DM) in their diet. Palm kernel cake inclusion in the goat kid diet increased the ether extract (EE; $P < 0.001$) and neutral detergent fiber (NDF; $P < 0.001$) intakes. Non-fiber carbohydrate (NFC; $P < 0.001$) intake, digestibility of DM ($P < 0.001$), NFC ($P < 0.001$) and total digestible nutrients ($P = 0.002$) were reduced with palm kernel cake inclusion. The hot ($P < 0.001$) and cold ($P < 0.001$) carcass yields of goat kids were reduced with palm kernel cake inclusion. The BUN of goat kids at 2 and 4 h presented a quadratic increase with the inclusion of palm kernel cake. The total weight gain ($P = 0.36$), average daily gain ($P = 0.36$), feeding efficiency ($P = 0.32$), slaughter weight ($P = 0.30$), hot ($P = 0.96$) and cold ($P = 0.92$) carcass weights, offal weight ($P = 0.88$), morphometric measurements ($P < 0.05$), tissue proportions ($P < 0.05$) and commercial cut weights ($P < 0.05$) were not affected by supplementation with palm kernel cake. However, an increase ($P = 0.003$) was observed in the gastrointestinal content of the goat kids. Palm kernel cake inclusion in the diet of crossbred Boer kids of up 21% of the DM is recommended because no negative effects were observed on the DMI, growth performance, morphometric measurements, tissue proportions, and commercial cut weights. Despite the reduction observed in the carcass yields (CY) and in the DM, NFC and TDN digestibility and observation of low-ADG kids, the performance did not change, and we should consider using palm kernel cake as an ingredient in rations because it reduces costs.

1. Introduction

Agro-industrial byproducts assume an important economic role and are often responsible for the viability of the production system; however, the use of such byproducts in animal diets must be carefully considered because their nutritional characteristics and availability may be a limiting factor for their use (Ben Salem and Nefzaoui, 2003; Gonzaga Neto et al., 2015; Oliveira et al., 2015a). Thus, biodiesel byproducts should be tested at different levels of inclusion in goat kid diets for the replacement of traditional ingredients such as corn and soybeans, with the goal of reducing ration costs (Silva et al., 2010; Chanjula et al., 2015; Ferreira et al., 2017).

Cakes are important alternative feeds for improving the viability of goat farming (Oliveira et al., 2015b; Silva et al., 2016a,b). Palm kernel cake is a byproduct of oil extraction from the fruit of the oil palm (*Elaeis guineensis*) and has been studied as an alternative feed for ruminants (Ribeiro et al., 2011; Oliveira et al., 2015a; Santana Filho et al., 2016). Its use is recommended due to its high fiber (61% NDF) and ether extract contents (11% EE), with the EE increasing the energy density of the diet (Santana Filho et al., 2016). However, an EE concentration greater than 7% of the total DM in the ruminant diet can decrease feed intake and fiber digestibility (Oliveira et al., 2015b; Morais et al., 2017; de Gouvêa et al., 2017).

In addition, another important aspect of the use of palm kernel cake is the its ability to meet the need to formulate diets at lower costs, resulting in increased profitability in the production system without compromising carcass characteristics and productive performance (Silva et al., 2015; de Gouvêa et al., 2016). Therefore, knowledge of the optimal levels of palm kernel cake to include in the diet of Boer goat kids is important. This study was conducted to test the hypothesis that

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palm kernel cake could be added to the diet of crossbred Boer goat kids with no negative effects on the intake, digestibility, growth performance, carcass characteristics and blood urea nitrogen (BUN).

2. Materials and methods

This study was conducted at the Federal University of Bahia, Brazil, in strict accordance with the recommendations in the Guide for the National Council for the Control of Animal Experimentation. The protocol was approved by the Committee on the Ethics of Animal Experiments of the Federal University of Bahia, Bahia State, Brazil (Permit Number: 03–2012).

2.1. Location, animals, and general procedures

Forty non-castrated, crossbred Boer × indigenous kids with an average age of 90 days ± 10.2 days and an average body weight of 15.1 ± 1.76 kg were tested. During the adaptation period, the animals were treated for internal and external parasites with ivermectin (Ivomec Gold®, Merial, Salvador, Bahia, Brazil) and vaccinated for polyvalent clostridiosis (Sintoxan®, Merial, Salvador, Bahia, Brazil). The goat kids were housed in individual stalls (1.0 × 1.0 m) with slatted wood floors and with a water trough and feed bunk. The trial lasted for 87 days and was preceded by 15 days of adaptation of the animals to the environment and diet.

2.2. Diets and chemical analysis

The goat kids were fed twice daily with a total mixed ration (TMR) in a 40:60 hay/concentrate ratio at each feeding (Table 1). The concentrate feed was mixed at the beginning of the experiment, and at the same time, samples of the ingredients were taken and chemically analyzed. Samples of the hay were collected weekly to create a pooled sample. Each ingredient of the TMR (concentrated feed and hay) was analyzed in triplicate.

The diet was offered in an amount that allowed between 10 and 15% refusal. The ingredients and refusals were weighed daily, and the refusals were sampled twice per week (to generate a pooled sample for each animal). The pooled refusal sample was collected for a period of 21 days, resulting in four pooled samples per animal during the experiment.

The concentrated feed was comprised of corn bran; soybean meal; mineral premix; and 0, 7, 14, or 21% palm kernel cake in the total dry matter (DM) (Table 1). The forage used was *Cynodon dactylon* hay, chopped into particles of approximately 5 cm in length. The diets were formulated according to the National Research Council (NRC, 2007) for an average daily gain (ADG) of 150 g. Water was supplied *ad libitum*.

All ingredients, orts and fecal samples were chemically analyzed (in triplicate) according to the Association of Official Analytical Chemistry (AOAC, 1990) to determine the DM (Method 967.03), ash (Method 942.05), CP (Method 981.10), and ether extract (Method 920.29) contents.

The neutral detergent fiber (NDF) and acid detergent fiber (ADF) were determined according to Van Soest et al. (1991), with the modifications that were proposed in the Ankom device manual (Ankom Technology Corporation, Macedon, New York, US). The NDF was corrected for ash and protein. The NDF residue was incinerated in an oven at 600 °C for 4 h, and the protein correction was determined by subtracting the neutral detergent-insoluble protein (NDIP). The acid detergent lignin (ADL) was determined according to AOAC (2002) method 973.18, in which the ADF residue was treated with 72% sulfuric acid. The nonfiber carbohydrates (NFC) were calculated according to Mertens (1997), with the value of NDF corrected for ash and protein being used. The NDIP and acid detergent-insoluble protein (ADIP) contents were determined according to Licitra et al. (1996).

Table 1
Composition and proportion of ingredients in diets with palm kernel cake fed to crossbred Boer goats.

Item	Corn bran	Soybean meal	Palm kernel cake	*Cynodon dactylon* hay
Chemical composition of ingredients (g/kg DM)				
Dry matter (g/kg, as fed)	888	886	920	901
Ash	14.0	63.0	32.3	82.4
Crude protein	77.7	460	169	37.7
Ether extract	55.0	17.0	96.6	15.4
Neutral detergent fiber	131	112	599	797
Acid detergent fiber	53.5	109	431	456
Neutral detergent insoluble protein	16.3	45.5	131	32.0
Acid detergent insoluble protein	8.50	20.1	31.2	10.1
Acid detergent lignin	22.7	22.1	136	121
Cellulose	30.8	87.1	295	335
Hemicellulose	77.8	3.1	169	341
Nonfiber carbohydrates	722	348	103	67.8
Proportions of	Palm kernel cake (% DM)			
ingredients (g/kg DM)	0%	7%	14%	21%
Corn bran	365	310	255	200
Soybean meal	205	190	175	160
Palm kernel cake	0.00	70.0	140	210
Mineral premix[a]	15.0	15.0	15.0	15.0
Urea[b]	15.0	15.0	15.0	15.0
Cynodon sp. Hay	400	400	400	400
Chemical composition of diets (g/kg DM)				
Dry matter (g/kg, as fed)	896	898	901	903
Ash	66.0	66.5	67.1	67.6
Crude protein	180	180	181	182
Ether extract	29.7	33.2	36.7	40.2
Neutral detergent fiber	390	423	456	489
Acid detergent fiber	223	250	275	301
Neutral detergent insoluble protein	28.1	35.6	43.2	50.8
Acid detergent insoluble protein	11.3	12.7	14.1	15.5
Acid detergent lignin	61.1	69.1	77.5	84.9
Cellulose	163	181	198	216
Hemicellulose	165	173	180	188
Non-fibrous carbohydrates	335	297	259	222

[a] Assurance levels (per kg in active elements): 135,000.00 U.I vitamin A, 68,000.00 U.I. vitamin D3, 450.00 U.I. vitamin E, 240.00 g calcium, 71.00 g phosphorus, 28.20 g potassium, 20.00 g magnesium, 20.00 g sulfur, 400.00 mg copper, 30.00 mg cobalt, 10.00 mg chromium, 250.00 mg iron, 40.00 mg iodine, 1350.00 mg manganese, 15.00 mg selenium, 1700.00 mg zinc, and maximum 710.00 mg fluoride. Sources of the minerals: dicalcium phosphate, potassium chloride, calcium carbonate, vitamin E, carbo-amino-phospho-chelate of zinc, carbo-amino-phospho-chelate of copper, carbo-amino-phospho-chelate of selenium, carbo-amino-phospho-chelate of chromium, magnesium oxide, vitamin D3, vitamin A, flowers of sulphur, carbo-amino-phospho-chelate of manganese.

[b] Mixture of urea and ammonium sulfate at a ratio of 9:1.

2.3. Intake and digestibility

Nutrient intake was estimated by calculating the difference between the total of each nutrient contained in the feed offered to the goats and the amount in the refusals.

Samples of the feces and refusals of each goat kid for the digestibility analysis were collected from day 28 to day 34 in the feedlot and quantified during this period (total collection). Appropriate canvas bags were attached to the goat kids for total fecal collection. After a period of