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ANIMAL PRODUCTION

Performance and carcass traits of goat kids fed high-concentrate diets containing citrus pulp or soybean hulls

Desempenho e características da carcaça de caprinos alimentados com dietas de alto teor de concentrado, contendo polpa cítrica ou casca de soja

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ABSTRACT

The objective in this trial was to determine the effects of partial replacement of ground corn by citrus pulp or soybean hulls on performance and carcass characteristics of feedlot goat kids. Twenty one Boer x Saanen kids (initial BW 15.8 ± 0.7kg), nine males and 12 females, were distributed in a complete randomized block design, according to sex and initial body weight. Treatments were set by replacing 50% of ground corn (DM basis) for citrus pulp or soybean hulls; whereas, forage concentrate ratio was of 10:90. Partial replacement of corn by citrus pulp or soybean hulls increased dry matter intake, average daily gain and final body weight, but feed efficiency was not affected. There was no difference between citrus pulp or soybean hulls. Inclusion of coproducts increased slaughter weight, hot and cold carcass weight and longissimus muscle area, with no difference between citrus pulp and soybean hulls. Subcutaneous fat thickness, hot and cold carcass yields, shrink after chilling and body wall thickness were not affected by treatments. Citrus pulp and soybean hulls can replace 50% of ground corn (DM basis) increasing dry matter intake and weight gain in goat kids enabling higher slaughter weight at earlier age.

Key words: *coproducts, feedlot, goats.*

RESUMO

O objetivo neste estudo foi avaliar a substituição parcial do milho pela polpa cítrica (PC) ou casca de soja (CS) sobre o desempenho e as características de carcaça de cabritos confinados. Foram utilizados 21 cabritos Boer x Saanen (PC inicial de 15,8±0,7kg), sendo nove machos e 12 fêmeas, distribuídos em delineamento experimental de blocos completos casualizados (7 blocos e 3 tratamentos). Os tratamentos foram definidos pela substituição de 50% do milho pela PC ou CS (% da MS). As dietas continham 90% de concentrado e 10% de volumoso. A substituição parcial do milho pela PC ou CS aumentou o consumo de matéria seca (CMS), o ganho médio diário de peso corporal (GMD) e o peso corporal final, porém a eficiência alimentar não foi alterada. A inclusão dos coprodutos aumentou o peso corporal ao abate (PCA), o peso de carcaça quente (PCQ) e fria (PCF) e a área de olho de lombo (AOL). Não houve diferença entre os coprodutos com relação ao desempenho e às características de carcaça. A substituição de 50% do milho (64,2% de MS) pela polpa cítrica ou casca de soja, em dietas com alto concentrado, aumenta o consumo de matéria seca e o ganho médio diário de peso dos cabritos, possibilitando maior peso ao abate com idade menor.

Palavras-chave: *coprodutos, confinamento, caprinos.*

INTRODUCTION

Goat meat has gained market mainly due to increased demand for healthy foods because of its low fat content. However, in many regions, the seasonality in the production of roughage and the low quality of pastures hinder the termination and the slaughter of grazing animals in an early age. One of the possible strategies to accelerate the growth of animals is confinement.

The price of ingredients used in feedlot diets tend to be influenced mainly by supply and demand. Thus, in order to reduce food spending and not compete with human consumption, the use of agro-industrial coproducts may be a reliable strategy to replace corn.

Soybean hulls (SH) are a coproduct from soybean processing. From each ton of processed soybean, approximately 2% SH is generated. Soybean

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hulls are characterized by high NDF (NRC, 2007) and low lignin content (ANDERSON et al., 1988; MULLIGAN et al., 1999). Also it is practically free of starch (HSU et al., 1987), which reduces the risk of ruminal acidosis in animals fed with diets containing high levels of concentrate (FERREIRA et al., 2011b).

The pelleted citrus pulp (CP) features low NDF content, 21.0% in the dry matter (DM), however it has a high concentration of pectin, 22.3% in the DM (NRC, 2007) and can be used as an energy ingredient (BAMPIDIS & ROBINSON, 2006). The pectin present in CP is a complex carbohydrate with high and rapid rumen degradation (VAN SOEST et al., 1991) and when added to the diet of ruminants, it stimulates the production of acetic acid rather than lactic acid, elevating the ruminal pH (WING et al., 1988).

There are few studies on the use of SH and CP in diets of early weaned goat kids. The objective in this study was to determine the effects of replacing 50% of corn for SH or CP, in 90% concentrate diets, on growth and carcass characteristics of early weaned goat kids.

MATERIALS AND METHODS

The trial was conducted at the Sheep and Goats Intensive Production System (SIPOC) of the Department of Animal Science of the “Luiz de Queiroz” College of Agriculture (ESALQ), University of São Paulo, in Piracicaba, state of São Paulo, Brazil. All procedures involving animals were approved by the Ethics Committee on Animal Use in Research (CEUAP) of the ESALQ.

Twenty-one Boer x Saanen goat kids were used, nine males and 12 females, with an average initial weight of 15.8±0.7kg and 80±1.3 days of age. Animals were kept indoors, in individual tie-stalls, with a slatted floor and provided with feed bunks and water cups.

The experimental design was a randomized complete block design with three treatments and seven replications, and the animals were blocked by sex, age and initial weight. The experiment lasted 56 days and was divided into two periods of 28 days. Diets were isonitrogenous (16.4±0.3% crude protein) consisting of 10% roughage (coastcross hay) and 90% concentrate (DM basis) and formulated as recommended by NRC (2007). Half of the dry matter content of corn in the control diet (CT) was replaced by citrus pulp (CP) or soybean hulls (SH), corresponding to the CP and SH diets, respectively (Table 1).

Feed ingredients (corn, citrus pulp, soybean hulls and hay) were grounded using a mill (Nogueira® DPM-4, Itapira, Brazil) fitted with a screen of 10mm sieve. Later, they were mixed with other ingredients (soybean meal, wheat bran, limestone, mineral salt and ammonium chloride) with the aid of a horizontal mixer (Lucato®, Limeira, Brazil) with capacity of 500kg. In all experimental diets, 25mg of sodium monensin was added per kg of feed.

Table 1 - Ingredients and chemical composition of the experimental diets (DM basis).

Item	---------------Diets[1]---------------		
	CT	CP	SH
Ingredients			
Coastcross hay	10.0	10.0	10.0
Soybean meal	16.5	17.6	13.3
Ground corn	64.2	32.1	32.1
Citrus pulp	-	32.1	-
Soybean hulls	-	-	32.2
Wheat bran	5.0	5.7	8.2
Limestone	1.8	0.0	1.7
Mineral mix[2]	2.0	2.0	2.0
Ammonium chloride	0.5	0.5	0.5
Chemical composition			
Dry matter	90.2	92.5	91.0
Crude protein	16.8	15.8	16.5
Neutral detergent fiber (NDF)	21.2	26.1	38.7
Organic matter	93.6	92.7	93.0
Mineral matter	6.4	7.3	7.0

[1]CT: Control diet, with 64.2% corn; CP: citrus pulp diet, replacement of 50% of corn by CP; SH: Soybean hulls diet, replacement of 50% of corn by SH.
[2]Composition: Ca: 13.4%, P: 7.5%, Mg: 1%, S: 7%, Cl: 21.8%, Na: 14.5%, Mn: 1100mg kg^{-1}, Fe: 500mg kg^{-1}, Zn: 4600mg kg^{-1}, Cu: 300mg kg^{-1}, Co: 40mg kg^{-1}, I: 55mg kg^{-1}, Se: 30mg kg^{-1}.

Ration was weighed daily on an electronic scale accurate to 1g (Marte®, LC 10, Sao Paulo, Brazil) and was offered *ad libitum* to animals. Amounts of feed given to animals were calculated according to previous DMI, and adjustments were made when needed, so that refused feed did not exceed 10% of daily intake. Orts were recorded weekly to determine DMI. A sample was taken from offered feed and orts of each experimental unit once a week. Orts samples were composed per treatment and kept at -18°C for later analysis.

Samples of offered feed and orts were processed in a Wiley type mill, fitted with screens with 1mm sieves. The determination of dry matter (DM), mineral matter (MM) and crude protein (CP) was performed according to AOAC (1990). The fiber insoluble in neutral detergent (NDF) was determined using heat-stable α-amylase and sodium sulfite, according to VAN SOEST et al. (1991). The organic matter (OM) was calculated by difference between DM and MM. The analyses were performed at the Laboratory of Food Science and Laboratory of Animal Nutrition and Reproduction, Department of Animal Science at ESALQ/USP.

Animals were weighed after a solid fasting period of 14 hours at the beginning of the experiment and at the end of each period. Using these weights and DMI, average daily gain (ADG) and feed efficiency (FE) were calculated. At the end of the 56-d feeding trial, after fasting for 14 hours, animals were weighed and slaughtered in a commercial abattoir. After slaughter the hot carcass weight (HCW) and yield (HCY) were calculated. After 24 hours in cold storage at 4°C, the chilled carcass weight (CCW) and yield (CCY) were recorded. Also the shrink after chilling was determined. After weighing, carcasses were ribbed between the 12^{th} and 13^{th} thoracic vertebra and the subcutaneous back fat thickness (SF), LM area (LMA) and body wall thickness (BWT) were determined. The SF and the BWT were determined using a digital caliper graduated in millimeters. Body wall thickness was measured 12.5cm laterally from the midline of the spine (NOTTER et al., 2004). For the determination of LMA, the exposed Longissimus dorsi muscle area was traced on acetate paper, and the area was determined by using a planimeter graduated in square centimeters.

Statistical analyses were performed using the MIXED procedure from SAS (2008). All data was subject to the Shapiro-Wilk test to verify the normality of residue and removal of outliers, the homogeneity of variances was also checked using the Levene test. The data set that did not respect those premises was subjected to logarithmic, inverse or square root transformation.

The ADG, DMI and FE variables were analyzed as repeated measures over time, using the following model: $Yijk = \mu + Bi + Tj + Eij + Pk + (BP) ik + (TP) jk + Eijk$, where μ = overall mean; Bi = block effect (i=1 to 7); Tj = treatment effect (j=1 to 3); Eij = residual error A; Pk = experimental period effect (k=1 to 2); (BP) ik = interaction block x trial period; (TP) jk = interaction treatment x trial period, and Eijk = residual error B. Block and interaction block x period were included as random effects. Nine covariance matrices were tested and defined according to the lowest value obtained for “Akaike’s Information Criterion” (AIC). The means of the treatments were obtained by LSMEANS command. The data sets were evaluated by orthogonal contrasts, being rated the control treatment versus CP and SH, as well as the CP versus SH. The effects of period and the interaction diet versus period were defined by the F test of the variance analysis.

For the animal weights and the carcass characteristics, the model used was: $Yij = \mu + Bi + Tj + Eij$, where μ=overall mean; Bi=block effect (i=1 to 7); Tj = treatment effect (j=1 to 3), and Eij = residual error. Block was included as a random effect. The treatment means were obtained by LSMEANS command. The data sets were analyzed by orthogonal contrasts same as the ones mentioned above. All analyzed variables were considered as significant effects when $P \leq 0.05$.

RESULTS AND DISCUSSION

The partial replacement of corn by CP or SH resulted in increased DMI ($P<0.01$). However, there was no difference between CP and SH diets (Table 2). The ADG was also higher ($P=0.02$) for the diets containing the coproducts compared to the control, with no difference between the CP and SH diets. Feed efficiency was not affected by diets. Thus, the higher ADG of the animals receiving the coproducts can be justified by the greater DMI. These results indicate that, despite the high NDF content of SH, it did not promote physical limitation to the consumption, which must be attributed to its high ruminal digestibility (IPHARRAGUERRE & CLARK, 2003), high rate of passage through the rumen due to its small particle size (MERTENS, 1997) and high specific gravity (BHATTI & FIRKINS, 1995). Additionally, the fact that the inclusion of SH (FERREIRA et al., 2011a) or CP (WING et al., 1988) in diets with high concentrate maintains rumen pH higher and stable throughout the day may have contributed to the increase in the DMI and consequently higher ADG of the animals receiving the coproducts. FERREIRA et al. (2011a) also observed a linear increase in the DMI in response to the replacement of up to 45% of the corn of lamb’s diet by SH without effects on ADG. The authors justified that this increase in DMI occurred to compensate reduction in dietary energy concentration as SH was included in the diets. According to NRC (2007), the energy concentration in corn is higher than in SH (3.9 and 3.4Mcal of ME kg^{-1} of DM, respectively).

In this experiment, the increased DMI in the second period was already expected due to the increased weight of animals. However, there was an interaction between diet and time for DMI ($P=0.05$). After analyzing the interaction between diet and period (Figure 1), it was noted that for all diets there was an increase in the DMI from the first to the second period, but this increase was more pronounced for animals in the CP and SH diets. This effect on the DMI of the

Table 2 - Growth and intake of goat kids fed diets with citrus pulp or soybean hulls in partial replacement of corn.

Variables[1]	------------------------Diets[2]------------------------			SEM[3]	---------------------------------P value[4]----------------------------			
	CT	CP	SH		CT*COP	CP*SH	Per	Diet*Per
IBW, kg	15.9	15.8	15.6	0.73	0.50	0.72	-	-
MBW, kg	20.9	22.0	21.5	0.92	0.12	0.43	-	-
FBW, kg	24.9	27.3	26.9	1.06	0.02	0.56	-	-
ADG, kg	0.16	0.21	0.20	0.01	0.02	0.70	0.13	0.64
DMI, kg/day	0.65	0.80	0.79	0.03	<0.01	0.73	<0.01	0.05
FE, gain:feed	0.25	0.26	0.27	0.01	0.37	0.66	<0.01	0.30

[1]IBW: initial body weight; MBW: medium body weight, weight at 28-d of the experimental period; FBW: final body weight, weight at 56-d of the experimental period; ADG: average daily gain; DMI: dry matter intake; FE: feed efficiency (gain:feed).

[2]CT: Control diet, with 64.2% corn; CP: citrus pulp diet, replacement of 50% of corn by CP; SH: Soybean hulls diet, replacement of 50% of corn by SH.

[3]SEM: Standard error of the mean.

[4]CT x COP: Control x Coproducts; CP x SH: Citrus pulp x Soybean hulls; Per: Period; Diet x Per: Diet x Period interaction. P≤0.05.

animals that received the coproducts can be attributed to the adaptation of the animals to the diets, as well as the more favorable rumen environment due to the 90% of concentrate used (FERREIRA et al., 2011b; GILAVERTE et al., 2011).

The weight of goat kids at the end of the first period (28-d) was not affected by the diets; however, the weight at the end of the second period (56-d) was higher (P=0.02) for those that received diets containing coproducts compared to the control diet, with no difference between the CP and SH diets. The increase in ADG for animals fed diets containing CP and SH was not sufficient to alter the weight after 28 days of confinement. However, at the end of the 56 days, it resulted in higher weight, 9.6% for the diet with CP and 8.0% for the diet with SH in relation to the control diet. There was no difference between diets containing CP and SH (Table 2).

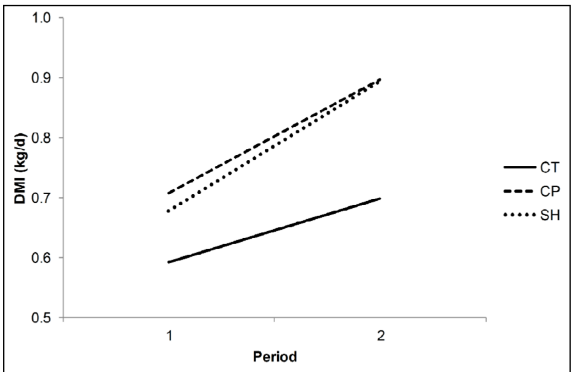

Figure 1 - Dry matter intake (DMI) of goat kids fed diets with citrus pulp (CP) or soybean hulls (SH) in partial replacement of corn (CT).

Carcass weights were higher (P=0.02) for animals fed diets containing the coproducts compared to the control one (Table 3). This response is explained by the higher slaughter weight (P=0.03) of animals fed diets containing PC and CS. Therefore, the better performance for the animals receiving CP or SH resulted in higher carcass gain, especially in relation to the muscular deposition, since differences were observed between treatments (P=0.03) for LMA (Table 3). RYAN et al. (2007) also reported an increase in carcass weight and LMA as well as thicker subcutaneous fat, when they provided more than 50% of concentrate in the diet of Boer goats compared to a range diet. In the present study, no difference was observed among diets for SF, HCY, CCY, shrink after chilling and BWT (Table 3). Since the amount of concentrate was the same (90%) in all diets and half the corn was replaced by SH or CP, the coproducts caused an increase in weight, but without changing the subcutaneous fat which is likely to be due to the animals being young and goats having a more lean meat deposition. Since the animals used in this experiment were slaughtered young, before puberty, it was expected that animals showing better performance had a positive impact on muscle deposition more than fat deposition. Furthermore, goats have a distinctive feature, with increasing animal physiological maturity there is a decrease in muscle deposition rate while the adipose tissue increases. However, that deposition occurs primarily in the form of visceral fat (PEREIRA FILHO et al., 2005). In addition, FERREIRA et al. (2011a) reported that carcass characteristics of lambs slaughtered at same weight were not affected by the inclusion of 45% of SH in high-concentrate diets.

Table 3 - Carcass characteristics of goat kids fed diets with citrus pulp or soybean hulls in partial replacement of corn.

Variables[1]	--------------------------------Diets²--------------------------------			SEM[3]	-------------------P value[4]-------------------	
	CT	CP	SH		CT*COP	CP*SH
SW, kg	26.1	28.6	27.6	0.97	0.03	0.31
HCW, kg	13.7	15.2	14.5	0.59	0.02	0.25
HCY, %	52.2	52.9	52.6	0.41	0.41	0.73
CCW, kg	13.4	14.9	14.3	0.58	0.02	0.22
CCY, %	51.1	52.0	51.6	0.40	0.30	0.58
SaC, %	2.02	1.60	1.87	0.12	0.06	0.11
SF, mm	1.08	1.03	1.05	0.09	0.85	0.95
BWT, mm	13.02	13.69	13.21	0.47	0.57	0.58
LM area, cm^2	9.63	10.33	10.64	0.28	0.03	0.46

[1]SW: slaughter weight; HCW: hot carcass weight; HCY: hot carcass yield; CCW: chilled carcass weight; CCY: chilled carcass yield; SaC: Shrink after chilling; SF: subcutaneous fat; BWT: body wall thickness; LM area: Longissimus muscle area.

[2]CT: Control diet, with 64.2% corn; CP: citrus pulp diet, replacement of 50% of corn by CP; SH: Soybean hulls diet, replacement of 50% of corn by SH.

[3]SEM: Standard error of the mean.

[4]CT x COP: Control x Coproducts; CP x SH: citrus pulp x soybean hulls. $P \leq 0.05$.

CONCLUSION

Citrus pulp or soybean hulls can replace 50% of corn in high-concentrate diets (90% DM) fed to feedlot goat kids, increasing the average daily gain and dry matter intake enabling higher slaughter weight at earlier age.

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