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SAANEN CARCASS QUANTITATIVE AND *Longissimus dorsi* QUALITATIVE CHARACTERISTICS OF FEEDING WITH PROTECTED FAT[1]

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ABSTRACT – Twenty-eight uncastrated male Saanen goat kids, on a feedlot, with an average slaughter weight of 28 kg were used to evaluate the effects of feeding goat kids with metabolizable energy levels by the addition of protected fat to the diet. The effects on the quantitative characteristics of the carcass and qualitative characteristics of the loin were assessed. The animals were randomly distributed into one of the four groups: one control group (without protected fat) was fed a diet containing 2.5 Mcal of metabolizable energy/kg dry matter (ME/kg DM). The other three groups were fed diets containing 2.6, 2.7 or 2.8 Mcal of ME/kgDM, using protected fat to increase the energy levels. The carcass quantitative characteristics were not influenced by the diets; however, a reduction was observed on the days of the feedlot and slaughter age for the animals fed protected fat diets. The short length and fat thickness in the loin has improved from diets with protected fat addition. The muscle, fat and bone proportions and the chemical composition of the *Longissimus dorsi* were similar between the diets. There was an increase in the fatty acid profiles of the polyunsaturated fatty acids linoleic and linolenic and improvements in the total omega-3 levels and the ratios of omega-6: omega-3. The protected fat can be used to feed Saanen kid goats as an alternative, increasing the energetic density of the diets up to 2.8 Mcal of ME/kg DM with improvements on the omega-3 quantity. And it can also be used to increase the ratio of omega-6:omega-3 in the *Longissimus dorsi*.

Keywords: Fatty acids. Goats Lactoplus®. Meat quality. Metabolizable Energy.

CARACTERÍSTICAS QUANTITATIVAS DA CARCAÇA E QUALITATIVAS DO *Longissimus dorsi* DE CABRITOS SAANEN ALIMENTADOS COM GORDURA PROTEGIDA

RESUMO - Vinte e oito cabritos Saanen, não castrados, confinados, com peso médio de abate de 28 kg foram utilizados para avaliar os efeitos da alimentação de cabritos com níveis de energia metabólica por meio da adição de gordura protegida na dieta. Foram avaliados os efeitos sobre as características quantitativas da carcaça e qualitativas do lombo. Os animais foram distribuídos aleatoriamente em quatro grupos: um grupo controle (sem gordura protegida) foi alimentado com uma dieta contendo 2,5 Mcal de energia metabolizável/kg de matéria seca (EM/kg MS), e três grupos foram alimentados com dietas contendo 2,6; 2,7 ou 2,8 Mcal EM/kg MS, utilizando gordura protegida para aumentar os níveis de energia. As características quantitativas da carcaça não foram influenciadas pelas dietas; no entanto, uma redução foi observada nos dias no confinamento e idade de abate para os animais alimentados com dietas com adição de gordura protegida. O comprimento menor e a espessura maior de gordura do lombo aumentou nos cabritos que foram alimentados com dietas com adição de gordura protegida. As proporções de músculo, gordura e osso e a composição química do *Longissimus dorsi* foram semelhantes entre as dietas. Houve um aumento nos perfis de ácidos graxos entre os ácidos graxos poliinsaturados linoléico e linolenico, e melhorias no total de ômega-3 e nas proporções de ômega-6:ômega-3. A gordura protegida pode ser usada na alimentação de cabritos Saanen como uma alternativa para aumentar a densidade energética das dietas até 2,8 Mcal de EM/kg MS, com melhorias na quantidade de ômega-3 e na razão de ômega-6:ômega-3 no músculo *Longissimus dorsi*.

Palavras-chave: Ácidos graxos. Lactoplus®.Qualidade de carne. Energia metabolizável.

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INTRODUCTION

Due to the high prolificacy of the goat species, the number of newborn kids in a dairy herd through the year represents a big potential to meat production (YÁÑEZ et al., 2006).The goat meat has a big consumption potential because of its nutritional value and acceptability, due to characteristics such as reduced fat concentration in the tissues, which make it a thin meat and a healthy option for the exigent public consumer (MADRUGA, 2008).

According to Gonzaga Neto et al. (2006), the performance and carcass characteristics are directly influenced by the nutritional composition of the diet. The supplementation of ruminant diets with concentrates is one of the alternatives to improve the production parameters and improve carcass quality.

Most of the foods that are used in ruminant feeding have a low concentration of fat, with values from 1 to 4% of the DM (VAN SOEST, 1994). The energetic density increases of the diets by the addition of fat in the concentrates leads to a higher energy intake without overly increasing the amount of concentrate.

Palmquist and Jenkins (1980) suggested limiting the addition of fat to the ruminants' diets to 5% of the total DM, because ruminal microorganisms do not have a physiological mechanism to digest fat as efficiently as they digest carbohydrates and proteins. To minimize the negative effect derivative from the high fat supplementation with oil, research has focussed on new methods to supply energy intake with fewer influences on ruminal fermentation. The use of protected fat as a supplement increases the diet energetic content, enabling a better efficiency in energy utilization.

Among the kinds of protected fat, calcium salts are obtained by the reaction of calcium ions with long chain fatty acids (unsaturated and saturated). This principle is based on the passage of this complex by the rumen without suffering significant structural alterations and dissociation in the acidic conditions of the abomasum, allowing for proper digestion and absorption (PALMQUIST; MATTOS, 2011).

In general, the diet effect in the content of fatty acids in the goat tissues is similar to that of other ruminants because of the biohydrogenation in the rumen environment caused by the ruminal microorganisms (GOETSCH et al., 2011). The protected fat does not suffer modification on its structures during the ruminant environmental pass, principally the polyunsaturated fatty acids (omega-6 and omega-3), which are deposited in the tissues with their appropriate functional properties.

It is emphasized that the physical and chemical properties of the fat directly changes the nutritional, sensorial and conservational qualities of the meat. The saturated fatty acids solidify after cooking, which influences the meat palatability. On the other hand, the unsaturated fatty acids increase their oxidation potential, which directly influences their shelf life *in natura* or cooked. (WOOD et al., 2003). Thus, research has demonstrated that the fatty acid profile is the main source of the characteristic flavor of a particular species (MADRUGA et al., 2008).

The objective of this trial was to evaluate the carcass characteristics, the cut yields, the *Longissimus dorsi* tissue content, the chemical composition, and the fatty acid profiles of Saanen goat kids goats fed diets with the addition of protected fat in feedlot to increase the metabolizable energy level.

MATERIAL AND METHODS

This study was carried out at the State University of Maringá (UEM), conducted at the Experimental Farm of Iguatemi– Goat Sector. The analyzes were performed in the Feed and Animal Nutrition Laboratory.

Twenty-eight carcasses of male uncastrated Saanen goat kids (112.86 ± 4.81 days of age and 19.54 ± 2.76 kg of body weight) were randomly distributed into one of the four treatment groups: one control group was fed a diet containing 2.5 Mcal of ME/kg DM, and three treatment groups were fed diets containing 2.6, 2.7 and 2.8 Mcal of ME/kg DM, using protected fat to increase the energy levels.

During the experimental period (fattening), the animals were housed in individual pens with a suspended slatted floor equipped with individual feeders with access to water *ad libitum*.

The rations had a roughage:concentrate ratio of 50:50, which was adjusted according to NRC guidelines (2007), for an average daily gain (ADG) of 0.100 kg for growing kids, and the rations contained 20% of undegradable intake protein. The total mixed ration was pelleted to avoid the selection of feed and wasting ration. The composition (g/kg) and chemical analyzes of the experimental diets are shown in Table 1.

Diets were fed in the morning (0800 h) at a ratio of 3.5% dry matter to body weight, in such a way that would provide 10% orts.

Samples of rations were collected and processed for analyzes by grinding in a knife mill until they were small enough to pass through a 1-mm screen sieve. The dry matter was determined according to method no. 934.01 of the AOAC guidelines (2012). Ash was measured by combustion in a muffle furnace according to method no. 942.05 (AOAC, 1998). Total nitrogen (TN) was evaluated using a Tecnal TE-036/1 (Tecnal, Piracicaba, São Paulo, Brazil), following method no. 988.05 of the AOAC guidelines (2012) and crude protein (CP) was estimated as TN x 6.25. An ether extraction from the

diets was conducted with a Tecnal TE-044/1(Tecnal, Piracicaba, São Paulo, Brazil), according to the method no. 920.39 of the AOAC guidelines (1998). The neutral detergent fiber (NDF) was evaluated as described by Mertens (2002), using a heat-stable α-amylase and sodium sulfite and was expressed inclusive of residual ash. Procedures for NDF determination were adapted for use in an Ankom^{200} Fiber Analyzer (Ankom Technology Corp., Fairport, NY).

Table 1. Composition (g/kg DM) and chemical analyzes of the experimental diets

Item	Diets (Mcal ME/kg DM)			
	2.5	2.6	2.7	2.8
Oat hay	500.00	500.00	500.00	500.00
Ground corn	318.58	306.65	285.97	252.79
Lactoplus®[1]	-	18.39	39.71	65.34
Soybean meal	80.00	80.00	80.00	80.00
Inactive dry yeast	66.55	69.37	74.20	81.98
Calcium carbonate	10.00	5.89	0.03	-
Dicalcium phosphate	4.03	4.77	4.81	4.88
Salt	3.95	-	-	-
Ammonium chloride	10.00	10.00	10.00	10.00
Mineral supplement[2]	6.87	5.00	5.00	5.00
Dry matter	901.62	907.48	919.39	914.40
Organic matter	934.07	936.27	930.90	933.08
Ash	65.93	63.73	69.10	66.92
Crude protein	143.00	145.70	145.11	142.25
Ether extract[3]	18.78	18.36	17.63	16.46
Supplemental fat[4]	-	15.09	32.55	53.55
Neutral detergent fiber	435.56	464.39	443.62	474.02

[1]Protected fat; [2]Commercial product[3]Obtained from the analysis of oat hay, ground corn, soybean meal and dry yeast inactive; [4]Estimate based on information from manufacturer's manual Lactoplus® (DalquimIndústria Chemical Industry Ltd).

When the animals reached an average body weight of 28 kg, they were fasted for solids (16 hours), and then weighed before the slaughter to obtain the body weight at slaughter (BWS). The animals were stunned using an electrical shock of 220 volts for 8 seconds, bled by sectioning the jugular veins and carotid arteries, skinned and eviscerated.

During evisceration, the gastrointestinal tract was emptied to get the empty body weight (body weight at slaughter minus the gastrointestinal tract content) in order to determine the carcass biological yield (SAÑUDO; SIERRA, 1986), that is the ratio of hot carcass weight to empty body weight.

At the end of evisceration, the carcass was obtained by the separation of the paws in the carpal metacarpal and tarsal metatarsal articulations and excision of the head of the atlanto occipital articulation, thus the carcasses were weighed (hot carcass weight HCW) and stored in a cold room at 4 ºC for 24 hours, the Achilles's tendon hung on hooks appropriated for the maintenance of the tarsometatarsal joints spaced at 17 cm. After cooling for 24 hours, the carcasses were weighed, getting the cold carcass weight (CCW) to calculate the percentage of weight loss by cooling (WLC) and carcass commercial yield (CCY = CCW/BWSx100) as described by Pereira Filho et al. (2005).

To determine the index compactness, the following measures were performed on the carcass: the leg length - distance between the anterior edge of the symphysis pubis, ischium and inner edge of the tarsometatarsal joint surface, the inner side of the leg, internal length of the carcass – the maximum distance between the anterior edge of the symphys is pubis and the anterior edge of the first rib at its mid point, and rump width – maximum width between the trochanters of both femurs, surrounded by a compass and tape measure.These measurements were used to determine the carcass compactness index (CCI), the ratio between the cold carcass weight and internal carcass length and leg compactness index (LCI),which is the ratio between the rump width and the leg length.

Subsequently, the carcasses were cut longitudinally, and the left half of each one was weighed and divided into seven anatomic regions and weighed individually to determine cut percentages. The following carcass areas were recorded: lower leg – all of the gluteus region, femoral and leg, based on the tarsal bone, tibia, femur, is chium, pubis and ileum, separated by a perpendicular cut to the spine between the last lumbar vertebra and first tarsometatarsal joint and sacral, lumbar – formed by the vertebrae and the area corresponding to the incident perpendicular to the spine, between the 13th thoracic vertebra and the last lumbar vertebra; shoulder – consisting of the scapula, humerus, ulna, carpal, and radio; ribs – formed by the last eight thoracic vertebrae, with the upper half of the corresponding ribs; ribs under the shoulder – based on the first five thoracic vertebrae, with the upper half of the corresponding ribs; breast and rib points - a straight line of the dorsal border of the abdomen to the sternum; and neck – the seven cervical vertebrae obtained by means of an oblique cut between the seventh cervical vertebra and first thoracic.

The *Longissimus dorsi* limits were realized (between the last thoracic vertebrae and the first lumbar, the loin) on the transversal cut of the muscle, with the plastic blade of a transparency and

appropriate pen. The loin eye area was measured using the software AUTOCAD®.

Also four measurements on the *Longissimus dorsi* muscle were made by using a caliper rule: *Measure A* – large length of the muscle perpendicular to the axis; *Measure B* – short length of the muscle, considering as maximum depth of the same; *Measure C*–short fat thickness over the muscle transversal section, adjacent to the axis B; *Measure J* – maximum fat thickness covering the loin in the profile.

The loins from the left half of the carcasses were collected, packed in polyethylene bags and stored in the freezer (-18 ºC) until further analyzes. For analyzes and dissection, the loins were thawed at four ºC for 24 h in the refrigerator, and then were dissected into muscle, fat and bone proportions. After dissection, the muscles of the loins were ground in a processor, homogenized and analysed for their chemical compositions related to the water content, ashes, and crude protein following the same procedures used for the ration samples.

The total fat extraction was carried out by the method according to Bligh and Dyer (1959). For the triacylglycerol transesterification, the method 5509 from ISO (1978) in n-heptane and KOH/methanol solution was used.

The methyl esters of the fatty acids were analysed using an auto sampler for gas chromatography (Chromatograph Trace GC Ultra, Thermo Scientific, EUA), equipped with ionization detection with flame at 235ºC and a capillary column of fused silica (100 m length, 0.25mm internal diameter and 0.20 µm, Restek 2560). The gas flux was 350 mL/min of synthetic air, 35 mL/min of H_2 (drag gas) and 30 mL/min of N_2 (auxiliary gas). The initial temperature of the column was set at 165ºC, kept for 8 min, elevated to 185ºC with a tax of 4ºC/min, kept for 4 min, reaching a final temperature of 220ºC, then elevated with a tax of 5ºC/min and kept for 17 min. Quantification of the fatty acid samples were carried out by comparing the time of the methyl ester retention from standard fatty acid samples (Sigma-Aldrich).

The study data underwent a variance analyzes with polynomial regression ($P \leq 0.05$), using the energy levels of diets (2.5, 2.6, 2.7 and 2.8 Mcal of ME/kg DM). SAS software (2001) was employed using the general model:

$$Y_{ij} = b0 + b1G + b2G + e_{ij}$$

Where: Y_{ij} = the observation of the variable studied in the animal j, receiving treatment i; $b0$ = general constant; $b1$ = the linear coefficient regression as a function of metabolizable energy levels; G = metabolizable energy level (2.5, 2.6, 2.7 and 2.8 Mcal of ME/kg DM); $b2$ = the quadratic coefficient regression as a function of the metabolizable energy level; e_{ij}= random error related to each observation

RESULTS AND DISCUSSION

The carcass characteristics evaluated from Saanen goat kids fed with protected fat levels in the diet to increase the metabolizable energy of the diet (Table 2) did not differ among the treatments.

Table 2. Carcass quantitative characteristics and slaughter age of Saanen goat kids related to the levels of protected fat added to the diet.

Parameters	Diets (Mcal of ME/kg DM)				Regressionequation; R^2	CV (%)
	2.5	2.6	2.7	2.8		
BWS (kg)	28.58	29.33	29.98	29.12	Ŷ=29.25	9.13
EBW (kg)	24.68	25.30	26.00	25.47	Ŷ=25.39	7.27
HCW (kg)	12.63	12.92	13.70	12.99	Ŷ=13.06	7.66
CCW (kg)	12.50	12.68	13.55	12.68	Ŷ=12.85	8.02
WLC (%)	1.04	1.88	1.09	2.40	Ŷ=1.60	45.72
CCY (%)	43.79	43.32	45.31	43.54	Ŷ=43.99	4.61
CBY (%)	51.06	51.20	52.59	51.08	Ŷ=51.48	3.15
CCI (kg/cm)	0.22	0.23	0.24	0.24	Ŷ=0.24	7.49
LCI	0.46	0.45	0.45	0.45	Ŷ=0.45	6.94
DF (days)	94.15	74.74	77.42	63.96	Y=309.669-87.584X; 0.83	21.99
AS (days)	209.86	183.84	191.46	176.54	Y=433.998-91.913X; 0.69	8.93

BWS = body weight at slaughter; HCW = hot carcass weight; CCW = cold carcass weight; WLC = weight loss by cooling; CCY = carcass commercial yield; CBY = carcass biological yield; CCI = carcass compactness index; LCI = leg compactness index; DF = days in feedlot; AS = age at slaughter.

The WLC were similar between the treatments with an average 1.60% value, which is less than those observed on goat carcasses with 3.13, 5.44, and 4.63% from Dhanda et al. (2003), Hashimoto et al. (2007) and Grande et al. (2011), respectively. The WLC values directly affect the carcass commercial yield, thus the WLC observed in this research can be suitable for goat kid carcasses, because McMillin (2010) who considered values between 3 and 5% acceptable for goat kid carcass. This low value in WLC is probably due to the covering with plastic bags of the carcasses during the

cooling to avoid the burn and cold shortening, contributing to the less weight loss.

The CBY and CCY showed average values of 51.48 and 43.99%, respectively. These values are in the same range as those previously reported for Saanen goat kids in feedlots slaughtered with similar weights, which varying from 46.79 to 53.73% for CBY and 43.54 to 46.03% for CCY (FREITAS et al., 2011; GRANDE et al., 2011; SALLES et al., 2013). The CCY is influenced by several factors, such as breeding, fat deposition, conformation, muscularity, age and the animal physiological nutritional stage, so animals from dairy herd tend to have a lower CCY than those from meat production.

For the carcass compactness index (CCI), an average of 0.24 kg/cm was observed, which is similar to the values reported in the literature for Saanen kid goats, which vary from 0.17 to 0.27 kg/cm (FREITAS et al., 2011; GRANDE et al., 2011; SALLES, et al. 2013). The CCI is an indirect measure of the confirmation, obtained from the relation between the weight and the carcass length, and it is important because can be used to assess the muscle production for animals with similar body weights (SIMELA et al., 1999).

The leg compactness index (LCI),which is determined from the quotient between the rump width and the leg length, did not differ between the treatment and presented an average of 0.45; this is a value similar to that observed for kid goats of this breed from 0.19 to 0.40 (FREITAS et al., 2011; GRANDE et al., 2011; SALLES et al., 2013).

The days in the feedlot presented a decreasing linear effect, showing reduction of 87.584 days in the animal's feedlot time, leading to a negative linear effect on the age at slaughter, with a reduction of 91.913 days for each unit of ME added into the diet, enabling animals ready to slaughter up to 33.34 days younger when animals fed diet with 2.8 Mcal ME/kg DM than those that are fed with diets without protected fat.

There were no effects of the treatments (Table 3) for the proportions of the first, second and third cut of the Saanen goat kids goat carcasses. The results of the carcass yield for the first, second and third cuts were close to those observed in other trials with Saanen goat kids terminated on feedlots (HASHIMOTO et al., 2007; FREITAS et al., 2011; GRANDE et al., 2011), with observed yields of 38.19 to 42.96% for the first cut; 24.24 to 29.43% for the second cut and 27.71 to 32.17% for the third cut.

Table 3.Commercial cuts yield of Saanen kid goats related to the levels of protected fat added to the diets

Parameters	Diets (Mcal de ME/kg DM)				Regressionequation; R^2	CV (%)
	2.5	2.6	2.7	2.8		
First Cut (%)						
Lowerleg	29.25	29.25	29.63	29.51	$\hat{Y}$=29.41	7.98
Loin	10.49	10.21	9.65	9.50	$\hat{Y}$=9.96	12.51
Total	39.74	39.46	39.28	39.02	$\hat{Y}$=39.37	7.74
Second Cut (%)						
Shoulder	20.91	21.39	20.76	22.08	$\hat{Y}$=21.28	6.31
Ribs	8.70	8.29	8.53	7.87	$\hat{Y}$=8.34	13.16
Total	29.62	29.68	29.29	29.95	$\hat{Y}$=29.63	5.27
Third Cut (%)						
Ribs under the shoulder	12.71	12.14	12.44	11.96	$\hat{Y}$=12.31	18.18
Breast and rib points	9.32	9.78	10.17	10.43	$\hat{Y}$=9.92	12.51
Neck	9.01	8.85	8.14	8.35	$\hat{Y}$=8.58	15.27
Total	31.04	30.76	30.75	30.74	$\hat{Y}$=30.82	8.41

Freitas et al. (2011) assessed kid goats ¾ Saanen + ¼ Boer, and observed an average of 41.95% for the first cut, a value that is 6.15% higher than the ones found in this trial.The carcass and consequently the cut yields are related to intrinsic factors (sex, breed) and extrinsic factors to the animals (feeding, age at slaughter, finishing). Inside the intrinsic factors, the breed is one of the principal barriers associated with the meat production. Animals of the Saanen breed are considered milk producers and have a lower efficiency for the meat production than specific meat breeds, such as the Boer.

Piola Jr. et al. (2009), assessing rations with various metabolizable energy levels (2.23, 2.54 and 2.85 Mcal of ME/kg DM) and different proportions of forage: concentrate did not observe an effect of the supplementation on the cuts yields of 32 kg lambs finished on feedlot.

The participation of the cuts in the carcass allows their qualitative assessment, thus allowing for the best possible proportion of the cuts, with the higher participation of the edible tissues, principally the muscles.

From the commercial point of view, the third cut yield should not be bigger than the first, because it presents a lower commercial value and is not considered a noble part, which is consistent with the data observed in this trial where the higher cuts participation were the first (39.37%) in relation to the other ones (29.63% second cuts and 30.82% third cuts).

There were no effects of the diets, for considering the parameters, loin eye area (LEA),

large length and short fat thickness among the treatments (Table 4), however the values observed for the maximum fat thickness and short length presented a positive linear relationship with the increase in protected fat.

Dhanda et al. (2003) used Saanen + Angora goat kids (26.1 kg) and observed a LEA of 9.7 cm^2. Freitas et al. (2011) evaluated Saanen goat kids slaughtered at 29.51 kg and obtained an average of 11.76 cm^2 for the LEA; similar measures were obtained for the large length (44.49 mm) and short length (23.56 mm) of *Longissimus dorsi.*

The *Longissimus dorsi* area or the loin eye area analysis is considered a representative measure of the amount, distribution, and quality of the musculature. Muscles of older maturity are indicated to represent the most reliable index of the muscular tissue development and size. Therefore, the *Loingissimus dorsi* is the most useful because its older maturity allows for easier mensuration (SAINZ, 1996).

According to Grande et al. (2011), the *Longissimus dorsi* large, and short lengths are used to assess the amount of muscle in the carcass and present a high correlation with the LEA and the carcass conformation.

Grande et al. (2011), assessing Saanen goat kids carcasses terminated on feedlots with the addition of oilseed grains, presented values of higher maximum fat thickness that varied from 1.02 to 1.73 mm; these are consistent with the values observed in this trial.

Table 4. Loin measures of Saanen goat kids related to the levels of protected fat added to the diet

Parameters	Diets (Mcal de ME/kg DM)				Regression equation: R^2	CV (%)
	2.5	2.6	2.7	2,8		
Loin eye area (cm^2)	8.10	8.40	8.49	7.09	$\hat{Y}$=8.02	26.24
Large length (mm)	46.53	48.31	49.45	51.84	$\hat{Y}$=49.03	13.17
Short length (mm)	20.65	22.02	23.39	24.76	Y=-13.547+13.681X; 0.95	18.81
Short fat thickness (mm)	0.66	0.82	0.79	0.83	$\hat{Y}$=0.77	28.74
Maximum fat thickness (mm)	1.10	1.20	1.31	1.42	Y=-1.597+1.077X; 0.66	24.91
Muscle (%)	52.37	58.13	57.84	56.10	$\hat{Y}$=56.11	10.32
Fat (%)	9.46	8.26	9.66	9.80	$\hat{Y}$=9.30	34.03
Bone (%)	33.50	29.03	28.62	30.16	$\hat{Y}$=30.32	21.08
Muscle:Bone	1.62	2.09	2.14	2.02	$\hat{Y}$=1.97	31.93

For the muscle, fat and bone proportions of the loins, the data showed a high average presence of bone in the cut. Freitas et al. (2011) and Grande et al. (2011) observed values of 13.40 and 12.82% bone proportion from goats slaughtered weighing 29.51 and 30.55 kg, respectively. Marichal et al. (2003) reported a variation of 31.47, 29.17 and 28.11% in the bone proportion from goats slaughtered at 6, 10, and 25 kg. And, in addition, McMillin (2010) observed a variation of 19.2 to 36.9% in the bone proportion of goat carcasses.

According to the age, the goats suffer a variation in tissue composition. The bone tissue is the developing component most precocious in the carcass; the fat tissue is the last, and the muscle tissue has an intermediary position (CEZAR; SOUSA, 2007).

The bone, muscle and fat proportion changes during the growth and development. According to Menezes et al. (2009), the loin tissues (muscle, fat and bone) tend to increase with advanced age, following the growth and increase of the carcass weight. Thus, when studying these components, the carcass results can exceed the whole.

Because of the high bone proportion observed, the muscle:bone ratio presented a lower average than that obtained with Saanen kid goats reported by Salles et al. (2013), who presented a value of 4.29 for the muscle: bone ratio. Freitas et al. (2011) observed a ratio of 6.13 for Saanen animals and 7.40 for ¾ Boer + ¼ Saanen animals. The muscle: bone ratio represents the proportion available for the carcass consumption and is, therefore, of significant economic importance.

There was no treatment influence in the *Longissimus dorsi* chemical composition (Table 5). Trials of kid goats showed chemical composition values similar to those previously observed, with a variation between 70.96 to 78.52% of water; 16.60 to 24.58% for crude protein; 1.42 to 7.2% of total fat and 0.97 to 1.67% for ashes (HASHIMOTO et al., 2007; MADRUGA et al., 2008; MADRUGA et al., 2009; FREITAS et al., 2011; SALLES et al., 2013;).

The fatty acids observed in the greatest amount in the fatty acids profiles were oleic (C18:1n9), palmitic (C16:0) and stearic (C18:0) (Table 5). This is consistent with the data observed in trials conducted by Madruga et al. (2008) and Grande et al. (2011) (22 and 30.55 kg, respectively) with Saanen kid goats fed with levels of concentrates and oilseeds, respectively.

In the fatty acid profiles of the meat, a square effect was observed for the contents of caprylic acid (C8: 0), octadecanoic acid (C 15:0) and palmitic acid (C16: 0). The maximum amounts were 2.65, 2.62 and 2.65 Mcal of ME/kg DM, and a negative linear effect was observed for arachidic acid (C20: 0) with protected fat addition to the diet.

Table 5. Chemical composition and fatty acid profile of the *Longissimus dorsi* of Saanen goat kids fed with various levels of protected fat added to the diet.

Parameters	Diets (Mcal of ME/kg DM)				Regressionequation;R^2	CV (%)
	2.5	2.6	2.7	2.8		
Water (g/100g)	74.79	75.05	75.33	74.70	$\hat{Y}$=74.96	1.67
Protein (g/100g)	22.00	21.28	21.25	21.45	$\hat{Y}$=21.50	4.39
Ashes (g/100g)	1.03	1.02	1.06	1.00	$\hat{Y}$=1.03	3.33
Total fat (g/100g)	2.19	2.10	2.18	2.48	$\hat{Y}$=2.23	32.42
Fatty acids (g/100g of total fatty acids)						
C6:0	6.54	5.94	4.06	7.55	$\hat{Y}$=6.03	46.78
C8:0	0.37	1.04	1.04	0.42	$Y=-224.309+169.966X-32.037X^2$; 1.00	54.91
C10:0	0.01	0.01	0.01	0.01	$\hat{Y}$=0.01	62.10
C14:0	1.08	1.28	1.32	1.24	$\hat{Y}$=1.23	15.92
C15:0	0.38	0.45	0.43	0.27	$Y=-38.50+29.74X-5.67X^2$; 1.00	14.07
C16:0	15.97	18.41	17.65	16.32	$Y=-643.830+499.410X-94.175X^2$; 0.93	10.53
C17:0	2.23	2.81	2.42	3.22	$\hat{Y}$=2.67	47.59
C18:0	15.50	17.34	15.66	14.91	$\hat{Y}$=15.85	10.26
C20:0	0.04	0.02	0.02	0.02	Y=0.263-0.089X; 0.80	58.47
C14:1	0.02	0.02	0.02	0.01	$\hat{Y}$=0.02	31.31
C18:1n9	49.08	41.06	46.25	44.80	$\hat{Y}$=45.30	8.25
C22:1n9	0.14	0.14	0.15	0.05	$\hat{Y}$=0.12	72.14
C18:2n6	5.28	7.45	7.56	7.71	Y=-12.582+7.389X; 0.67	16.58
C18:3n3	0.12	0.15	0.16	0.26	Y=-0.966+0.431X; 0.85	35.46
C18:3n6	0.04	0.02	0.07	0.03	$\hat{Y}$=0.04	44.82
C20-4n-6	2.50	3.15	2.31	2.15	$\hat{Y}$=2.53	31.18
Others	0.70	0.71	0.87	1.03	$\hat{Y}$=0.83	-
SFA	42.62	47.72	43.24	44.63	$\hat{Y}$=44.55	7.59
MFA	49.30	41.27	46.43	44.93	$\hat{Y}$=45,48	8.22
PFA	8.07	11.00	10.33	10.43	$\hat{Y}$=9.96	19.12
PFA/SFA	0.19	0.23	0.24	0.23	$\hat{Y}$=0.22	21.42
Omega 3 (n3)	0.18	0.26	0.29	0.38	Y=-1.426+0.643X; 0.96	34.69
Omega 6 (n6)	7.87	10.69	9.98	9.96	$\hat{Y}$=9.63	19.05
n6 : n3	46.59	42.13	41.24	27.47	Y=193.756-58.263X;0.83	22.41

SFA = saturated fatty acids; MFA = monounsaturated fatty acids; PFA =polyunsaturated fatty acids

The content reduction of some saturated fatty acids (C8:0, C15:0, C16:0 and C20:0) associated with the high content of oleic acid (C18:1n9) in the *Longissimus dorsi* of goats, can provide a healthier meat for human consumption. This is because saturated fatty acids, such as palmitic acid (C16:0), are responsible for the increase in blood cholesterol levels in humans (RHEE et al., 2000), while oleic acid(C18:1n9) has the opposite effect (RHEE, 1992).

Even though stearic (C18:0) fatty acid is a significant component of the total, it does not have harmful effects on human consumption. According to Bressan et al. (2004), stearic acid is quickly converted into oleic acid by the organism after its intake and does not influence the overall blood cholesterol levels.

The fat addition favored the concentration increases of polyunsaturated fatty acids linoleic (C18:2n6) and linolenic acid (C18:3n3). The increase of these fatty acids is desirable because they are not synthesized by animals and are, therefore, considered essential (Costa et al., 2009). They are responsible for the inflammatory (C18:2n6) and anti-inflammatory (C18:3n3) responses of the immune system (GARÓFOLO; PETRILLI, 2006). Therefore, it is important to keep an appropriate balance between these fatty acids.

The increase in linoleic and linolenic acids shows the efficiency of the polyunsaturated fatty acid transfer from the protected fat to the meat. The protected fat (Lactoplus®) is formed based on soya oil, which according to TACO (2006) has a significant content (60%) of polyunsaturated fatty acids, with linoleic as the main fatty acid.

Hashimoto et al. (2007), assessed Boer x Saanen goats kid terminated on feedlots (32.82 kg), that were fed with rations with added soybean shelf in substitution of the corn in the diets. They observed an increase in the amount of linoleic acid (3.16, 8.11 and 12.78% of linoleic acid for the control diets and 50 and 100% for the soybean shelf, respectively).

The PFA:SFA did not change between the treatments and presented an average value of 0.22 g/g, which is lower than previous results (WOOD et al., 2003), that recommending values higher than 0.4 g/g as the ideal to prevent diseases associated with fatty food consumption.

The fatty acid content in the muscles resulting from omega-3 showed a positive linear effect with the addition of protected fat. For this reason, a negative linear effect was observed for the ratio of omega-6:omega-3, with a reduction of 9.57, 11.48 and 41.03% in this ratio when 2.6, 2.7 and 2.8 Mcal of ME/kg DM were added, respectively, compared with the control diet. Although the omega-6: omega-

3 ratios were reduced, they were still higher than those obtained by Grande et al. (2009). They observed omega-6:omega-3 ratios of 10.02, 6.73, 10.85 and 5.52 in the *Longissimus dorsi* of ¾ Boer + ¼ Saanen kid goats fed control diets and diets with grain flaxseed, sunflower seeds and canola, respectively.

According to Emken et al. (1994), the omega-6 and omega-3 fatty acids, compete for the same enzymes during reactions of desaturation and elongation of the carbon chain, influencing the final product of these fatty acids. Although these enzymes have a greater affinity for omega-3, the conversion of alpha-linolenic acid (omega-3) in eicosapentaenoic acid (EPA) and docosahexaenoic (DHA) is strongly influenced by the levels of linoleic acid (omega-6) in diet. Therefore, a higher intake of fatty acids omega-6 affects the metabolic processes of omega-3, reducing its biological role.

CONCLUSIONS

Protected fat can be used in the feeding of Saanen goats kid as an alternative to an increase in the energetic density of the diets up to 2.8 Mcal of ME/kg DM, without influencing the quantitative characteristics of the carcass. It presents improvements on the amount of omega-3, the ratio of omega-6: omega-3 of the *Logissimus dorsi* and the reduced age at slaughter.

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