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Carcass, Physical-Chemical Characteristics and Lipid Fraction of Goat Meat Affected by Genetic Crossbreed Saanen x Boer

Carcaça, Características Físico-Químicas e Fração Lipídica da Carne Caprina sob efeito do Grupo Genético Saanen x Boer

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Abstract

Goats contribute to sustainable livestock farming and food security, adaptable to varied agricultural environments. However, raising goats for better performance is essential for sustainable production, which requires a clear definition of objectives and selection criteria, taking into account the needs of goat farmers. The objective of this study was to evaluate the effect of breed on the qualitative and quantitative characteristics of the carcass, meat cuts and lipid profile of Saanen and Crossbreed kid goat (Boer x Saanen). Cut weight and yield did not differ between genetic groups ($p > 0.05$). However, a higher external length value was determined for the Saanen group (42.44 ± 6.28 cm) ($p < 0.05$). Shear force was also influenced by genetic group, higher in Crossbred animals (2.20 ± 2.27 kgf/cm²) than in Saanen animals (1.57 ± 3.48 kgf/cm²) ($p < 0.05$). Regarding the lipid fraction, higher levels of saturated fatty acids (45.03 ± 0.14 g/100 g of lipids) and cholesterol (49.62 ± 0.23 mg/100 g, wet basis) were identified in Crossbred animals ($p < 0.05$). Furthermore, this group also had a higher content of ω3 fatty acids, which highlights the nutritional value of their meat due to the reduced ω6/ω3 ratio. Therefore, the adoption of both groups is a viable alternative for goat milk producers who wish to diversify their activities, as males can be used for meat production, as long as they are slaughtered in accordance with technical standards.

Keywords: Biometric Measurements. Color. Cholesterol. Fatty Acids. Texture

Resumo

As cabras contribuem para a pecuária sustentável e segurança alimentar, e são adaptáveis a ambientes agrícolas variados. No entanto, para produção sustentável de cabras é essencial aprimorar o desempenho, o que requer uma definição clara dos objetivos e dos critérios de seleção, em atenção às necessidades dos caprinocultores. O objetivo deste estudo foi avaliar o efeito da raça sobre as características qualitativas e quantitativas da carcaça, cortes cárneos e perfil lipídico de cabritos Saanen e Mestiços (Boer x Saanen). O peso e o rendimento dos cortes não diferiram entre os grupos genéticos ($p > 0,05$). No entanto, um maior valor de comprimento externo foi determinado para o grupo Saanen (42,44 ± 6,28 cm) ($p < 0,05$). A força de cisalhamento também foi influenciada pelo grupo genético, superior nos animais mestiços (2,20 ± 2,27 kgf/cm²) do que nos animais Saanen (1,57 ± 3,48 kgf/cm²) ($p < 0,05$). Em relação à fração lipídica, teores superiores de ácidos graxos saturados (45,03 ± 0,14 g/100 g de lipídios) e colesterol (49,62 ± 0,23 mg/100 g, base úmida) foram identificados nos animais mestiços ($p < 0,05$). Além disso, esse grupo também apresentou teor superior de ácidos graxos ω^3, o que destaca o valor nutricional de sua carne devido à reduzida relação ω^6/ω^3. Assim, a adoção de ambos os grupos é uma alternativa viável para produtores de leite caprino que desejam diversificar as atividades, visto que os machos podem ser destinados para a produção de carne, desde que sejam abatidos de acordo com as normas técnicas.

Palavras-chave: *Medições Biométricas. Cor. Colesterol. Ácidos Graxos Textura.*

1 Introduction

Brazilian goat breeding is an activity of economic and social relevance. The effective herd of goats in 2020 was equivalent to 12,101,298 animals, which was higher than in 2017 (about 8,252,706 animals). The Northeast region showed the greatest share, where the herd of Bahia can be highlighted with 3,645,234 animals (IBGE, 2022). This variation over the years may be due to different factors such as changes in managing practices, disease incidence, feed availability, breeding systems, and others (Tesema *et al.,* 2020).

The genetic trend plays an important role in the growth traits, the inclusion of other characteristics, such as the ones related to fitness and milk production, is necessary, which allows adjusting the breeding program to different farming settings (Rout *et al*., 2018). Morphological aspects, such as nose shape, body length, udder size, ear size, and body color, are the most selection traits used. Thus, the main objectives of the breeders include the production of animals with target morphological attributes along with improved meat and milk production (Ramzan *et al*., 2020).

The production of dairy animals using specialized breeds is predominant in the South and Southeast of Brazil, and more recently, the production of kid goat meat as well. Some matrices have been used for mating with Boer breeders in dairy herds, aiming at the production of kid goats with better weight gain and carcass yield for slaughter to diversify the

activities and sources of income in farms (Gomes *et al*., 2011). Moreover, there is an increasing interest in dairy goat production as these goat breeds present great performances in low-input production systems, showing acceptable growth and carcass attributes even when consuming low to moderate quality forages, characteristics of tropical conditions.

The Brazilian goat production is mainly developed by small family producers, which have scarce resources for analyses and selection (Fonseca *et al*., 2021). A mating policy that simultaneously allows low breeding, high genetic diversity, and maximum genetic progress must be designed (Hidalgo-Moreno *et al.*, 2020). According to Tesema and coauthors (2020), in terms of growth performance and efficiency, producing the first filial generation with Boer goats would be suitable for medium to high input production systems to exploit the expected benefits of crossbreeding.

Goat meat has been highlighted due to its nutritional properties. It contains high concentrations of protein and low levels of saturated fat and cholesterol, as well as low calories (Kessler *et al*., 2014). The lipid fraction of red meat is mostly composed of saturated fatty acids (SFA), while monounsaturated fatty acids (MUFAs) and polyunsaturated fatty acids (PUFAs) are found in minor concentrations. As reported by Lopes and coauthors (2014), exotic breeds, such as Boer, have been used in crossbreeding schemes to improve productivity and meat quality. Regardless of the breed, goat meat showed a fatty acid profile that is beneficial to health due to the high concentration of oleic acid, the presence of essential fatty acids, and low levels of lauric, myristic, and palmitic acids when compared to meats of other species.

The current research has focused on the production of meat with reduced contents of SFAs and increased levels of unsaturated fatty acids (UFAs) since this fatty acid profile has been linked to the prevention of metabolic and cardiovascular diseases (Lopes *et al*., 2012). The literature has described the potential of MUFAs to reduce the development of chronic inflammation and heart diseases (Nigam *et al*., 2014; Virtanen *et al*., 2014). Moreover, the recommended intake of ω^3 PUFAs must be at least 250 mg/day. Thus, red meats can be considered relevant sources of these compounds, particularly when considering the low intake of marine food (Fonteles *et al.,* 2018).

The qualitative characteristics of the carcass are directly related to the product quality. Therefore, evaluating them is a crucial step of the production process. Little is known about the effects of the animal breed on the goat meat quality attributes; however, these parameters may be fundamental to developing and optimizing goat meat production and processing systems. Therefore, this study evaluated the effects of breed and crossbreed on the qualitative and quantitative characteristics of the carcass, meat cuts, and lipid profile in whole male Saanen and Crossbred Boer x Saanen kid goats.

2 Material and Methods

The experiment was conducted at the Institute of Animal Science and the Department of Food Technology of the Federal Rural University of Rio de Janeiro. Eighteen whole male kid goats were used: nine Saanen and nine Boer x Saanen Crossbred (3/4 and 7/8 Boer). The animals, which were ten months old, were born in the same place and on the same season and year of birth. The suckling was performed individually in two daily meals until the kid goats completed two months of age. From the third week, they were fed with elephant grass ad libitum, Tifton hay, and a concentrate containing milled corn, soybean bran, and wheat bran. This feed was formulated to meet the nutritional requirements described by the National Research Council (NRC, 2007). The animals had fresh and clean water at their disposal and were housed in two collective bays covered with a slatted and elevated floor, according to the racial group combination.

When they were ten months of age, the animals were submitted to a pre-slaughter hydric diet for 16 hours. The live weight (LW) and post-fasting live weight (PFW) were measured. The slaughter occurred through stunning with a pneumatic pistol (cerebral concussion) followed by bleeding. Then, the warm carcass weight (WCW) was used to estimate the warm carcass yield (WCY). The carcasses were transferred to a cold chamber at 4°C, where they were kept for 24 hours. Cold carcass weight (CCW), cold carcass yield (CCY = CCW / PFW x 100), and percentage of loss by cooling (LC = (WCW-CCW) / WCW x 100) were determined.

The carcasses were divided longitudinally. Subsequently, the external carcass length (ECL), internal carcass length (ICL), lower leg length (LLL), higher leg length (HLL), thoracic perimeter (TP), and leg width (LW) were measured. They were divided into six anatomical regions (neck, shoulder, round, rack, loin, and leg) to obtain their commercial cuts and yield. The carcass compactness index (CCI) was calculated as described by Cezar and Sousa (2007). The loin eye area (LEA) was measured with a checkered grid (10 mm x 10 mm) between the 12th and 13th thoracic vertebrae, in the cross-section of the Longissimus dorsi muscle.

The Longissimus dorsi muscle was used for color and pH analyzes. The pH was measured in each steak using a digital pH meter (PH-MV-TEMP Meter-206, LUTRON) inserted longitudinally on the muscle fibers. The color was analyzed by the CIE L*a*b* colorimetric system, using a colorimeter (Hunter Lab, model Color Quets XE) (Bressan; Beraquet, 1998). Six observations were made per steak, with fifty-four observations per treatment.

The instrumental texture analysis regarding the shear force was performed on a steak of each animal on the Longissimus dorsi muscle, approximately 2.5 cm thick. The steaks were roasted in electric grill, achieving the minimal internal temperature of 72 ºC. The losses in weight by cooking were measured as described by the American Meat Science

Association (AMSA, 1995). Five cylinders of 1.25 cm in diameter per steak were removed parallel to the longitudinal direction of the muscle fibers. The shear force was determined using a texture analyzer (TA-HDi, Texture Technologies Corp./ Stable Micro Systems, UK) equipped with a Warner-Bratzler blade of 1 mm, calibrated with 5 kg of a traceable pattern. The speed of the blade was set at 200 mm/min and the distance of the blade to the platform was 25 mm (AMSA, 1995). The results were expressed in Kgf/cm^2.

Regarding the lipid fraction of goat meet, it was evaluated by its fatty acid composition and cholesterol content. For fatty acids analysis, lipids were extracted from the meat samples according to Bligh and Dyer (1959) and converted into methyl esters by transesterification with sodium methoxide (Zhu *et al*., 2011). The methyl esters analyzed using gas chromatographer (Shimadzu GC 2010, Tóquio, Japan) as described by Ferreira and coworkers (2017). The chromatographer was equipped with a split injector (1:50), fused silica CP-SIL 88 capillary columns (100 m x 0.25 mm i.d., 0.20 µm film thickness) (Chrompack, Middelburg, The Netherlands), and flame ionization detector. The chromatographic conditions were initial temperature of 100°C (5 minutes), then the temperature increased at a rate of 5 °C / minute up to 160ºC (0 minutes), then 8°C / minute up to 230°C (12 minutes). The injector and detector temperatures were stabilized at 250°C and 280°C, respectively. The injector and detector temperatures were stabilized at 250°C and 280°C, respectively. Hydrogen was the carrier gas (1 mL/min), and nitrogen was used as the make-up gas (30 mL/min). Identification of the chromatographic peaks of the samples was done by evaluating the retention times of FAME standards and quantification was performed by internal standardization, applying the undecanoic methyl ester as standard.

Cholesterol was extracted by direct saponification (Saldanha *et al*., 2006). The extracts were analyzed using a HPLC system (Waters, Milford, MA, EUA), equipped with photo-diode array/refractive index detectors. A CN Hyperchrome 250 mm × 4.3 mm × 5.0 µm (Phenomenex, Colorado, USA) analytical column was used. The chromatographic conditions were according to Ferreira *et al.* (2017). The mobile-phase was n-hexane: 2-propanol (97:3, v/v) at a flow rate of 1 mL/min. Quantification was done by external standardization with a concentration ranging from 0.1 to 2.0 mg/mL.

The results were expressed by the average, followed by the standard deviation. To compare the averages, variance analysis and Tukey test were carried out using the Software BioEstat (analyses of meat and carcass characteristics) and the Software Origin © 6.0 (analyses of cholesterol and fatty acids). All statistical analyses were performed using a significant level of 5%.

3 Results and Discussion

The genetic group did not influence ($p > 0.05$) most of the variable's animal measurements and carcass yield, presented in Table 1. However, the Saanen animals showed higher warm carcass yield (WCY = 46.02 ± 7.73%) and cold carcass yield (CCY = 44.81 ± 7.55%) than Crossbred animals (WCY = 42.44 ± 2.57%; CCY = 41.24 ± 2.50% ($p < 0.05$). Results in the same range were reported in previous studies that evaluated Boer crossbreds with Alpine, Saanen, and SRD animals: from 44.40 to 55.06% for WCY and from 38.86 to 48.16% for CCY (Cartaxo *et al*., 2014; Freitas *et al*., 2011).

The loss by cooling reflects the difference in weight, regarding the warm carcass weight and the weight after cooling. In the present study, the different groups did not present statistical differences for the loss by cooling (LC) ($p > 0.05$). For the Saanen animals, the LC was higher (2.63 ± 0.35%) than that reported by Possamai *et al.* (2015), with an average of 1.6% among the treatments. A similar trend was observed for the crossbred animals, where the LC had a value (2.81 ± 0.42%) above that found by Freitas *et al.* (2011) in animals ¾ Boer x Saanen (average of 1.23%). Variable values can be described for the loss by cooling, which is mainly influenced by factors such as the fat cover, body conditions, and loss of moisture by the carcass. Thus, these results may reflect the low percentage of fat cover obtained in the animals' carcasses.

Table 1 - Live weight, fasting live weight, warm carcass weight, cold carcass weight, warm carcass yield, cold carcass yield, and loss by cooling of whole male goats according to each genetic group

Variable	Treatment	
	Crossbred	**Saanen**
Live Weight (kg)	35.00 ± 4.37[a]	31.37 ± 5.37[a]
Fasting Live Weight (kg)	32.55 ± 4.32[a]	30.16 ± 3.80[a]
Warm Carcass Weight (kg)	14.91 ± 2.50[a]	14.26 ± 2.25[a]
Cold Carcass Weight (kg)	14.49 ± 2.45[a]	13.88 ± 2.18[a]
Warm Carcass Yield (%)	42.44 ± 2.57[b]	46.02 ± 7.73[a]
Cold Carcass Yield (%)	41.24 ± 2.50[b]	44.81 ± 7.55[a]
Loss by Colling (%)	2.81 ± 0.42[a]	2.63 ± 0.35[a]

Different letters in the same row indicate significant differences ($p < 0.05$).
Source: research data.

The weights and yields of commercial cuts did not differ ($p > 0.05$) between the treatments (Table 2). This can be explained by the great potential for weight gain of the Saanen animals that contributes to the high weight of the crossbred animals. The findings of this study were different from those previously reported by other researchers: 32.33% for leg yield and 9.62% for loin yield in ¾ Boer x Saanen animals (Freitas *et al.,* 2011), 28.28% for leg weight and 12.42% for loin weight in Boer x SRD animals (Cartaxo *et al*., 2014), and from 26.26 to 30.75% for leg yield, from 16.79 to 18.37% for shoulder yield, and from 9.26 to 10.40% for loin yield in Saanen animals (Grande *et al.,* 2011). Higher values were also reported in Saanen animals slaughtered with 28 kg for leg (29.41%), loin (9.96%), and shoulder yields (21.28%) (Possamai *et al.,* 2015). This variation may be due

to differences in the animals' diet and weight at the slaughter.

Table 2 - Weight and yield of commercial cuts (shoulder, leg, rack, round, loin, and neck) of whole male goats according to each genetic group

Variable	Treatment	
	Crossbred	Saanen
Shoulder weight (kg)	1.60 ± 0.29[a]	1.58 ± 0.29[a]
Leg weight (kg)	2.29 ± 0.34[a]	2.15 ± 0.31[a]
Rack weight (kg)	1.04 ± 0.26[a]	1.03 ± 0.30[a]
Round weight (kg)	0.92 ± 0.11[a]	0.87 ± 0.14[a]
Loin weight (kg)	0.64 ± 0.12[a]	0.69 ± 0.11[a]
Neck weight (kg)	1.55 ± 0.29[a]	1.46 ± 0.28[a]
Shoulder yield (%)	16.76 ± 1.35[a]	17.08 ± 1.01[a]
Leg yield (%)	23.63 ± 0.83[a]	23.36 ± 1.25[a]
Rack yield (%)	10.50 ± 1.02[a]	10.82 ± 1.93[a]
Round yield (%)	9.77 ± 1.34[a]	9.53 ± 1.38[a]
Loin yield (%)	6.34 ± 0.50[a]	6.26 ± 1.00 [a]
Neck yield (%)	10.78 ± 1.74[a]	10.57 ± 1.54[a]

Different letters in the same row indicate significant differences ($p < 0.05$).
Source: research data.

Regarding the biometric measurements, a higher value of external length was assessed for the Saanen group (42.44 ± 6.28 cm) ($p < 0.05$) (Table 3). In fact, these animals are longer compared to Boer animals, which have more compacts carcasses.

Table 3 - Loin eye area, external length, internal length, thoracic perimeter, lower leg length, higher leg length, leg width, and carcass compactness index of whole male goats according to each genetic group

Variable	Treatment	
	Crossbred	Saanen
Loin eye area (cm²)	15.33 ± 2.82[a]	16.66 ± 1.41[a]
External length (cm)	35.88 ± 4.16[a]	42.44 ± 6.28[b]
Internal length (cm)	62.22 ± 3.66[a]	63.77 ± 3.15[a]
Thoracic perimeter (cm)	63.55 ± 4.44[a]	61.88 ± 3.98[a]
Lower leg length (cm)	39.44 ± 2.35[a]	40.33 ± 2.06[a]
Higher leg length (cm)	53.22 ± 3.34[a]	53.77 ± 1.98[a]
Leg width (cm)	37.22 ± 2.16[a]	36.00 ± 2.95[a]
CCI (kg/cm)	0.23 ± 0.03[a]	0.22 ± 0.03[a]

Different letters in the same row indicate significant differences ($p < 0.05$).
Source: research data.

The other variables shown in Table 3 did not differ between the groups ($p > 0.05$). The value of the loin eye area found in crossbred animals (15.33 ± 2.82 cm²) was higher than the one obtained by Salles et al. (2013) (5.65 cm²) in 7/8 Boer x Saanen animals. For the Saanen group, the loin eye area (16.66 ± 1.41 cm²) was similar to those described in animals slaughtered with 30 kg (from 15.04 to 16.19 cm²) (Grande *et al.,* 2011), and higher than the results reported in Saanen animals slaughtered with 28 kg (from 7.09 to 8.49 cm²) (Possamai *et al.,* 2015).

Other factors could influence carcass and meat quality in small ruminant production. The performance and meat quality traits of ewe lambs were similar in the evaluated finishing systems. However, ewe lambs in finishing systems with the presence of their mothers showed carcasses with greater weight and yield, which can increase the production system profitability.

The carcass compactness index (CCI) did not present significant differences ($p > 0.05$) between the genetic groups (0.23 ± 0.03 and 0.22 ± 0.03 kg/cm for Crossbred and Saanen animals, respectively) (Table 3), being similar to those determined in Boer x SRD animals (0.23 kg/cm) (FERREIRA *et al*., 2015). Moreover, other authors showing the following values also determined the CCI: 0.18 kg/cm in 7/8 Boer x Saanen animals Salles et al. (2013) and from 0.22 to 0.24 kg/cm in Saanen animals (Possamai *et al.,* 2015).

To physical-chemical characteristics of goat meat in crossbreeding schemes, the pH values did not change between the genetic groups ($p > 0.05$), varying from 6.14 ± 0.35 (Saanen) to 6.17 ± 0.34 (Crossbred). In a study carried out with Angora, Creole, and Anglo-Nubian crossbred, the final pH of the meat varied from 6.10 to 6.30. Besides, the authors also reported no alterations in water retention capacity, greater muscle pigmentation, and lower shear force (Lemes *et al*., 2013). The high pH of goat meat compared to red meat from other animals may be an inherent characteristic of the species, which is caused by increased stress during the pre-slaughter period or errors occurred during the slaughter procedures.

Table 4 - Values of pH, luminosity (L*), red intensity (a*), yellow intensity (b*), cooking loss, and shear force of whole male goats according to each genetic group

Variable	Treatment	
	Crossbred	Saanen
pH	6.17 ± 0.34[a]	6.14 ± 0.35[a]
L*	39.02 ± 3.25[a]	38.82 ± 3.37[a]
a*	12.74 ± 1.53[a]	12.87 ± 1.21[a]
b*	11.52 ± 1.69[a]	11.53 ± 1.29[a]
Cooking loss (%)	48.11 ± 12.08[a]	42.42 ± 8.54[a]
Shear force (kgf/cm²)	2.20 ± 2.27[a]	1.57 ± 3.48[b]

Different letters in the same row indicate significant differences ($p < 0.05$).
Source: research data.

Regarding the color, significant differences were not observed for luminosity (L*), red intensity (a*), and yellow intensity (b*) factors either (Table 4), with values ranging from 38.82 ± 3.37 (Saanen) to 39.02 ± 3.25 (Crossbred), from 12.74 ± 1.53 (Crossbred) to 12.87 ± 1.21 (Saanen), and from 11.52 ± 1.69 (Crossbred) to 11.53 ± 1.29 (Saanen) for L*, a*, and b*, respectively.

Yalcintan, Ekiz and Mustafa (2018) obtained a similar average of a* (13.27), while lower values of b* (5.81) and L* (46.21) were assessed in Saanen kid goats slaughtered at approximately 3 months of age. In crossbred F1 Boer x SRD animals, lower values than those found in this study for a*, b*, and L* (9.34, 7.21, and 24.85, respectively) were reported (Lopes *et al.,* 2014). Abhijith *et al.* (2021) evaluated Boer goats of two age groups (two years and six to nine months) and showed the influence of age on the final pH and retail color stability, where better stability was observed in young goats (33.50, 15.20, and 13.60 for L*, a*, and b* values,

respectively).

For the cooking loss, values of 48.11 ± 12.08 and 42.42 ± 8.54% were determined in Crossbred and Saanen animals, respectively ($p > 0.05$) (Table 4), which were higher when compared to those described for both Saanen (22.91%) and 7/8 Boer x Saanen crossbred (21.18%) (Salles *et al.,* 2013). Abhijith et al. (2021) observed 29.50% of cooking loss in Boer goat meat, with six to nine months of age.

The shear force (Table 4) was significantly higher in Crossbred (2.20 ± 2.27 kgf/cm²) than in Saanen animals (1.57 ± 3.48 kgf/cm²) ($p < 0.05$). Taking into account that meat with acceptable tenderness can be defined as that with a shear force lower than 4.5 kgf/cm², both genetic groups presented meat with high tenderness. The tenderness was greater than that described for both 7/8 Boer x Saanen (4.86 kgf/cm²) and Saanen (4.70 kgf/cm²) animals (Salles *et al*., 2013).

In the present study, the lipid fraction of the goat meat was characterized considering the fatty acid composition and cholesterol content. Thirty-one fatty acids were identified in the goat meat (Table 5).

Table 5 - Fatty acid composition (g/100 g lipids) of the meat of whole male goats according to each genetic group

Fatty Acids	**Treatment**	
	Crossbred	**Saanen**
Butyric acid (C4:0)	0.15 ± 0.03[a]	---
Caproic acid (C6:0)	8.61 ± 0.30[a]	0.05 ± 0.00[b]
Caprylic acid (C8:0)	0.04 ± 0.00[b]	0.09 ± 0.00[a]
Capric acid (C10:0)	0.68 ± 0.16[a]	0.50 ± 0.00[b]
Lauric acid (C12:0)	0.26 ± 0.07[a]	0.17 ± 0.00[b]
Myristic acid (C14:0)	1.19 ± 0.04[b]	1.36 ± 0.06[a]
Pentadecanoic acid (C15:0)	0.48 ± 0.03[a]	0.43 ± 0.01[a]
Palmitic acid (C16:0)	18.75 ± 3.15[a]	18.34 ± 0.04[a]
Margaric acid (C17:0)	0.54 ± 0.36[b]	0.89 ± 0.00[a]
Stearic acid (C18:0)	13.17 ± 3.36[b]	17.56 ± 0.16[a]
Arachidonic acid (C20:0)	0.33 ± 0.02[a]	0.15 ± 0.00[b]
Heneicosanoic acid (C21:0)	0.25 ± 0.08[a]	0.02 ± 0.00[b]
Behenic acid (C22:0)	---	0.18 ± 0.00[a]
Tricosanoic acid (C23:0)	0.58 ± 0.17[a]	0.08 ± 0.01[b]
ΣSFA	**45.03 ± 0.14[a]**	**39.82 ± 0.02[b]**
Myristolic acid (C14:1cis)	0.03 ± 0.00[a]	0.05 ± 0.00[b]
Cis 10-pentadecanoic acid (C15:1)	0.04 ± 0.02[a]	---
Palmitoleic acid (C16:1cis)	1.04 ± 0.27[b]	1.26 ± 0.02[a]
Heptadecanoic acid (C17:1)	0.34 ± 0.07[b]	0.62 ± 0.00[a]
Oleic acid (C18:1cis ω^9)	34.54 ± 1.64[b]	38.03 ± 1.40[a]
Gadoleic acid (C20:1 ω^9)	0.13 ± 0.04[a]	---
Erucic acid (C22:1 ω^9)	---	0.03 ± 0.00[a]
Nervonic acid (C24:1 ω^9)	1.47 ± 0.05[a]	0.35 ± 0.01[b]
Σ MUFAs	**37.59 ± 0.30[b]**	**40.34 ± 0.24[a]**
Linoleic acid (C18:2 ω^6cis)	5.33 ± 0.03 [b]	7.46 ± 0.57[a]
Linolenic acid (C18:2 trans ω^6)	---	0.01 ± 0.00[a]
¥-Linolenic acid (C18:3 ω^6)	---	0.07 ± 0.01[a]
α-linolenic acid (C18:3 ω^3)	2.36 ± 0.00[a]	---
¥-eicosatrienoic acid (C20:3 ω^6)	---	0.02 ± 0.00[a]
α-eicosatrienoic acid (C20:3 ω^3)	2.53 ± 0.22[b]	4.09 ± 0.87[a]
Arachidonic acid (C20:4 ω^6)	0.02 ± 0.00[b]	3.32 ± 0.19[a]
Eicosapentaenoic acid (EPA, C20:5 ω^3)	0.03 ± 0.00[a]	---
Docosahexaenoic acid (DHA, C22:6 ω^3)	2.10 ± 0.61[a]	0.13 ± 0.02[b]
Σ PUFAs	**12.37± 4.18[b]**	**15.35 ± 1.29[a]**
Σ*Trans*	**---**	**0.01 ± 0.01[a]**
$\Sigma\omega^3$	**7.02 ± 0.00[a]**	**4.48 ± 0.50[b]**
$\Sigma\omega^6$	**5.35 ± 0.01[b]**	**10.88 ± 0.80[a]**
ω^3/ω^6	**1.31[a]**	**0.41[b]**
ω^6/ω^3	**0.99[b]**	**2.44[a]**
PUFA/SFA	**0.27[a]**	**0.31[a]**

Different letters in the same row indicate significant differences ($p < 0.05$). ΣSFA (total saturated fatty acids); ΣMUFAs (total monounsaturated fatty acids); ΣPUFAs (total polyunsaturated fatty acids).
Source: research data.

The main fatty acids determined in both Crossbred and Saanen groups were oleic acid (C18:1 ω^9, 34.54 ± 1.64 and 38.03 ± 1.40 g/100 g lipids, respectively), followed by palmitic acid (C16:0, 18.75 ± 3.15 and 18.34 ± 0.04 g/100 g lipids, respectively) and stearic acid (C18:0, 13.17 ± 3.36 and 17.56 ± 0.16 g/100 g lipids, respectively). These fatty acid profiles are in agreement with the data reported by other authors regarding the composition of goat meat (Putra; Wattanachant; Wattanachant, 2017).

The sum fatty acid contents decreased as follows: SFAs (45.03 ± 0.14 and 39.82 ± 0.02 g/100 g lipids) > MUFAs (37.59 ± 0.30 and 40.34 ± 0.81 g/100 g lipids) > PUFAs (12.37 ± 4.18 to 15.35 ± 0.35 g/100 g lipids), for Crossbred and Saanen animals, respectively. Higher levels of SFAs were observed in Crossbred animals, while the Saanen animals showed higher contents of MUFAs due to the high concentration of oleic acid (C18:1 ω^9) (38.03 ± 1.40). In contrast to our results, similar values for MUFAs and PUFAs when determined in kid goat meat, where the levels ranged from 42.10 to 45.06 g/100 g lipids for SFA, from 32.25 to 38.24 g/100 g lipids for MUFAs, and from 18.80 to 25.65 g/100 g lipids for PUFAs, respectively (Ripoll *et al.,* 2012).

The main fatty acids regarding PUFAs for Crossbred animals were linoleic (C18:2 ω^6, 5.33 ± 0.03 g/100 g lipids), α-eicosatrienoic (C20:3 ω^3, 2.53 ± 0.22 g/100 g lipids), and α-linolenic acids (C18:3 ω^3, 2.36 ± 0.00 g/100 g lipids), respectively. However, this profile diverged from PUFAs in Saanen animals, where linoleic and α-eicosatrienoic acids were predominant, followed by arachidonic acid (C20:4 ω^6, 3.32 ± 0.19 g/100 g lipids). The PUFAs/SFAs ratio did not show significant variations between samples ($p > 0.05$), with values ranging from 0.27 and 0.31.

The sum of ω^3-fatty acids determined for the Crossbred group was 7.02 ± 0.00 g/100 g lipids, while Saanen animals presented 4.48 ± 0.50 g/100 g ($p < 0.05$). For the ω6-fatty acids, the highest level was found in meat from Saanen animals (10.88 ± 0.80 g/100 g lipids), which may be attributed to the higher concentration of linoleic and arachidonic acids. Thus, differences in the ω^3/ω^6 (1.31 for Crossbred and 0.41 for Saanen) and the ω^6/ω^3 (0.99 for Crossbred and 2.44 for Saanen) ratios were observed, with the highest ω^6/ω^3 ratio in Saanen animals. Kiani and Fallah (2015) reported a higher ω^6/ω^3 ratio for goat meat compared to the ones assessed in this study, which can be expected since the fatty acid composition is influenced by factors such as breed, feeding, and breeding system.

PUFAs have presented many health benefits; however, the high intake of ω^6-PUFAs has been associated with inflammatory processes and the occurrence of cardiovascular diseases (Saini RK; Keum, 2018). On the other hand, ω^3-fatty acids, such as eicosapentaenoic (EPA, C20:5 ω^3) and docosahexaenoic acids (DHA, C22:6 ω^3), are linked with reduced risks of various inflammatory, metabolic, and neurologic disorders. Thus, the nutritional value of the meat from Crossbred animals can be highlighted due to higher levels of ω^3-fatty acids and lower contents of ω^6-fatty acids (Djuricic; Calder, 2021).

Cholesterol levels differed significantly ($p < 0.05$), being higher in Crossbred animals (49.62 ± 0.23 mg/100 g, wet basis) than in the Saanen breed (45.39 ± 0.19 mg/100 g, wet basis) (Table 6).

Table 6 - Cholesterol content (mg/100 g, wet basis) of whole male goats according to each genetic group

Treatment	Cholesterol
Crossbred	49.62 ± 0.23[a]
Saanen	45.39 ± 0.19[b]

Different letters in the same column indicate significant differences ($p < 0.05$).
Source: Research Data.

The results were superior to those obtained in ¾ Boer x Saanen animals (from 36.39 to 39.52 mg/100 g) (Djuricic; Calder, 2021), and lower than the ones reported by Kessler et al. (2014) in Angora breed animals slaughtered between eight and twelve months of age (from 73.33 and 76.27 mg/100 g).

4 Conclusion

The use of Boer animals in crossbreeding may be a promising alternative for dairy production systems, where there is diversification of activities and the sale of kid goats for cutting. Moreover, it may provide meat with high levels of ω^3-fatty acids, which play a role in the maintenance of human health. The Saanen animals presented satisfactory yields and weights, reinforcing the possible use of culled males for meat production. However, further studies must be conducted to better understand the pathway of the goat meat supply chain in Brazil and ensure an adequate lipid profile from the nutritional point of view. In particular, strategies to elucidate the influence of genotype schemes on lipid stability and sensory analyses should be considered due to the relevance of these parameters in promoting goat meat quality in Brazil.

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