Effect of rearing system and slaughter weight on carcass traits and proportions of the meat cuts of crossbred kids

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Abstract

The objective was to evaluate the influence of the rearing system and slaughter weight on the carcass traits and meat cut proportions of 83 crossbred kids (½ Anglo Nubian × ½ Pardo Alpina), 41 intact males and 42 females distributed in an experimental design. A randomized design with a 2x2x3 factorial design and two sexes, two rearing systems (without milk and with milk), and three slaughter weights (20, 30 and 40 kg). The kids were artificially fed with natural goat milk, and from the 10th day of life, they began to receive the experimental diet (28.1% CP, 2.8% EE, 46.0% NDF, 25.5% ADF and 67.2% TDN) *ad libitum,* which contained 700 g.kg-1 mash concentrate and 300 g.kg-1 *Coast cross* hay. After slaughter, the carcasses were evaluated for hot (HCY) and cold (CCY) carcass yield, chilling loss, ribeye area, and degree of finish, and the left half of the carcass was separated into meat cuts: shoulder, neck, rib, loin and leg. The collected data were analyzed via SAS statistical software, version 9.4, via PROC GLM at the 5% significance level. Animals with milk had increases in HCY (48.7% vs. 47.5%) and CCY (47.7% vs. 46.5%). The slaughter weight of 40 kg presented HCY and CCY values of 49.6 and 48.6%, respectively, which were higher than those of the other weights. For the precociously developing cuts (shoulder and leg), the slaughter weight of 20 kg yielded better results than did 40 kg. However, it was lower than that of the late development cuts (neck and rib) compared to the slaughtered cuts at 40 kg. Compared with female kids, male kids presented a greater carcass yield (49.14 vs. 48.21%), followed by higher proportions of neck and shoulder cuts. Therefore, slaughtering up to 20 kg live weight is recommended because it increases the proportions of prime meat cuts.

Keywords: carcass quality; goat; meat cuts; rib eye area

Introduction

Goat husbandry being less input and less capital demanding is important source of livelihood for the marginal and landless farmers across the developing world (Mandal et al 2022). Milk production has been the main activity explored in goat farming, and in this system, male kids are usually discarded. Currently, small producers find it difficult to sell their products (artisanal milk) because of competition from industrialized milk producers, who sell their milk in packages with a prolonged shelf life and stand out commercially because of this practical approach (Souza et al., 2016), in addition to the dissemination of products to other regions. Recently modern approaches have been used for increase in productivity (Eloriaga et al 2024), but the quality of meat is still the most influencial factor for deciding the income to goat farmer (Besana & Paller, 2024).

However, in recent years, the increased consumption of goat meat has increased sales and encouraged producers to keep males for this production, as the price has become attractive, especially at the end-of-year or Easter festivities, because it is considered a "gourmet" meat. Thus, there are possibilities that male kids of dairy origin are destined for slaughter to provide additional income to the producer.

With this new opportunity, kids born in August/September during the natural breeding season need to be ready for slaughter in December at four months of age. Within this period, the animals need to develop to ensure adequate weight, yield and fat deposition in the carcass to meet consumer expectations, especially in terms of the proportion of their noblest cuts (ham, ham and loin), which are considered to be of greater commercial value (Silva et al., 2014).

However, the feeding of these animals can make the production system more expensive, and it is necessary to adopt a new rearing system where the excess milk from the properties during the period from September to December can be used to feed the kids until slaughter. Thus, in addition to increasing the profitability of farming, the use of surplus milk in the feed of these animals can reduce expenses.

Thus, several questions arise related to the adoption of this system, such as the following: does the supply of milk until slaughter influence the development and carcass characteristics of kids? Can commercial kid goat carcass cuts be influenced by milk supply until slaughter? In this sense, the objective of this study was to evaluate the effects of the rearing system and slaughter weight on the carcass characteristics and proportions of the meat cuts of crossbred kids.

Materials and methods

The experiment was conducted in Botucatu, São Paulo State, at the experimental area of goats with the following geographical coordinates: 22°52' south latitude and 48°26' west longitude, situated at 800 m altitude, after approval by the Committee on Ethics in the Use of Animals, according to Protocol No. 140/2016. For this study, 83 crossbred newborn kids, 41 intact males and 42 females from mating involving the Anglo Nubian and Pardo Alpina breeds, were used.

After birth and receiving initial care, colostrum was artificially supplied for two days. The animals were then fed artificially with natural goat milk, which was divided into two daily supplies, at 8:00 am and 4:00 pm, with 750 mL/meal administered in individual bottles, until they were thirty days old. After this period, the amount of milk offered to each animal was 1.5 liters/day in a single offering in the afternoon, and a collective bucket was used. Newborn kids were randomly selected to compose pens into which the treatments would be distributed (pen/treatment). These pens were collective, covered, slatted and suspended, with a partition for the separation of males and females.

At 60 days of age, 21 males and 19 females stopped receiving milk, composing the "No milk" treatment, and 43 kids continued to be suckled until slaughter, composing the "With milk" rearing system (20 males and 23 females). In both systems, a sample of animals was slaughtered at 20, 30 and 40 kg.

From the 10th day of life, the animals began to receive the experimental diet *ad libitum* containing 700 g/kg mash concentrate and 300 g/kg *Coast cross* hay, which was supplied naturally at the beginning of the morning and at the end of the day. afternoon to allow for leftovers of approximately 10% of the amount supplied.

The concentrate composition was 343 g/kg corn, 266 g/kg soybean meal, 70 g/kg cottonseed meal, 14 g/kg limestone, 7 g/kg mineral salt, 0.49 g/kg calcium chloride and 0.35 g/kg Rumensin® 100 Premix, which was based on dry matter and formulated according to the recommendations of the NRC (2007), to meet the nutritional requirements of male and female kids of dairy breeds growing with a gain of 150 g/day (Table 1).

Samples of each ingredient were collected, dried at 55°C in a forced ventilation oven for 72 hours, and then processed in a Willye-type knife mill (TE-650, Tecnal) through a stainless steel sieve with a diameter of 1 mm and packed in containers for the analysis of dry matter (DM) according to the methods of AOAC 934.01 (AOAC, 2012a), mineral matter (MM) according to the methods of AOAC 942.05 (AOAC, 2012b), crude protein (CP) according to the methods of AOAC 954.01 (AOAC, 2012c) and ether extract (EE) according to the methods of AOAC 920.39 (AOAC, 2012d), and insoluble neutral detergent fiber (NDF) and insoluble acid

Table 1. Average daily intake of nutrients (g/day) of the experimental diet as a function of slaughter weight and rearing system

Slaughter Weight(kg)	System recreates	Nutrient intake (g/day) [1]							
		DM	MM	EE	CP	NDF	FDA	Total carbohydrates	CNF
Witness		233	17	6	49	93	47	161	67
20	With milk	253	18	10	52	106	54	173	67
	No milk	283	21	11	59	113	58	191	78
30	With milk	428	32	16	89	170	87	290	120
	No milk	627	46	25	129	254	130	427	173
40	With milk	563	42	22	118	229	115	382	153
	No milk	946	70	37	195	382	196	644	262

[1] DM: Dry matter, MM: Mineral matter, EE: Ether extract, CP: Crude protein; NDF: Fiber insoluble in neutral detergent, FDA: Fiber insoluble in acid detergent; CNF: non fibrous carbohydrates.

Table 2. Chemical composition of goat milk as a function of lactation period

Constituents[1]	Lactation			Mean
	Beginning	Middle	End	
Protein (g/kg)	35.5	35.9	31.1	34.2
Total solids (g/kg)	127.7	128.7	109.7	122.0
Fat (g/kg)	39.4	39.8	26.3	35.2
Lactose (g/kg)	43.9	44.1	43.1	43.7
Defatted dry extract (mg/dL)	88.3	88.9	83.4	86.9
Log Somatic cell count (cell/mL)	3.2	3.3	2.6	3.1

detergent fiber (ADF) according to the methods described by Van Soest et al. (1991) and modified by Berchielli et al. (2001), using a fiber determiner (M-444/CI – MARCONI). The total digestible nutrient (TDN) content was estimated according to Patterson et al. (2000): TDN= [88.9 - (0.779 × ADF)], characterizing the final diet composition as follows: 892.2 g/kg DM, 63 g/kg BM, 28.2 g/kg EE, 2811.1 g/kg CP, 460.1 g/kg NDF, 254.9 g/kg ADF, 205.2 g/kg hemicellulose, 606.7 g/kg total carbohydrates, 146.5 g/kg carbohydrate non fibrous, and 671.7 g/kg TDN.

Three milk collections were performed corresponding to the beginning, peak and end of the lactation period. Each individual sample was proportional to the milk produced from the morning and afternoon milkings, conditioned with the preservative bronopol (2-bromo-2-nitropropane-1,3-diol) and sent to the determination of fat, protein, lactose, total solids, defatted dry extract and somatic cell count via Bentley® 2000 equipment (Table 2).

The weights of the kids were monitored weekly, and those that reached the preestablished weight at slaughter were sent to the slaughterhouse the following week. Age at slaughter was also evaluated, consisting of the time in days to reach slaughter weight. Before slaughter, the animals were subjected to a 16-hour solid fast and then weighed again to obtain the fasting weight (FW) before being sent to a commercial slaughterhouse for slaughter. After slaughter, the gastrointestinal tract (GIT - rumen/reticulum, omasum, abomasum, small and large intestines) was weighed fully and then emptied, washed and weighed again to determine the empty body weight (EBW), which was obtained by the difference between the fasting weight and gastrointestinal tract content to estimate the true carcass yield: CY (%) = [HCY/EBW]x100. The rumen-reticulum, omasum and abomasum were also weighed separately, and the individual proportions were calculated on the basis of the empty gastrointestinal tract. Immediately after evisceration, the carcasses were cleaned and weighed to determine the hot carcass weight (HCW). The hot carcass yield was calculated via the following formula: HCY (%) = [HCW/FW]x100. The carcasses were transferred to a cold storage chamber at 4°C for 24 hours, and then the cold carcass weights (CCW) were measured to obtain the following indices: cold carcass yield: CCY (%) = [CCW/FW]x100 and weight loss weight per chill: CW (%) = [HCW-CCW/HCW]x100.

The carcasses were longitudinally divided, and the left half was sectioned into five anatomical regions, which were weighed individually to determine their percentage in relation to the whole. The following anatomical regions were evaluated according to the methodology proposed by Yáñez et al. (2004): the leg, separated between the penultimate and last lumbar vertebrae; the loin, cut between the twelfth and thirteenth thoracic vertebrae to the penultimate lumbar vertebra; the ribs, between the last cervical and first thoracic vertebrae up to the second to last thoracic vertebra; the palette, cut in the axillary region of the muscles that unite the scapula and humerus in the ventral part of the thorax; and the neck, the region of the cut corresponding to the seven cervical vertebrae.

In the sirloin section, at the separation between the 12th and 13th ribs, the cross-sectional area of the *Musculus longissimus lumborum was obtained* on transparent plastic film with the aid of an overhead projector pen with a fine tip. ribeye (REA), using the ImageJ® computer program (National Institutes of Health, USA).

The experimental design was completely randomized. The traits were analyzed in a 2x2x3+1 factorial design, with two sexes (S), two rearing systems (SR), three slaughter weights (SW) and an additional treatment (control), via the following model:

$$Y_{ijkl} = \mu + S_i + SR_j + SW_k + SR * SW_{(jk)+1} + I + e_{ijkl}$$

wherein:

Y_{ijkl} = trait evaluated in the animal$l$ slaughtered with slaughter weight$k$, in the breeding system$j$ sex$i$;μ = constant inherent to the data; S_i = sex effect$i$, being$i$ = 1: male and 2: female; SR_j = effect of the rearing system$j$, being$j$ = 1: without milk and 2: with milk; SW_k = effect of slaughter weight$k$, being$k$ = 1: 20 kg, 2: 30 kg and 3: 40 kg;$SR * SW_{(jk)+1}$ = effect of interaction between SR and SW + Witness; I = other interactions between S, SR and SW;e_{ijkl} = experimental error referring to the observationY_{ijkl} ~N(0; σ^2_{and}).

For the analyses, the statistical software SAS version 9.4 TS Level 1M2 (SAS Institute, Cary, NC, USA) was used to apply the GLM procedure (analysis of variance). Comparisons between the rearing systems were performed via the F test, the Tukey test for slaughter weights and the Dunnett test to compare the control treatment with the other treatments. For all comparisons, a significance level of 0.05 was adopted.

Results

Animals fed without milk had a higher dietary intake, with approximately 12%, 46% and 68% higher DM intake in animals weighing 20, 30 and 40 kg, respectively. The same trend was observed for the consumption of crude protein. The composition of the milk had no great variation during the lactation curve, presenting protein levels above 30g/kg, the greatest variation presented was about the amount of total solids and fat, which reduced 5.7g/Kg and 4.2 g/Kg respectively.

The hot carcass yield (HCY), cold carcass yield (CCY) and true yield (CY) increased with increasing slaughter weight (Table 3). Presenting values of 20.32; 15.41 and 10.28 kg HCW for animals slaughtered weighing 40.30 and 20 kg; and 55.42, 53.59 and 53.52% true yield, respectively. Gender also influenced carcass weight and yield, with true yield 54.94% for males and 54.26% for females. Difference that did not appear in the REA or finishing degree. The ribeye area (REA) increased until the weight reached 30 kg (Table 3). There was no effect of the rearing system on age at slaughter, but it did affect the hot and cold carcass yield (Table 3), and the rearing system "With milk" presented higher values for these traits than did the "Without milk" system. The full gastrointestinal tract, empty gastrointestinal tract and gastrointestinal tract contents of kids slaughtered at 40 kg were greater than those of kids slaughtered at 20 and 30 kg (Table 4). The rearing system without milk had a greater full gastrointestinal tract than did the system with milk (Table 4).

Sex influenced only the characteristics of the full, empty and abomasal gastrointestinal tract, with females showing better results than males. Compared with the other treatments, the control treatment presented lower proportions of the rumen-reticulum and omasum but obtained a greater proportion of the abomasum.

In view of the results obtained, kids slaughtered to 20 kg have a smaller gastrointestinal tract, which may directly reflect higher carcass yields. The slaughter weight influenced the proportions of the rib, shoulder, neck and ham cuts. The proportion of prime cuts of shoulder and ham decreased as slaughter weight increased (Table 5). The number of neck and rib cuts (secondary cuts) increased with increasing slaughter weight (Table 5). The rearing system did not affect the proportion of meat cuts. However, sex influenced the proportion of loin, shoulder and neck cuts (Table 5). Males have greater proportions of the shoulder and neck related to the need for greater development in the forequarters, The neck may be more developed in noncastrated males, Females represented a greater proportion of the sirloin cut. The control treatment presented proportions of shoulder cuts and ham similar to those of the kids slaughtered at 20 and 30 kg, which were lower than those of the 40 kg group, confirming that they were cuts of early growth. Unlike the rib and neck cuts, which showed late growth, the test treatment resulted in lower proportions of these cuts than those slaughtered with higher weights (Table 6).

Thus, kids slaughtered to 20 kg have higher proportions of prime cuts, such as loins, shoulders and ham, with no influence of suckling.

Discussion

The hot carcass yield and cold carcass yield increased with increasing slaughter weight, this increase can be understood as a direct response to animal growth, in which kids with high slaughter weights have higher fasting weights and empty body weights, which may be reflected in higher hot carcass weights and cold carcass weights, corroborating the findings of Pereira Filho et al. (2008) and Souza et al. (2018).

Notably, the CCY remained at the same level was lower than the HCY because of the loss of water by evaporation that occurred in the muscle during cooling in the cold room as a result of the reduced amount of fat cover that protects the carcass from drying out (Lisboa et al., 2010; Gomes et al., 2011), and a lower degree of carcass finish can be observed in animals slaughtered at lower weights and, consequently, greater chilling losses. The ribeye area (REA) increased until the weight reached 30 kg (Table 3). These animals slaughtered at 188 days of age may have reached the physiological maturity phase, in which muscle mass reaches the maximum point and fat deposition begins in the carcass (Owens et al., 1993), considering that the REA is a representative measure of the amount and distribution of muscle mass (Hashimoto et al., 2007). Thus, animals slaughtered early have little muscle mass because they are still growing compared with animals slaughtered later (Pereira Filho et al., 2008; Menezes et al., 2009), a fact attributed to the lower REA values observed in animals with lower weights, regardless of the rearing system adopted.

There was no effect of the rearing system on age at slaughter, but it did affect the hot and cold carcass yield (Table 3), and the rearing system "With milk" presented higher values for these traits than did the "No milk" system. "Milk", which may be explained by the lower total weight of the full gastrointestinal tract present. Kids from the rearing system without milk retained a greater amount of solid feed after fasting due to the greater development of the rumen-reticulum and omasum (Table 4), in addition to the increase in the gastrointestinal tract, which represented 29.45% of the weight participation in goats. compared with the rearing system with only 27.65% milk, which was fast. This fact also explains the higher carcass yields of animals slaughtered at 60 days of age that constituted the control treatment (Table 3), with lower participation of the full gastrointestinal tract (3.99 kg), approximately 25% in relation to the fasting weight (15.82 kg), compared with the 20 and 30 treatments without milk and with milk, ranging from 27--30%. However, the true yield of these animals was similar to that of the 40% milk treatment group, which was due to the greater deposition of fat present in these animals after they reached physiological maturity, emphasizing that the adipose tissue is the last to be deposited in the animal carcass, after bone and muscle tissue.

On the basis of the results obtained in relation to the carcass characteristics, the kids slaughtered at weaning, weighing approximately 15 kg, presented similar carcass yields to those of the animals slaughtered at 40 kg. However, they experience high levels of chilling loss due to the lower fat cover in the carcass.

The full gastrointestinal tract, empty gastrointestinal tract and gastrointestinal tract contents of kids slaughtered at 40 kg were greater than those of kids slaughtered at 20 and 30 kg that's because according to Silva and Pires (2000), an increase in the gastrointestinal tract occurs with increasing weight and/or age at slaughter. weight, attributing the proportionality of these characteristics to weight and/or advanced age. However, there was no influence of slaughter weight on the rumen–reticulum, omasum or abomasum proportions.

The rearing system without milk had a greater full gastrointestinal tract than did the system with milk (Table 4) because of its greater content due to the increase in solid diet intake, which was justified by the withdrawal of the liquid diet (milk), promoting greater proportional development of the rumen-reticulum and omasum, favored by the settlement of the microbial population and the transition phase from preruminant to ruminant (Costa et al., 2003). Notably, kids fed a liquid diet for a long period of time can delay the development of the rumen and papillae, since the acceleration of rumen development is associated with the consumption of solid foods (Bittar et al., 2009).

On the other hand, the greater proportion of abomasum in kids from the dairy rearing system may be the result of greater stimulation of enzymatic digestion in this compartment, since it is the place where milk is digested (Souza et al., 2016). Thus, the supply of a liquid diet, in large amounts or *ad libitum*, accelerates the growth of the animal, delaying the ingestion of solid food and, consequently, the anatomical-physiological and metabolic changes in its digestive tract (Gouveia et al., 1996 apud). Costa et al., 2003). These results corroborate the results reported by Souza et al. (2016) when milk was used in a feeding system for kids.

Table 3. Adjusted means and standard errors of carcass traits of crossbred kids as a function of slaughter weight (SW), rearing system (SR) and sex

Features	Weight at slaughter			Rearing system		Sex		*P* -value			
	20 kg (n=28)	30 kg (n=27)	40 kg (n=28)	No milk (n=40)	With milk (n=43)	Female (n=49)	Male (n=50)	SW	SR	Sex	SW*SR
Slaughter age (d)	$111.6^{c} \pm 7.2$	$187.8^{b} \pm 7.4$	$261.3^{a} \pm 7.2$	192.9 ± 6.1	181.4 ± 5.8	$185.7^{a} \pm 4.6$	$156.1^{b} \pm 4.5$	<0.0001	0.1760	<0.0001	0.1869
EBW, kg	$19.2^{c} \pm 0.3$	$28.5^{b} \pm 0.$	$36.6^{a} \pm 0.3$	$27.7^{b} \pm 0.2$	$28.5^{a} \pm 0.2$	25.9 ± 0.2	26.4 ± 0.2	<0.0001	0.0099	0.1670	0.3052
HCW, kg	$10.3^{c} \pm 0.2$	$15.4^{b} \pm 0.2$	$20.3^{a} \pm 0.2$	15.2 ± 0.1	15.4 ± 0.1	$14.0^{b} \pm 0.1$	$14.6^{a} \pm 0.1$	<0.0001	0.2452	0.0090	0.3268
CCW, kg	$9.9^{c} \pm 0.2$	$15.1^{b} \pm 0.2$	$19.9^{a} \pm 0.2$	14.9 ± 0.1	15.1 ± 0.1	$13.8^{b} \pm 0.1$	$14.2^{a} \pm 0.1$	<0.0001	0.1947	0.0325	0.2682
HCY, %	$46.8^{b} \pm 0.3$	$47.8^{b} \pm 0.4$	$49.6^{a} \pm 0.3$	$47.5^{b} \pm 0.3$	$48.7^{a} \pm 0.3$	$48.2^{b} \pm 0.3$	$49.1^{a} \pm 0.3$	<0.0001	0.0084	0.0339	0.2975
CCY, %	$45.5^{c} \pm 0.3$	$47.0^{b} \pm 0.3$	$48.5^{a} \pm 0.3$	$46.4^{b} \pm 0.3$	$47.6^{a} \pm 0.3$	47.1 ± 0.3	47.7 ± 0.3	<0.0001	0.0076	0.1223	0.3103
CY, %	$53.5^{b} \pm 0.4$	$53.6^{ab} \pm 0.4$	$55.4^{a} \pm 0.4$	54.6 ± 0.3	54.0 ± 0.3	$54.2^{b} \pm 0.3$	$54.9^{a} \pm 0.3$	0.0013	0.2010	0.1350	0.1209
CW, %	$2.8^{a} \pm 0.2$	$1.7^{b} \pm 0.2$	$1.9^{b} \pm 0.2$	2.2 ± 0.1	2.1 ± 0.2	$2.2^{b} \pm 0.2$	$2.8^{a} \pm 0.2$	0.0013	0.3408	0.0152	0.2861
REA, cm²	$9.1^{b} \pm 0.3$	$12.3^{a} \pm 0.3$	$12.1^{a} \pm 0.3$	11.1 ± 0.2	11.2 ± 0.2	10.8 ± 0.2	10.5 ± 0.2	<0.0001	0.2584	0.1945	0.2571
Finishing degree	$3.1^{b} \pm 0.1$	$3.1^{b} \pm 0.1$	$3.5^{a} \pm 0.1$	3.3 ± 0.1	3.1 ± 0.1	3.1 ± 0.1	3.1 ± 0.1	0.0186	0.1712	0.2216	0.3452

[1]EBW: empty body weight, HCW: hot carcass weight, CCW: cold carcass weight, HCY: hot carcass yield, CCY: cold carcass yield, CY: true yield, CWR: chilling loss, REA: rib eye area. [a,b,c] Mean BP followed by the same superscript letter on the line do not differ from each other ($P \geq 0{,}05$) to the Tukey test.

Table 4. Adjusted means and standard errors of the characteristics of the gastrointestinal tract of crossbred kids as a function of slaughter weight (SW), rearing system (SR) and sex

Features[1]	Weight at slaughter			Rearing system		Sex		*P* -value			
	20 kg	30 kg	40 kg	No milk	With milk	Female	Male	SW	SR	Sex	SW*SR
FGT, kg	$6.4^{c} \pm 0.2$	$9.1^{b} \pm 0.3$	$11.7^{a} \pm 0.3$	$9.4^{a} \pm 0.2$	$8.7^{b} \pm 0.2$	$8.9^{a} \pm 0.2$	$7.7^{b} \pm 0.2$	<0.0001	0.0607	<0.0001	0.3168
EGT, kg	$3.6^{c} \pm 0.2$	$5.5^{b} \pm 0.2$	$7.3^{a} \pm 0.2$	$5.3^{b} \pm 0.2$	$5.7^{a} \pm 0.2$	$5.6^{a} \pm 0.1$	$4.5^{b} \pm 0.1$	<0.0001	0.0976	<0.0001	0.2364
CGT, kg	$2.8^{c} \pm 0.2$	$3.7^{b} \pm 0.2$	$4.3^{a} \pm 0.2$	$4.1^{a} \pm 0.1$	$3.1^{b} \pm 0.1$	3.3 ± 0.1	3.2 ± 0.1	<0.0001	<0.0001	0.3249	0.3462
RUM-RET, %	74.6 ± 0.6	74.5 ± 0.6	75.8 ± 0.5	$76.5^{a} \pm 0.4$	$73.3^{b} \pm 0.4$	73.7 ± 0.4	74.4 ± 0.4	0.1883	<0.0001	0.2392	0.2060
OMASUM, %	8.4 ± 0.3	8.8 ± 0.3	8.4 ± 0.3	$9.1^{a} \pm 0.3$	$7.9^{b} \pm 0.3$	7.9 ± 0.2	8.3 ± 0.2	0.2873	0.0038	0.2484	0.3492
ABOMASUM, %	17.0 ± 0.5	16.7 ± 0.5	15.8 ± 0.5	$14.3^{b} \pm 0.4$	$18.7^{a} \pm 0.4$	$18.8^{a} \pm 0.4$	$17.3^{b} \pm 0.4$	0.1820	<0.0001	0.0361	0.2564

[1]FGT: full gastrointestinal tract, EGT: empty gastrointestinal tract, CGT: gastrointestinal tract contents, RUM-RET: rumen-reticulum.[a,b,c] Mean BP followed by the same superscript letter on the line do not differ from each other ($P \geq 0{,}05$) to the Tuckey test. N for all traits is same as table 3

Table 5. Adjusted means and standard errors of the characteristics of the gastrointestinal tract of crossbred kids as a function of control *versus* factorial treatment

Features[1]	Test[2] (n=16)	No milk			With milk			Contrast *P* -value
		20 kg (n=13)	30 kg (n=13)	40 kg (n=14)	20 kg (n=15)	30 kg (n=14)	40 kg (n=14)	Test vs Fat
FGT, kg	$4.0^{a} \pm 0.3$	$6.0^{b} \pm 0.3$	$9.5^{b} \pm 0.3$	$12.0^{b} \pm 0.3$	$6.0^{b} \pm 0.3$	$8.7^{b} \pm 0.3$	$11.4^{b} \pm 0.3$	<0.0001
EGT, kg	$2.8^{a} \pm 0.2$	$3.6^{b} \pm 0.2$	$5.4^{b} \pm 0.2$	$6.9^{b} \pm 0.2$	$3.7^{b} \pm 0.2$	$5.5^{b} \pm 0.2$	$7.8^{b} \pm 0.2$	<0.0001
CGT, kg	$1.2^{a} \pm 0.2$	$3.1^{b} \pm 0.2$	$4.1^{b} \pm 0.2$	$5.0^{b} \pm 0.2$	$2.4^{b} \pm 0.2$	$3.2^{b} \pm 0.2$	$3.6^{b} \pm 0.2$	<0.0001
RUM-RET, %	$68.5^{a} \pm 0.7$	$75.6^{b} \pm 0.8$	$76.9^{b} \pm 0.8$	$77.2^{b} \pm 0.8$	$73.5^{b} \pm 0.7$	$72.1^{b} \pm 0.8$	$74.4^{b} \pm 0.8$	<0.0001
OMASUM, %	$5.9^{a} \pm 0.4$	$9.2^{b} \pm 0.5$	$9.1^{b} \pm 0.5$	$8.8^{b} \pm 0.5$	$7.7^{b} \pm 0.4$	$8.4^{b} \pm 0.5$	$7.8^{b} \pm 0.5$	<0.0001
ABOMASUM, %	$25.6^{a} \pm 0.6$	$15.2^{b} \pm 0.7$	$13.9^{b} \pm 0.7$	$14.0^{b} \pm 0.6$	$18.8^{b} \pm 0.7$	$19.55^{b} \pm 0.7$	$17.8^{b} \pm 0.7$	<0.0001

[1]FGT: full gastrointestinal tract, EGT: empty gastrointestinal tract, CGT: gastrointestinal tract contents, RUM-RET: rumen-reticulum.

[a,b] Means followed by the same letter of the control treatment superscript in the line do not differ from each other ($P \geq 0{,}05$) to the Dunnett test.

Table 6. Adjusted means and standard errors of the proportions of the meat cuts of the half-carcass of crossbred kids as a function of slaughter weight (SP), rearing system (SR) and sex

Features[1]	Weight at slaughter			Rearing system		Sex		*P* -value			
	20 kg (n=28)	30 kg (n=27)	40 kg (n=28)	No milk (n=40)	With milk (n=43)	Female (n=49)	Male (n=50)	SW	SR	Sex	SW*SR
Sirloin, %	11.5 ± 0.2	11.7 ± 0.2	11.8 ± 0.2	11.7 ± 0.2	11.7 ± 0.2	12.1[a] ± 0.1	11.4[b] ± 0.1	0.2671	0.2654	0.0024	0.2988
Rib, %	25.6[b] ± 0.3	27.0[a] ± 0.3	27.6[a] ± 0.3	26.6 ± 0.3	26.93± 0.3	26.5 ± 0.2	26.3 ± 0.2	0.0003	0.3363	0.2896	0.2111
Palette, %	22.9[a] ± 0.2	21.7[b] ± 0.2	21.0[b] ± 0.2	22.0 ± 0.2	21.7 ± 0.2	21.7[b] ± 0.2	22.3[a] ± 0.2	<0.0001	0.2166	0.0132	0.3532
Neck, %	7.9[b] ± 0.2	8.4[b] ± 0.2	9.4[a] ± 0.2	8.5 ± 0.2	8.6 ± 0.2	8.2[b] ± 0.2	8.7[a] ± 0.2	0.0001	0.3132	0.0243	0.1612
Ham, %	32.1[a] ± 0.3	31.1[ab] ± 0.3	30.2[b] ± 0.3	31.3 ± 0.2	31.1± 0.2	31.5 ± 0.2	31.2 ± 0.2	0.0004	0.3563	0.2877	0.2983

[a,b] Means followed by the same superscript letter on the line do not differ from each other ($P \geq 0,05$) to the Tukey test.

Table 7. Adjusted means and standard errors of the proportions of the meat cuts of the half-carcass of crossbred kids as a function of the control treatment *versus* the factorial treatment

Features[1]	Control (n=16)	No milk			With milk			Contrast *P* -value
		20 kg (n=13)	30 kg (n=13)	40 kg (n=14)	20 kg (n=15)	30 kg (n=14)	40 kg (n=14)	Test vs Fat
Sirloin, %	12.3[a] ± 0.2	11.7[b] ± 0.3	11.5[b] ± 0.3	11.8[b] ± 0.3	11.3[b] ± 0.3	11.8[b] ± 0.3	11.9[b] ± 0.3	0.0403
Rib, %	24.2[a] ± 0.4	25.5[a] ± 0.4	26.9[b] ± 0.4	27.2[b] ± 0.4	25.7[b] ± 0.4	27.1[b] ± 0.4	28.2[b] ± 0.4	<0.0001
Palette, %	22.9[a] ± 0.3	23.3[a] ± 0.3	21.6[b] ± 0.3	21.1[b] ± 0.3	22.5[a] ± 0.3	21.8[b] ± 0.3	21.0[b] ± 0.3	0.0045
Neck, %	8.0[a] ± 0.3	7.5[a] ± 0.3	8.6[a] ± 0.3	9.2[b] ± 0.3	8.3[a] ± 0.3	8.2[a] ± 0.3	9.6[b] ± 0.3	0.0216
Ham, %	32.6[a] ± 0.4	31.9[a] ± 0.4	31.3[a] ± 0.4	30.6[b] ± 0.4	32.2[a] ± 0.4	31.0[b] ± 0.4	30.3[b] ± 0.4	0.0027

[a,b] Means followed by the same letter of the control treatment superscript in the line do not differ from each other ($P \geq 0,05$) to the Dunnett test.

Compared with the other treatments, the control treatment presented lower proportions of the rumen-reticulum and omasum but obtained a greater proportion of the abomasum. These compartments are dependent on the type of diet supplied during the developmental phase of the child, as described above, and the abomasum is the most developed compartment in the animal after birth (Ribeiro, 1997). In view of the results obtained, kids slaughtered to 20 kg have a smaller gastrointestinal tract, which may directly reflect higher carcass yields.

The slaughter weight influenced the proportions of the rib, shoulder, neck and ham cuts. The proportion of prime cuts of shoulder and ham decreased as slaughter weight increased (Table 5), indicating earlier development than other cuts because they contain muscle groups responsible for locomotion and support of the animal (Zapata et al., 2001). Cunha et al., 2004). This result agrees with that of Colomer-Rocher et al. (1992), who evaluated slaughtered Saanen goats weighing 4.7--115 kg and reported that the shoulder and ham grew faster than the body did, whereas the ribs, loin and neck grew more slowly.

The number of neck and rib cuts (secondary cuts) increased with increasing slaughter weight (Table 6), which can be explained by the late development of these regions, which are sites of greater fat deposition and a lower proportion of muscle (Yáñes et al., 2004). Notably, as an animal matures, growth waves from the extremities of the body become progressive and continue toward the thorax and lumbar axis, which is in agreement with the concept of centripetal growth (Yáñes et al., 2006). Unlike the shoulder and ham cuts, they are not related to the displacement/locomotion of the animal.

The rearing system did not affect the proportion of meat cuts. However, sex influenced the proportion of loin, shoulder and neck cuts (Table 5), which was explained by the difference in the reproductive function of each one. Males have greater proportions of the shoulder and neck related to the need for greater development in the forequarters, since they develop more muscles, such as *M. splenius*, *M. longissimus capitis* and *M. atlantis,* to support the body at the time of mounting. The neck may be more developed in noncastrated males because it is considered a secondary sexual trait. Females represented a greater proportion of the sirloin cut because they have an anatomical advantage in the development of the hindquarter due to gestation and suckling and thus have characteristics of growth associated with parturition, which is necessary for the support of the fetus and the lactation system (Siqueira et al., 2001).

The control treatment presented proportions of shoulder cuts and ham similar to those of the kids slaughtered at 20 and 30 kg, which were lower than those of the 40 kg group, confirming that they were cuts of early growth. Unlike the rib and neck cuts, which showed late growth, the test treatment resulted in lower proportions of these cuts than those slaughtered with higher weights (Table 6), corroborating the findings of Cunha et al. (2004) and Menezes et al. (2009).

Conclusions

The rearing system of crossbred kids suckled until slaughter increases the carcass yield and does not affect the performance or proportions of prime cuts (shoulders and ham). The slaughter of kids weighing up to 20 kg is recommended if the objective is to increase the proportion of prime cuts, and if the goal is to increase the carcass yield, kids are slaughtered at weaning or at 40 kg. Additionally, when there is excess milk on a farm, this may be a good option for enabling the use of males in the herd.

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