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Prediction of carcass tissue composition of goat kids of different breeds through meat cuts

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Resumo. An experiment was carried out with the carcasses of 78 male and female goat kids of five breed groups (Alpine; ½ Boer + ½ Alpine; ½ Anglo Nubian + ½ Alpine; ¾ Boer + ¼ Alpine; and ¼ Boer + ¼ Alpine + ½ Anglo Nubian), which were divided into two finishing systems (FS1, kid + dam on pasture; and FS2, weaned kid confined from 60 days of age onwards) and slaughtered at an average age of 120 days. The carcasses were cut in half and the left half was divided into the cuts of shoulder, leg, rib, loin and neck, which were dissected and separated into muscle, bone, fat and other tissues. Breed group, sex and finishing system influenced the yields of fat and bone in the carcass. Muscle yield was influenced only by the finishing system, whereas the yield of other tissues was influenced by sex. Crossing with the Boer breed influenced carcass tissue deposition, with the ½ Boer crossbred carcass exhibiting the highest degree of fatness. Females had a higher proportion of fat and a lower proportion of bones than males. Carcass muscle, fat and bone correlated significantly with all cuts. Rib and leg were the cuts that best represent the tissue composition of goat kid carcasses, based on the correlation coefficient and prediction equations.
Keywords: bone, crossbreeding, fat, muscle, prediction equations

Introduction

With the growing importance of goat meat for the Brazilian consumer market, additional and more comprehensive information on carcass yield and quality is required to support the domestic goat meat industry. Given the interest in exploiting this meat, research is necessary to improve the efficiency of the system and the quality of the product offered.

The percentage compositions of cuts and tissues are some of the factors that directly impact carcass quality. The cut composition is based on the dismemberment of the carcass into smaller pieces, which allows for better marketing, whereas the tissue composition is based on the amounts of muscle, fats and bone tissues in the carcass.

From an economic standpoint, determining the tissue composition can contribute to more accurately defining the most appropriate slaughter weight for each genetic group, since this would provide carcasses with a high proportion of muscle and adequate fat distribution, maximizing the value of the product.

Measurements of bone, muscle and fat can be taken on parts of the dissected carcass rather than on the entire carcass, thereby reducing time, costs and waste. However, different cuts are used to predict the tissue composition across different regions and countries, which leads to a lack of uniformity and difficulties in carcass tissue prediction.

On this basis, the present study was developed to examine the relationships between carcass constituents (muscle, bone, fat and other tissues) and cuts (neck, shoulder, leg, rib and loin) to determine the cut that best represents the carcass tissue composition; evaluate the effect of breed group, sex and finishing system on tissue composition of the carcass parts and on the whole; and establish prediction equations from the tissue composition of the parts to estimate the carcass composition.

Materials and Methods

The experiment was carried out in Botucatu - SP, Brazil (22°53'09 '' S and 48°26'42'' W, 840 m above sea level), after approval by the Ethics Committee on Animal Use (approval no. 69/2006). According to the Köppen climate classification, the region has a Cwa climate type, characterized as mild, with an average temperature of 22 °C. Seventy-eight goat kids of both sexes, of five breed groups [Alpine (A); ½ Boer + ½ Alpine (½ BA); ½ Anglo Nubian + ½ Alpine (½ AA); ¾ Boer + ¼ Alpine (¾ BA); and ½ Anglo Nubian + ¼ Boer + ¼ Alpine ("three-cross" - TC)] were distributed into two finishing systems (Table 1).

After birth, the kids remained with their mothers in the pen, where they had access to hay and concentrate, while the mothers had free access to pastures. From 60 days of age, the kids were distributed into two finishing systems: FS1, kid + dam on pasture; and FS2, confined weaned kid.

The 39 goat kids in finishing system 1 (FS1) were kept on pasture, together with their mothers, from 09h00 to 17h00. After the grazing period, they were gathered in collective pens with access to water and mineral salt. A rotational grazing system was used in 10 paddocks of approximately 550 m2 established with Panicum maximum cv. Tanzania. The occupation period of each paddock was three days, with a free-access rest area equipped with artificial shade provided by a shade cloth (75% mesh).

After weaning, the 39 animals in finishing system 2 (FS2) were distributed into five collective pens with a feeder and a drinker, where they received a complete diet (Table 2) available ad libitum, allowing approximately 20% orts.

The kids received two meals a day: the first at 08h00 and the second at 16h00. Total dry matter intake was determined by measuring the feed and orts daily, and the analyses of the complete diet and forage were performed according to Silva & Queiroz (2006), in Pirassununga - SP, Brazil (Table 3).

The kids were slaughtered the following week after completing 120 days of life. The animals were slaughtered after being deprived of solid feed for 16 h, at an average age of 128.4±7.9 days and average live weight of 23.14 kg, following the normal flow of a commercial slaughterhouse. The carcass was obtained after separating the head, offal and feet at the carpometacarpal and tarsometatarsal joint. Then, the carcasses were kept in a cold chamber with forced ventilation for 24 h, at a temperature of 5 °C, and subsequently weighed to determine the cold carcass weight.

Next, the carcasses were sectioned lengthwise and the left half-carcass was weighed and divided into five cuts, namely, leg, loin, ribs, shoulder and neck, which were later weighed. These were extracted according to the method proposed by Yáñes (2002). The cuts were sectioned in the following regions: leg - separated between the penultimate and last lumbar vertebrae; loin - between the first lumbar and the penultimate vertebrae, with the abdominal wall (flank); ribs - between the last cervical and first thoracic vertebrae to the last thoracic vertebra; shoulder - corresponding to the region of the scapula, humerus, radius, ulna and carpus; and neck - region corresponding to the seven cervical vertebrae. The cuts were identified and weighed (adapted from Pereira Filho, 2003).

After weighing the cuts, their proportions were calculated relative to the left half-carcass.

The cuts were frozen at -20 °C to be subsequently thawed for 24 h in the refrigerator and dissected into muscle, bone and adipose tissue, the latter of which was subdivided into intermuscular and subcutaneous fat and other tissues (connective tissue, lymph nodes, nerves, blood vessels and tendons). At the end of the dissection, the half-carcass weight was restored and the amounts of bone, muscle, fat and other tissues in the half-carcass were used to determine tissue yield. Muscle, fat and bone weights were expressed in absolute weight and the yields of each tissue were calculated for the cuts and for the carcass.

The correlation between cut components and carcass components was estimated by the formula below:

$$r_{xy} = \frac{\sigma_{xy}}{\sqrt{\sigma_x^2 \sigma_y^2}},$$

where rxy = correlation between component in the cut and in the carcass; σxy = covariance between the component in the cut and in the carcass, estimated as the sum of the product of the residue between x and y of analysis of variance of Model I; σ2x = variance of the component of the cut, estimated as the sum of the square residue of analysis of variance of Model I; and σ2y = variance of the component in the carcass, estimated as the sum of the square residue of analysis of variance of Model I. The significance of the correlations was evaluated by the "t" test.

The correlation coefficient is used to establish the level of correlation between two variables. When it is equal to +1 or -1, the correlation is said to be perfect. The sign indicates the direction of the correlation: if positive, it indicates that y increases when x also increases, and if negative, it indicates that y decreases when x increases. According to Dancey & Reidy (2006), the results should be interpreted as follows: 1 to 0.70 - strong correlation; 0.60 to 0.40 - moderate correlation; and 0.30 to 0.10 - weak correlation.

The experiment was laid out in a completely randomized design. To evaluate the tissue composition of the cuts, analysis of variance was performed, adopting a 5 × 2 × 2 factorial arrangement (five breed groups, two finishing systems and two sexes), according to Model I. Means were compared by Tukey's test (P<0.05).

Model I:

$$Y_{ijkl} = \mu + FS_i + BG_J + S_k + I_{ijk} + e_{ijkl},$$

where Yijkl = trait evaluated in animal l, of sex k, of breed group j, subjected to finishing system i; μ = constant inherent to observation Yijkl; FSi = effect of finishing system i (i = 1: kid + dam on pasture and 2: confined weaned kid); BGj = effect of breed group j (j = 1: Alpine, 2: ½ Boer + ½ Alpine, 3: ¾ Boer + ¼ Alpine, 4: ½ Anglo Nubian + ½ Alpine and 5: ½ Anglo Nubian + ¼ Boer + ¼ Alpine ("three-cross"); Sk = effect of sex k (k = 1: male and 2: female); Iijk = interaction between the effects of FSi, BGj and Sk; and eijkl = error referring to observation Yijkl (0, σe2).

To establish the prediction equations, linear regression analyses were used—in some cases simple and, in others, multiple.

Linear regression analysis was performed according to Model II:

$$Y = \beta_0 + \beta_1 x_1 + ... + \beta_k x_k + \varepsilon,$$

where Y = percentage of muscle, fat and bone in the carcass; β0 = constant; β1 ... βk = partial regression coefficients; and x1 ... xk = independent variables included in the regression (tissues from different regions).

To select the variables of the prediction equations, the "stepwise" procedure was used, which selects, in a first step, the independent variable that generates the best model. In the following steps, variables that reduce the sum of square error (increasing R2) are added, and if any of the incorporated variables shows a regression coefficient with a high probability value, it is eliminated.

The fit of the prediction equations was evaluated by the coefficient of determination (R2), which indicates how much of the variance of the dependent variable is explained by the variance of the independent variables. The purpose of this indicator is to know if the model is fitting to the collected data. Its value ranges from 0 to 1, with values closer to 1 meaning the model is more explanatory.

The residual standard deviation (S) was calculated by the square root of the mean square of the independent variable, representing a measurement that indicates the difference in the mean observation of the group of a sample, i.e., it indicates the degree of variation of a set of elements. The best standard deviation is that with the lowest value.

Statistical analyses were performed using SAEG computer software version 8.0 (UFV, 2000).

Results and discussion

Slaughter weight (after a 16-h fast) and cold carcass weight in the animals in FS1 (kid + dam on pasture) were 17.96 kg and 7.93 kg, respectively, lower than those of the animals in FS2 (confined weaned kid), averaging 26.18 kg and 12.34 kg, respectively. This indicates that the on-pasture system (FS1) delayed animal development, which can be confirmed by the lower deposition of fat and greater bone and muscle deposition (Table 4). According to Owens et al. (1993), fat is a tissue of late deposition, whereas bones and muscles are of early and intermediate deposition, respectively.

Breed group, sex, and finishing system influenced the yields of fat and bone in the carcass. The amount of muscle was influenced only by the finishing system, whereas the amount of other tissues was influenced by the sex factor.

The Alpine animals had a lower proportion of fat as compared with the ½ BA group, and the latter did not differ from the other groups. This is because the Alpine breed is specialized for milk production, with little fat in the carcass and a tendency to store a greater proportion of visceral fat at the expense of subcutaneous and intermuscular deposits (Gibb et al., 1993). Boer crossbred animals, on the other hand, have a higher value for fat, which shows that this genotype is indicated for increasing the degree of fatness.

Sex also influenced fat deposition, which was higher in the females. This result agrees with Mahgoub et al. (2004), who studied the effect of body weight and sex on tissue distribution in the carcass of goats and found greater fat deposition in females (13%) as compared with males (7.4%). Females generally have greater fat deposition than males. According to Jacobs et al. (1972), this is due to the action of the male hormone (testosterone), which promotes animal muscle and bone growth, resulting in leaner carcasses with greater musculature in uncastrated males as compared with females.

As for the finishing system, the kids on pasture showed a lower proportion of adipose tissue than the confined kids, indicating that feeding can change the amount of this tissue in the carcass. Oman et al. (1999) concluded the same, after observing greater fat deposition in feedlot-finished Boer × Spanish crossbreds.

Confined animals develop faster than when raised on pasture and, for this reason, they accumulate fat more quickly.

The proportions of bone in the carcass of the ½ BA and TC animals did not differ and were lower than in the Alpine breed. This is possibly because animals of the Alpine breed were selected for milk production over the years, and hence they lost muscle mass (long-tailed). In contrast, animals specialized for meat production have more compact carcasses, with a higher proportion of tissues. These results agree with Gibb et al. (1993), who described that feedlot Anglo Nubian and British Saanen goat kids had a higher percentage of bone tissue than Boer × British Saanen crossbreeds.

In the present study, the animals on pasture showed a higher proportion of bone in the carcass than those which were kept confined. This finding corroborates Oman et al. (1999), who reported a lower percentage of bone tissue in feedlot Boer × Spanish kids as compared with those finished on pasture. This must have been due to the fact that the animals finished on pasture were slaughtered at a lower live weight and, therefore, before the growth deceleration phase described by Owens et al. (1993).

Males showed a greater proportion of bone tissue than females, as one of the effects of the male hormone testosterone is to promote animal muscle and bone growth (Jacobs et al., 1972). Sex influenced the proportion of other tissues in the carcass, which was higher in the males (3.05) than in the females (2.72) (Table 5). The highest yields of muscle and bone were found in the leg (221.9 and 75.1 g/kg of the half-carcass, respectively); of fat in the rib (40.9 g/kg); and of other tissues in the shoulder (20.2 g/kg). Adipose tissue is the last to be deposited and the rib is part of a body region that develops later, that is, it grows as the animal gains weight. Thus, late growth is related to a higher concentration of fat in that region.

Leg and rib represent more than 50% of the carcass, and due to the greater amount of tissues found in these cuts, they are expected to have a greater contribution to the carcass composition.

Muscle, fat and bone in the carcass correlated with all cuts. For other tissues, only the leg and shoulder were correlated with the carcass (Table 6).

The correlation coefficients between carcass muscle and the cuts of rib and leg were significant and considered strong (>0.70). The same was true for carcass fat with the cuts of rib, loin, leg and shoulder; carcass bone with rib, leg and shoulder; and other carcass tissues, which also showed a strong correlation (>0.70) with the shoulder cut.

Despite being significant, the other correlations between the tissues of the half-carcass and the cuts were considered moderate, i.e., their coefficients ranged between 0.40 and 0.60. Therefore, these relationships were not strong, except for other tissues, which showed moderate correlation only for the leg cut, whereas for the other cuts there was no correlation.

The correlations between carcass muscle, fat and bone with the rib were those with the highest coefficients. Rib is considered the cut that best represents the carcass tissue composition. This result is in agreement with Silva et al. (2011), who studied the prediction of tissue composition of crossbred F1 goat kids and obtained the highest correlation coefficients between rib and the muscle (r = 0.916), fat (r = 0.902) and bone (r = 0.766) tissues.

The greater correlations with the rib can be explained by the concept of centripetal growth, with growth waves occurring progressively from the extremities to the thorax and particularly to the dorsolumbar region. It is also noteworthy that the rib is the cut where fat accumulates at the highest speed, increasing its proportion as the animal's weight increases (Yañes, 2002). For this reason, the largest amount of this tissue is found in this cut. (Table 5).

High correlations were found between carcass muscle and leg and rib. This finding is in line with Dhanda et al. (1999), who observed that the older animals (chevon) showed high correlations between the carcass muscle and the leg (r = 0.81), shoulder and rib (r = 0.74) tissues.

The correlations between carcass fat and the cuts of leg and shoulder also agree with Naudé & Hofmeyer (1981), who reported correlation coefficients of 0.953 and 0.921 between carcass adipose tissue and shoulder and leg, respectively.

The correlations found between carcass bone and the cuts of shoulder and leg are in agreement with Dhanda et al. (1999), who detected higher correlations for the proportion of carcass bone corresponding to the leg bone (r = 0.79), followed by the shoulder (r = 0.72). These high correlations can be explained by the higher bone yield found in the leg (75.1 g/kg) and shoulder (51.1 g/kg), out of the total half-carcass bone yield (233 g/kg) (Table 5).

In the prediction equation for carcass muscle proportion, the stepwise procedure included the proportions of leg fat and bone as independent variables, with an R2 = 0.511 and S = 1.649 (Table 7).

For the proportion of fat, the included variables were the fat and muscle proportions in the leg. This equation explained 81.4% of the variation in the proportion of fat in the carcass, although its error was higher than in the first. The equation for predicting the proportion of bone using the leg tissues included the independent variables fat and muscle. The precision of this equation was considerably high, explaining 81% of the variation in this tissue.

In predicting the carcass muscle and fat proportions, the rib provided greater accuracy than the leg (Table 8). However, to predict the bone proportion, the leg was more accurate.

In the prediction equation for muscle proportion, the "stepwise" procedure included the proportion of rib muscle as a predictor variable. This equation explained 59.4% of the total variation in the proportion of muscle in the carcass.

To predict the proportion of fat, only the rib fat proportion was included as an independent variable, with an R2 = 0.893. This equation was the one with the smallest error among all the cuts. As for the proportion of bone in the carcass, the muscle and fat proportions were included in the prediction equation, which, combined, explained 80.1% of the variation.

The coefficient of determination of the equation for fat using the shoulder tissues was high (R2 = 0.834), with fat and muscle as independent variables (Table 9). The accuracy of the estimate of the proportion of bone in the carcass, using the shoulder, was R2 = 0.738 with S = 1.694.

The prediction equation for muscle proportion explained only 47.4% of the variation for the whole data set. In this equation, the proportions of muscle and bone were included as independent variables.

In this study, the loin was overall not a good estimator of carcass composition, as it showed low coefficients of determination (Table 10) with the highest standard deviations. The muscle prediction equation, which includes only the loin muscle as a predictor variable, explains only 41.9% of the variation. To predict the proportions of fat and bone, loin muscle and bone were included as independent variables, with precision of R2 = 0.612 and S = 2.587 and R2 = 0.506 and S = 2.328, respectively.

In general, the loin is considered a good cut to predict the tissue composition of the carcass by the ribeye area (REA)—a measurement of the muscle area of the Longissimus dorsi muscle section at the 12th or 13th dorsal vertebrae, which is used to estimate the amount of muscle present in the carcass (Yañes, 2002). This cut is in agreement with the concept of centripetal growth, with growth waves occurring progressively from the extremities to the thorax and particularly to the dorsolumbar region, according to Morand-Fehr (1981); however, this was not observed in the present study.

The neck region was also not a good predictor of tissues for the carcass (Table 11).

To determine the muscle, the neck provided the lowest prediction among all cuts, explaining only 24% of the variation, with muscle and bone being the independent variables. Prediction equations for carcass fat and bone included fat as an independent variable, with precision of R2 = 0.725 and R2 = 0.596, respectively.

According to the prediction equations, as already observed for the correlation coefficient, the regions that best estimated the carcass tissue composition were the rib, followed by the leg, as these are the cuts that represent the highest percentage of the carcass (Table 5) and are responsible for the greatest percentages of muscle and bone (leg and rib) and adipose (rib) tissue.

These results are in agreement with those described by Díaz-Chirón (2001), who investigated prediction equations for lamb carcass tissue and found that the rib cut most accurately predicted the proportions of muscle and fat (explaining 84.6% and 93.6% of the variation, respectively), whereas the leg best predicted the carcass bone proportion (86.7% of the variation).

In a study on the prediction of tissue composition of F1 crossbred mixed-breed goats finished on native pasture, Silva et al. (2011) observed that the leg muscle provided the best estimate for this tissue in the carcass due to its higher coefficient of determination (R2 = 0.95). The rib was characterized as a predictor of bone (R2 = 0.84) and fat (R2 = 0.90) tissues.

Table 1. Distribution of the animals according to breed group, finishing system and sex

	Finishing Systems				
	Kid + dam on pasture (FS1)		Confined weaned kid (FS2)		
Racial Group[1]	Male	Female	Male	Female	Total
Alpina	4	3	3	3	13
½ AA	4	3	5	3	15
½ BA	4	3	3	4	14
¾ BA	3	6	4	5	18
"Threecross"	4	5	5	4	18
Total	19	20	20	19	78

[1] ½ AA - ½ Anglo Nubian + ½ Alpine; ½ BA - ½ Boer + ½ Alpine; ¾ BA - ¾ Boer + ¼ Alpine e "Three cross"- ½ Anglo Nubian + ¼ Boer + ¼ Alpine

Table 2. Diet Composition

Ingredients	g/kg Natural Matter
Oat hay	300
Ground corn grain	300
Soy bran	280
Wheat bran	80
Limestone	10
Dicalcium phosphate	10
Mineral supplement *	20

*g/kg ou mg/kg: sulfur 200g, magnesium 150g, zinc 47210 mg, iron 27000 mg, copper 20000 mg, manganese 1200 mg, cobalt 1400 mg, iodine 1250 mg, selenium 315 mg.

Table 3. Chemical composition of the complete diet and forage

Chemical composition	Diet	Forage
Dry matter (g/kg)	945,9	243,1
Mineral matter (g/kg DM)	92,7	33,9
Crude protein (g/kg DM)	164,7	129,1
Ether extract (g/kg DM)[1]	31,0	14,8
Neutral Detergent fiber (g/kg DM)	251,4	664,6
Acid Detergent fiber (g/kg DM)	151,7	409,3
Non-Fibrous Carbohydrates (g/kg DM)[2]	381,4	152,2
Total digestible nutrients (g/kg DM)[2]	737,7	663,4
Metabolizable energy (Mcal/kg DM)[3]	2,66	2,39
Calcium (g/kg DM)	17,2	8,5
Phosphor (g/kg DM)	4,5	4,5

[1]Sniffen et al. (1992). [2]NRC (2001). [3]1kg TDN = 4,409 Mcal of DE e ME = 81,7% DE (NRC, 2001).

Table 4. Yields of muscle, fat, bone, and other tissues of the half-carcass as a function of breed group, sex, and finishing system

Tissues	Means	Racial Group[1]					Gender		Finishing System		CV[3]
		A	½ BA	½ ANA	¾ BA	TC	Male	Female	FS1	FS2	
Muscle	626,2	621,5	621,2	636,4	620,8	631,5	626,9	625,6	632,1a	620,4b	3,40
Fat	104,4	87,4b	120,7a	92,2ab	113,0ab	108,9ab	95,3a	113,6b	79,3a	129,6b	25,80
Bone	240,4	258,9a	229,8b	242,7ab	239,2ab	231,6b	247,3a	233,6b	259,7a	221,6b	9,25
Others	28,8	32,2	28,3	28,7	27,0	28,0	30,5a	27,1b	28,8	28,9	16,62

[1]Breed group – A: Alpine; ½ BA: ½ Boer + ½ Alpine; ½ ANA: ½ Anglo Nubian + ½ Alpine; ¾ BA: ¾ Boer + ¼ Alpine; and ½ Anglo Nubian + ¼ Boer + ¼ Alpine ("three-cross" - TC). [2]Finishing system - FS1: kid + dam on pasture and FS2: confined weaned kid. [3]CV – coefficient of variation.
Means followed by different letters in the same row for breed group differ from each other by Tukey's test (P<0.05) and for sex and finishing system by the F test (P<0.05).

Table 5. Proportion of cut tissues relative to the half-carcass tissues

Meat cuts	Means (kg)	Meat cuts percentage (%)	Half Carcass			
			Muscle (g/kg)	Fat (g/kg)	Bone (g/kg)	Other tissues (g/kg)
Rib	1,259	26,02	152,2	40,9	65,2	1,9
Loin	0,558	11,53	81,2	13,9	19,3	0,8
Leg	1,589	32,84	221,9	26,1	75,1	5,1
Neck	0,361	7,46	44,9	6,5	22,3	0,8
Shoulder	1,087	22,46	126,9	26,5	51,1	20,2
Half Carcass	4,839	100	627,1	113,9	233	28,8

Table 6. Correlation between percentages of tissues that compose the carcass and cuts

	Carcass	Rib	Loin	Leg	Neck
			Muscle		
Rib	0,752*	-	-	-	-
Loin	0,543*	0,214	-	-	-
Leg	0,701*	0,475*	0,404*	-	-
Neck	0,369*	0,161	0,099	0,091	-
Shoulder	0,592*	0,219	0,067	0,158	0,181
			Fat		
Rib	0,898*	-	-	-	-
Loin	0,708*	0,470*	-	-	-
Leg	0,841*	0,639*	0,629*	-	-
Neck	0,634*	0,540*	0,360*	0,568*	-
Shoulder	0,809*	0,603*	0,456*	0,674*	0,476*
			Bone		
Rib	0,865*	-	-	-	-
Loin	0,576*	0,359*	-	-	-
Leg	0,749*	0,467*	0,505*	-	-
Neck	0,535*	0,396*	0,106	0,216	-
Shoulder	0,728*	0,593*	0,133	0,462*	0,361*
			Other tissues		
Rib	0,128	-	-	-	-
Loin	-0,114	0,006	-	-	-
Leg	0,469*	-0,068	0,152	-	-
Neck	0,159	-0,063	0,098	0,076	-
Shoulder	0,804*	-0,108	-0,341	-0,003	-0,001

(*P<0,05, "t" test)

Table 7. Prediction equations for carcass tissue yield (Ŷ) using leg tissue yield (Independent Variables)

		Independent Variables Leg Tissues (g/kg)[1]			
Ŷ=	Constant	Fat	Bone	R^2	S
Muscle	846,0	-0,987	-0,523	0,511	1,649
Ŷ=	Constant	Fat	Bone	R^2	S
Fat	-166,1	1,660	0,212	0,814	1,791
Ŷ=	Constant	Fat	Bone	R^2	S
Bone	843,1	-1,195	-0,735	0,810	1,438

[1]Order given by the "stepwise" procedure. S: residual standard deviation.

Table 8. Prediction equations for carcass tissue yield (Ŷ) using rib tissue yield (Independent Variables)

		Independent Variables Rib tissues (g/kg)[1]			
Ŷ=	Constant	Muscle		R^2	S
Muscle	353,3	0,492		0,594	1,501
Ŷ=	Constant	Fat		R^2	S
Fat	22,4	0,602		0,893	1,356
Ŷ=	Constant	Muscle	Fat	R^2	S
Bone	627,3	-0,496	-0,609	0,801	1,473

[1]Order given by the "stepwise" procedure. S: residual standard deviation.

Table 9. Prediction equations for carcass tissue yield (Ŷ) using shoulder tissue yield (Independent Variables)

		Independent Variables Shoulder tissues (g/kg)[1]			
Ŷ=	Constant	Muscle	Bone	R^2	S
Muscle	325,4	0,471	0,102	0,474	1,711
Ŷ=	Constant	Fat	Muscle	R^2	S
Fat	-115,6	0,852	0,193	0,834	1,697
Ŷ=	Constant	Muscle	Fat	R^2	S
Bone	687,6	-0,562	-0,750	0,738	1,694

[1]Order given by the "stepwise" procedure. S: residual standard deviation.

Table 10. Prediction equations for carcass tissue yield (Ŷ) using loin tissue yield (Independent Variables)

		Independent Variables Loin tissues (g/kg)[1]			
Ŷ=	Constant	Muscle		R^2	S
Muscle	438,9	0,290		0,419	1,797
Ŷ=	Constant	Muscle	Bone	R^2	S
Fat	540,6	-0,458	-0,590	0,612	2,587
Ŷ=	Constant	Muscle	Bone	R^2	S
Bone	49,3	0,148	0,504	0,506	2,328

[1]Order given by the "stepwise" procedure. S: residual standard deviation.

Table 11. Prediction equations for carcass tissue yield (Ŷ) using neck tissue yield (Independent Variables)

		Independent Variables Neck tissues (g/kg)[1]			
Ŷ=	Constant	Muscle	Bone	R^2	S
Muscle	383,0	0,329	0,202	0,240	2,05
Ŷ=	Constant	Fat		R^2	S
Fat	36,61	0,870		0,725	2,174
Ŷ=	Constant	Fat		R^2	S
Bone	297,6	-0,630		0,596	2,104

[1]Order given by the "stepwise" procedure. S: residual standard deviation.

Conclusion

Based on the correlation coefficients, coefficients of determination and residual standard deviations of the regression equations, the cut that provides the best estimates of carcass tissue composition is the rib, followed by the leg.

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