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Carcass quality of crossbred steers with different degrees of zebu blood in the genotype: meta-analysis

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ABSTRACT - In order to evaluate the effect of the different percentages of zebu blood in the genotype of crossbred steers on carcass traits, a meta-analysis was carried out, using 30 studies conducted in Brazil that have been published since the year 2000. The parameters evaluated were hot carcass weight (221 estimates), cold carcass weight (232), hot carcass (236) and cold carcass yield (223), subcutaneous fat thickness (238) and the percentages of saw cut (233), forequarter (234) and sidecut (246 estimates). Initially, exploratory analysis was performed for each of the variables for detection of publication vices through the dispersion of observations by pointing out the outliers eliminated. Normality tests were normal and the data were subjected to analysis of variance for the regression study, which were assessed to the third degree. Weights of hot carcass and cold carcass, hot and cold carcass yield and the percentage of saw cut had a quadratic effect on animals with the presence of zebu blood, indicating superiority of crossbred animals. The regression equation showed that 66; 50; 72; 81 and 59% of zebu in crossbred animals showed higher hot and cold carcass weight, hot and cold carcass percentage and saw cut, respectively. Fat thickness was not influenced by the degree of zebu in the genotype. The percentage of forequarter has a positive response by increasing the degree of zebu in the genotype, while the sidecut has a negative answer. The crossbreeding between zebu and European breeds provides carcasses with better quality than purebred animals.

Key Words: carcass yield, crossbreeding, heterosis

Introduction

With the increase in the production and the amount of beef produced and exported, the production chain of this segment in Brazil has stood out internationally. A major concern in the country for the consumer market is the compliance with the requirements and needs in relation to the quantity and quality of the final product; in other words, the carcass and meat produced (Pacheco et al., 2005), keeping the basic conditions required, which are hygienic and sanitary safeness, nutritional value, produce traceability and sensory characteristics (Pineda & Rocha, 2002).

The crossbreeding between European and Zebu breeds is one of the practices used to increase animal performance, widely used in countries with emphasis on beef production, like the United States of America, New Zealand, Canada and Australia, reaching levels above 80% of application on herds (Sundstrom et al., 1994).

The use of European breeds (*Bos taurus taurus*) in crossbreeding helps to improve the quality of carcass and meat, besides reducing the age at slaughter. Since the genotype zebu (*Bos taurus indicus*) collaborates with its rusticity and adaptation to tropical climates, due to its greater resistance to pests and tolerance to heat, allied to these factors, the crossbreeding provides greater heterosis (Menezes et al., 2005).

In the study of carcass production quality, several factors of commercial interest such as improving the yield of the carcass and commercial cuts, the weight of the cut and the degree of final touch are taken into account by the slaughterhouses (Costa et al. 2002; Arboitte et al., 2004).

The literature has several studies related to carcass quality and beef and they often report conflicting results. Thus, this study aims to evaluate the variations found in experimental research and conduct a scientific systematization of information to obtain more precise information to support producers in the definition of which degree of participation of zebu in the genotype provides greater income to the producers, as well as to assess the possibility of the beef industry's being more profitable and pay a fairer price for the product.

One way to standardize the results and observe trends is a meta-analysis, which combines the results of several experiments related to the same subject in order to cover a group of evidences (Hauptli et al., 2007). In this study, the influence of the degree of zebu in genotype on the characteristics that affect carcass quality of beef cattle was evaluated.

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Material and Methods

The study was conducted at the Universidade Tecnológica Federal do Paraná - Campus Dois Vizinhos (UTFPR-DV). Twenty-two articles published on the Revista Brasileira de Zootecnia (Leme et al., 2000, Prado et al. 2000; Feijó et al. 2001; Restle et al. 2001; Zervoudakis et al., 2001; Costa et al. , 2002; Faturi et al., 2002; Santos et al., 2002; Vaz et al., 2002; Vaz & Restle, 2003; Arboitte et al., 2004; Menezes et al., 2005, Pacheco et al., 2005 ; Vaz & Restle, 2005; Canesin et al., 2006; Bonilha et al., 2007; Coan et al., 2008; Freitas et al., 2008; Igarasi et al., 2008; Marcondes et al., 2008; Ribeiro et al., 2008; Silva et al., 2008; Metz et al., 2009) six dissertations (Aferri, 2003; Kuss, 2004; Menezes, 2004; Pacheco, 2004; Sachet, 2009; Santos, 2005) and two theses (Pereira, 2006; Menezes, 2008) in Animal Science at Universidade Federal de Santa Maria (UFSM) and Universidade de São Paulo (USP) from 2000 to 2009 were used (Table 1) .

From the articles published in the journals, the average data were extracted, and in dissertations, individual results were published in the appendices. The survey included characteristics that affect carcass quality, and was performed using as keywords: carcass, cattle, calves and degree of blood. One-hundred and eight articles related to the characteristics sought were found and, after accurate analysis, 30 articles were selected for meta-analysis having as criteria the use of bulls aged 24 months, purebred or crossbred.

The main variables analyzed were: hot carcass weight (221 estimates extracted), cold carcass weight (232), hot carcass yield (236) and cold carcass (223), fat thickness (238), percentage of saw cut (233), percentage for forequarter (234) and percentage of sidecut (246 animals evaluated).

The values mentioned in the selected studies were related to the interference of the percentage of zebu blood of animals evaluated. The animals used in experiments were divided into nine categories according to their genotypes: 0, 25, 31.25, 37.5, 50, 58.75, 62.5, 75 and 100% of zebu blood in the genotype. The database was developed in a Microsoft Excel® spreadsheet from the values discussed in the publications. The meta-analysis of the variables followed the following steps: exploratory analysis of the data set, which aims to detect the presence of addiction to publication,

Table 1 - List of studies addressed to perform the meta-analysis

Author	Breed		Author	Breed	
	Zebu (%)	European (%)		Zebu (%)	European (%)
Pacheco et al. (2005)	Nellore (37.5, 62.5)	Charolais (62.5, 37.5)	Menezes (2004)	*	Charolais (100)
Pacheco (2004)	Nellore (62.5; 37.5)	Charolais (37.5; 62.5)		Nellore (25; 32.5; 37.5; 62.5; 68.5; 75)	Charolais (25; 32.5; 37.5; 62.5 ; 68.5; 75)
Freitas et al. (2008)	Nellore (100)	*		Nellore (100)	*
Leme et al. (2000)	Nellore (100)	*	Kuss (2004)	Nellore (25; 32.5; 62.5; 75)	Charolais (25; 32.5; 62.5; 75)
	Nellore (50)	South Devon (50)	Ribeiro et al. (2008)	Nellore (100)	*
	Nellore (50)	Hereford (50)		Guzerá/Nellore (100)	*
	Nellore (50)	Aberdeen angus (50)		Brahman/Nellore (100)	*
	Nellore (50)	Red angus (50)	Bonilha et al. (2007)	Nellore (100)	*
	Nellore (50)	Caracu (50)		Guzerá (100)	*
	Nellore (50)	Limousin (50)		Gir (100)	*
	Nellore (50)	Simental (50)		*	Caracu(100)
	Nellore (50)	Charolais (50)	Silva et al. (2008)	Nellore (100)	*
	*	Holandês (100)	Metz et al. (2009)	Nellore (62.5)	Charolais (37.5)
Prado et al. (2000)	Nellore (50)	Angus (50)	Sachet (2009)	Nellore (50)	Charolais (50)
Zervoudakis et al. (2001)	Nellore (50)	Holandês (50)	Aferri (2003)	Nellore (25)	Simental/Brangus (75)
Feijó et al. (2001)	Nellore (50)	Aberdeen angus (50)	Pereira (2006)	Nellore (50)	Aberdeen angus (50)
Santos et al. (2002)	Nellore (50)	Limousin (50)		Brahman/Nellore (100)	*
Santos (2005)	Nellore (25; 37.5; 62.5; 75)	Charolais (25; 37.5; 62.5; 75)		Nellore (100)	*
Vaz et al. (2002)	Nellore (37.5)	Hereford (62.5)	Coan et al. (2008)	Nellore (100)	*
	*	Jersey/Hereford (100)	Restle et al. (2002)	Nellore (50)	Charolais (50)
	*	Hereford (100)		*	Charolais (100)
Vaz et al. (2005)	*	Hereford (100)	Restle et al. (2001)	*	Charolais (100)
Vaz et al. (2002)	*	Hereford (100)		Nellore (100)	*
Vaz et al. (2003)	*	Charolais (100)		Nellore (25; 50; 75)	Charolais (25; 50; 75)
Arboitte et al. (2004)	Nellore (62.5)	Charolais (37.5)	Costa et al. (2002)	*	Red angus (100)
Canesin et al. (2006)	Nellore (50)	Charolais (50)	Faturi et al. (2002)	*	Charolais (100)
Igarasi et al. (2008)	Nellore (50)	Red angus (50)		Nellore (100)	*
Menezes et al. (2005)	Nellore (50)	Charolais (50)		Nellore	Charolais
Menezes (2008)	*	Devon (100)	Marcondes et al. (2008)	Nellore (100)	*

in other words, the presence of disparate data (outliers) for a certain trait in the studies. Outliers were determined with the help of TC2D software, which pointed the data with values of twice the standard deviation, allowing the elimination of values over this limit . The tests of normality applied to the variables were: Kolmogorov-Smirnov, Cramer-von Mises, Anderson-Darling, Kuiper, Watson, Lilliefors and Shapiro-Wilk test, using the software Assistat (Silva & Azevedo, 2002). The data were subjected to analysis of variance and the estimation of regression equations to the third grade was achieved through the statistical software SAS (2001).

Results and Discussion

Only purebred animals did not reach the average cold carcass weight of 230 kg (Table 2), minimum sought by the beef industry to reduce the costs of production (Costa et al., 2002). In all degrees of blood, there were animals that showed carcasses with weights inferior to 230 kg. Carcasses with less weight (over 180 kg) are being gradually accepted by butchers and supermarkets, because the animals are associated with lower age and better meat quality (Costa et al., 2002).

In spite of the use of meta-analysis, which could lead to high variability of the data, the coefficient of variation (CV = 11.5%) for hot carcass weight was similar to that found in the literature: Zervoudakis et al. (2001), 8.9%; Canesin et al. (2006), 7.74%; Marcondes et al. (2008), 11.63%. On the other hand, the coefficient of variation for the cold carcass weight (14.1%) was higher than that observed in the literature: Kuss et al. (2005), 8.83%; Canesin et al. (2006), 7.96%; Silva et al. (2008), 6.63%. The cold carcass weight is influenced by other factors that are not inherent by the

Table 2 - Statistics of position and dispersion for hot and cold carcass weight and fat thickness according to the degree of blood in the genotype of zebu bulls

	% zebu blood									
Descriptive statistics	0	25	31.25	37.5	50	58.75	62.5	75	100	General
	Weight of hot carcass, kg									
N*	38	8	4	31	61	4	35	11	29	221
Minimum	169.2	214.0	213.0	200.8	203.9	212.9	206.0	209.5	198.0	169.2
Maximum	242.6	273.2	244.5	287.6	292.0	224.3	299.0	270.2	276.2	299.0
Arithmetic mean	204.2	245.3	234.1	247.2	251.5	218.6	252.2	243.4	246.2	240.6
LCI*	198.3	225.3	211.1	238.7	246.1	210.9	244.5	229.1	237.1	237.0
UCL*	210.1	265.3	257.1	255.8	256.9	226.2	260.0	257.6	255.3	244.3
Mean deviation	14.8	20.6	10.6	19.4	17.6	3.6	18.3	16.2	19.4	22.9
Standard deviation	18.4	24.0	14.5	24.3	21.6	4.8	23.4	21.2	24.0	27.7
Variance	339.7	575.4	209.7	590.7	464.8	23.3	545.6	450.9	573.7	768.2
CV*	9.0	9.8	6.2	9.8	8.6	2.2	9.3	8.7	9.7	11.5
DN**	TN	TN	TN	TN	TN	TN	TN	TN	1,4,6	1,6
	Weight of cold carcass, kg									
N*	55	13	7	31	41	6	36	14	29	232
Minimum	165.2	210.60	210.4	195.0	183.8	206.7	193.5	183.7	144.6	144.6
Maximum	264.2	297.30	292.5	281.6	295.4	275.6	291.5	264.0	267.4	297.3
Arithmetic mean	207.2	255.93	255.1	241.0	240.2	233.7	243.9	231.9	202.7	229.0
LCI*	201.2	237.64	224.2	232.5	232.6	199.9	235.9	215.9	188.4	224.9
UCL*	213.7	274.22	285,9	249.4	247.7	267.5	251.8	247.8	216.9	233.2
Mean deviation	17.7	25.89	29.2	19.1	18.9	27.5	19.4	23.1	30.4	26.5
Standard deviation	22.6	30.25	33.3	24.0	24.6	32.2	24.3	27.6	37.4	32.2
Variance	512.4	915.25	1110.6	576.2	606.9	1035.8	590.9	764.2	1401.3	1039.6
CV*	10.9	11.82	13.1	9.9	10.3	13.8	10.0	11.9	18.5	14.1
DN**	TN	1,2,3,5,6,7	1,2,3,5,6,7	TN	TN	3	TN	2,3,4,5,6,7	TN	TN
	Fat thickness, mm									
N*	52	10	7	28	44	5	37	16	39	238
Minimum	1.3	3.0	3.0	2.5	2.0	3.5	2.4	2.5	1.9	1.3
Maximum	6.3	6.6	6.0	7.5	7.9	6.5	7.3	7.0	7.4	7.9
Arithmetic mean	4.0	4.2	4.9	4.5	4.4	4.9	4.8	5.0	4.5	4.5
LCI*	3.6	3.5	3.8	4.0	4.0	3.6	4.3	4.4	3.9	4.3
UCL*	4.3	5.0	6.0	5.1	4.9	6.3	5.2	5.6	5.0	4.6
Mean deviation	1.1	0.8	0.9	1.2	1.3	0.7	1.2	0.9	1.5	1.2
Standard deviation	1.3	1.1	1.2	1.5	1.6	1.1	1.5	1.1	1.7	1.5
Variance	1.7	1.1	1.4	2.1	2.4	1.2	2.1	1.3	3.0	2.1
CV*	33.3	25.1	24.3	32.0	35.1	22.1	30.3	22.7	38.8	32.8
DN**	TN	TN	TN	3.7	TN	TN	TN	TN	NN	NN

* N = number of observation; LCI = lower confidence limits; UCL = upper confidence limits; CV = coefficient of variation; DN = adherence data.
** The values follow a normal distribution for the Kolmogorov-Smirnov (1), Cramer-von Mises (2), Anderson-Darling (3), Kuiper (4), Watson (5), Lilliefors (6), Shapiro-Wilk (7), show normal distribution for all tests (TN) and do not present normal distribution for any test (NN).

animal; for instance, the temperature in the cold may increase or decrease the carcass yield during the cooling, which could not be measured in the meta-analysis.

The loss by chilling reflects the decrease of the carcass weight during the cooling process in the first 24 hours after slaughter (Menezes et al., 2005). Moreover, studies show that chilling loss is influenced by the thickness of subcutaneous fat (Muller, 1987; Arboitte et al., 2004). According to Muller (1987), lower rates of breakdown are observed in carcasses with higher degree of subcutaneous fat, since it acts as an insulator, preventing losses from dehydration. The subcutaneous fat thickness (FT) presented high variability (32.80% average CV), which may have contributed to the increase in the coefficient of variation of the cold carcass weight. The high variability for this characteristic is reported in the literature: Canesin et al. (2006), 44.84%; Silva et al. (2008), 52.92%; Igarasi et al. (2008), 22.98%. Lopes et al. (2008) conducted a meta-analysis for carcass traits of cattle from different genetic groups and found that the contribution of the degree of zebu blood on the thickness of fat was only positive when the crossbreeding was carried out with European continental origin ones, while when done between zebu and British, the presence of zebu genotype decreased the degree of finishing on the carcass. As in this analysis there was no such distinction between the origins of European breeds involved in the crossbreeds, the data variation for fat thickness was high.

The fat thickness was not influenced by the presence of zebu blood in the genotype of animals. The high variability (CV = 32.80%) data contributed to that outcome. Furthermore, the thickness of fat is one of the main criteria at the moment of slaughter, since, along with the carcass weight, is one of the requirements of beef industry. Slaughterhouses require 3 to 6 mm of fat thickness (Costa et al., 2002). In the studies evaluated, fat thickness ranged from 1.33 to 7.90 mm. The high variation in all genotypes and degree of finish was more influenced by the procedures of researchers than by the genotype involved.

The weights of hot and cold carcass were influenced in a quadratic pattern (Figure 1) by the degree of Zebu blood (HCW = 205.36 + 1.429 * -0.0108 * zebu2 zebu, PCF = 213.58 + 1.384 * zebu - zebu2 0.014 *), since the highest values were obtained from crossbred animals (66 and 50% of zebu blood, respectively).

The hot carcass weight of the animals showed differences of up to 47 kg between pure European and crossbred animals (66% of zebu blood) and this difference may have been favored by the increase in carcass weight caused by heterosis provided at the junction between European and zebu breeds (Menezes et al., 2005). Koger et al. (1975) were the first to demonstrate linearity between heterosis and heterozygosis. In this analysis, maximum results for cold carcass weight were found when the animals had 50% of zebu blood. Animals of ½ blood showed 100% heterozygosis and are expected to have maximum heterosis. In this analysis, the maximum results for cold carcass weight were observed when the animals had 50% of zebu blood. Restle et al. (1999), working with different degrees of blood Hereford × Nellore, and Menezes et al. (2005), with crossbreeding between Charolais and Nellore, verified that the maximum carcass weight occurs with 41 and 42% of European blood in the genotype, respectively.

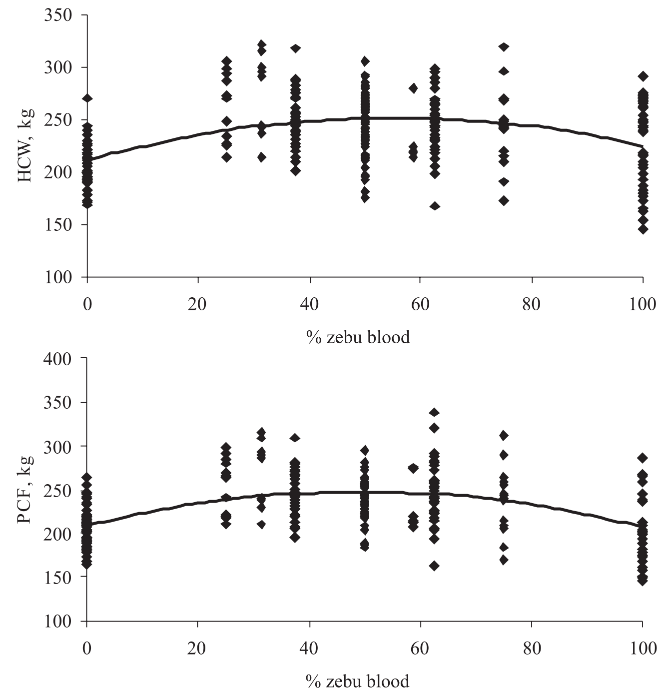


Figure 1 - Relationship between percentage of zebu blood and hot carcass weight (HCW) and cold carcass (PCF) of steers slaughtered at 24 months of age on average.

As it happened with the weights of carcass, the data variation of hot carcass yield (CV = 3.7%) and cold (CV = 4.3%, Table 3) was close to that found in the literature (Canesin et al., 2006, CV = 11.43 and 4.53%, Silva et al., 2008: 2.82 and 2.84% for hot and cold carcass yield, respectively).

The lowest values for the hot and cold carcass yield were observed in 100% European animals, both for the minimum (49.56 and 48.10%) and maximum values (55.87 and 55.20%). The superiority in carcass yield of zebu blood in animals with genotype can be attributed to the relative weight of lower legs, head, skin (Menezes et al., 2009) and especially of the gastrointestinal tract (Menezes et al., 2007), in addition to thinner skin and more surface area on the body, which are characteristics of zebu genotypes adapted to warmer climates.

Table 3 - Statistics of position and dispersion of hot and cold carcass yield according to the degree of blood in the genotype of zebu bulls

	% zebu blood									
Descriptive statistics	0	25	31.25	37.5	50	58.75	62.5	75	100	General
					Hot carcass yield, %					
N*	35	9	8	32	52	6	40	16	38	236
Minimum	49.6	53.1	53.9	52.8	52.1	55.9	52.0	54.8	52.0	49.6
Maxim	55.9	58.6	58.2	59.5	60.0	59.5	60.0	60.0	58.8	60.0
Arithmetic mean	53.5	56.8	56.4	55.9	55.1	57.5	56.0	56.5	56.1	10.4
LCI*	52.9	55.6	55.3	55.3	54.6	56.1	55.4	55.6	55.5	55.3
UCL*	54.1	58.0	57.6	56.5	55.7	59.0	56.6	57.4	56.7	55.8
Mean deviation	1.5	1.0	1.0	1.6	1.7	1.0	1.6	1.3	1.5	1.7
Standard deviation	1.8	1.5	1.3	1.8	2.0	1.4	2.0	1.6	1.8	2.1
Variance	3.3	2.4	1.8	3.4	4.1	1.9	3.9	2.7	3.2	4.3
CV*	3.4	2.7	2.4	3.3	3.7	2.4	3.5	2.9	3.2	3.7
DN**	1,2,4,5,6	4.6	TN	2,3,7	TN	TN	TN	NN	1,3,4,6,7	2,3,5,6,7
					Cold carcass yield, %					
N*	51	10	8	32	28	6	40	17	31	223
Minimum	48.1	51.4	52.8	51.2	50.7	54.3	50.8	51.8	51.0	48.1
Maximum	55.2	57.1	57.2	58.3	58.5	57.9	59.0	58.6	59.0	59.0
Arithmetic mean	51.9	54.8	55.3	54.5	54.1	56.2	54.6	55.1	55.0	54.1
LCI*	51.3	53.3	54.1	53.8	53.2	54.7	54.0	54.2	54.1	53.8
UCL*	52.4	56.3	56.5	55.2	55.0	57.8	55.1	56.0	55.8	54.4
Mean deviation	1.5	1.7	1.1	1.7	2.1	1.1	1.5	1.4	2.0	1.9
Standard deviation	1.9	2.1	14	1.9	2.4	1.5	1.9	1.8	2.4	2.3
Variance	3.5	4.4	2.0	3.7	5.6	2.2	3.5	3.3	5.6	5.5
CV*DN**	3.61,2,5,6	3.83,4,6,7	2.6TN	3.53.7	4.4NN	2.6TN	3.4TN	3.3TN	4.3TN	4.32,3,4,5,6

* N = number of observation; LCI = lower confidence limits; UCL = upper confidence limits, CV = coefficient of variation, DN = adherence data.
** The figures follow a normal distribution for the Kolmogorov-Smirnov (1), Cramer-von Mises (2), Anderson-Darling (3), Kuiper (4), Watson (5), Lilliefors (6), Shapiro-Wilk (7), show normal distribution for all tests (TN) and do not present normal distribution for any tests (NN).

Regression analysis (Figure 2) indicated a quadratic effect of the presence of blood in the zebu genotype in relation to carcass yield. Several studies indicate linearity of carcass yield in the presence of zebu blood in genotype (Restle et al., 1999, 2000). On the other hand, Menezes et al. (2005) observed positive heterosis for hot (3.22%) and cold (3.45%) carcass yield, indicating that the crossbreds were higher than purebreds. In that study, the authors remarked that all crossbred genotypes (Charolais - C and Nellore - N) studied (3/4ch 1/4N, 3/4N 1/4C, 5/8C 3/8N, 5/8N 3/8C; 11/16C 5/16C 5/16N and 11/16N) had higher carcass yield than Nellore purebreds.

Arboitte et al. (2004) and Kuss et al. (2005) report that several researchers found an increasing yield according to weight at slaughter. In this study there was no relationship between income and housing of animals slaughtered (r = - 0.03, P = 0.64). However, carcass yield was positively correlated with carcass weight (r = 0.34, P = 0.001).

Carcass yield has become very important to the production system in recent years, which was based on body weight and has to be done based on carcass weight. The carcass yield can be influenced by several aspects, including dietary fiber content (Ribeiro et al., 2001), animal category (Vaz et al., 2002), slaughter weight (Kuss et al, 2005) and genetic group (Menezes et al., 2005).

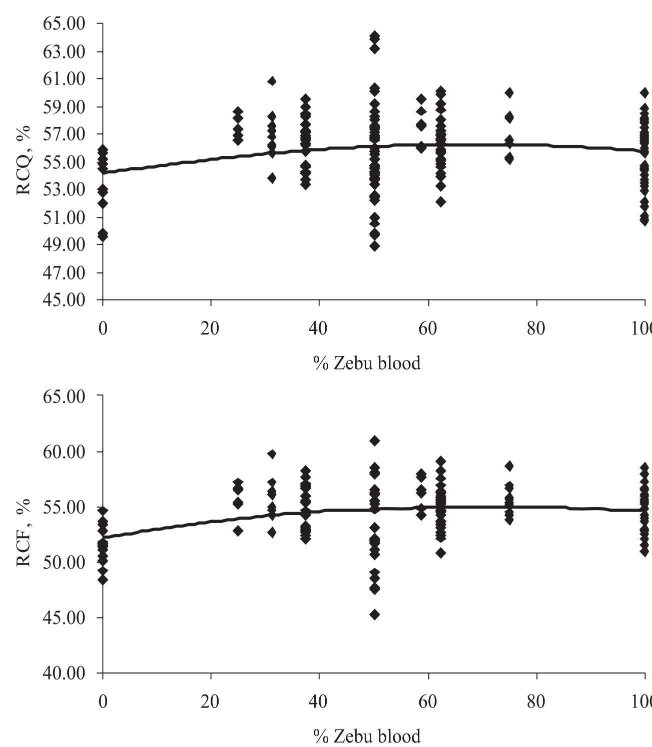


Figure 2 - Relationship between percentage of zebu blood and hot carcass yield (RCQ) and cold (RCF) of steers slaughtered at 24 months on average. [WC = 53.65 + 0.07026 * Zebu - Zebu 0.00049 * ² (r^2 = 0.45, P = 0.0002), RCF = 51.91 + 0.078 * Zebu - Zebu 0.00048 * ² (r^2 = 0.516, P = 0.0009)]

The basic cuts of carcasses of cattle are: forequarter, sidecut and sawcut. Economically, a higher yield of the sawcut, compared with other cuts would be desirable, because of its higher market value. In all genetic groups, the percentage of sawcut was less than 50% (Table 4).

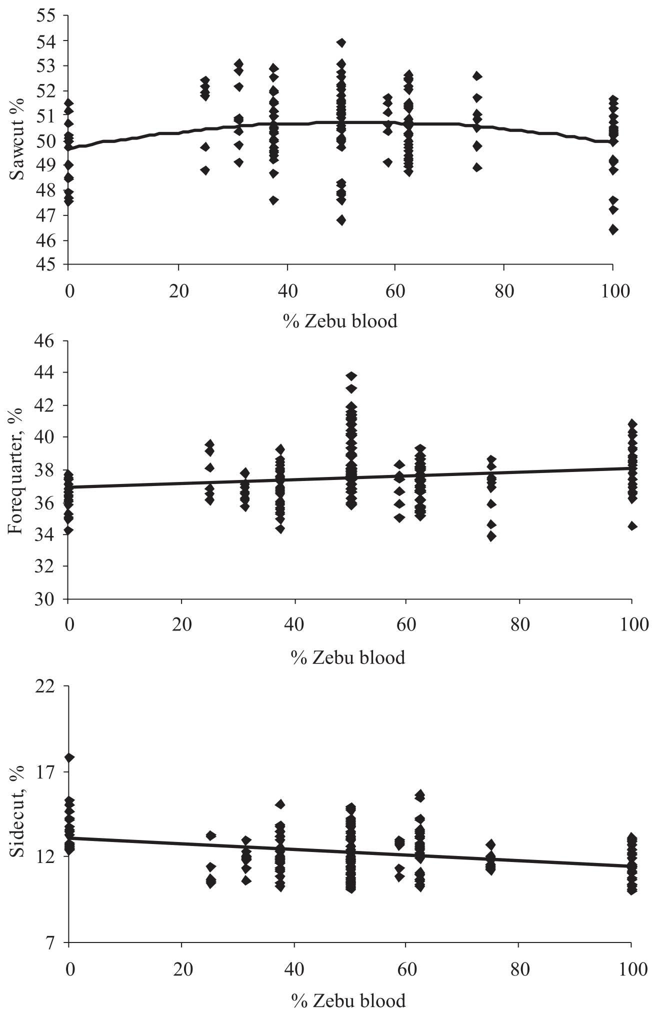
On average, purebreds (European and zebu) had a lower percentage in relation to the sawcut of crossbreds, a fact confirmed by the regression equation, which was significant and quadratic (Figure 3). According to the regression equation (TRAS = 49.21994 + 0.04374 * zebu - zebu ^{2} * 0.0003706), animals with 59% of zebu blood in the genotype had a higher percentage of sawcut (50.51%) than purebreds. In the literature, there are no reports of heterosis effects on the percentage of sawcut (Faturi et al., 2002; Vaz et al., 2002; Menezes et al., 2005). The greater presence of sawcut in the carcass indicates more profit to the meat packing house, since, by multiplying the carcass weight by the percentage of the sawcut, there is increased production in kg of this cut in crossbred animals. The percentage for forequarter was positively influenced by increasing the degree of zebu blood in the genotype (Figure 3). This behavior can be attributed in part to the presence of hump in zebu animals (Luchiari Filho et al., 1985).

The sidecut percentage showed downward trend as it increased the share of zebu blood in the genotype. The sidecut percentage may be associated with the deposition of fat on this cut (Vaz et al., 2002), characteristic of animals that reach a high degree of finishing (Table 2) due to the bending of ribs, associated with selection for increasing food intake. Zebu breeds present less bending of ribs compared with European ones. Restle et al. (1999) also observed that the increase of the proportion of Nellore blood, replacing the

Table 4 - Statistics of position and dispersion for the percentage of primary cuts of the carcass according to the degree of blood in the genotype of zebu bulls

Descriptive statistics	% zebu blood									
	0	25	31.25	37.5	50	58.75	62.5	75	100	Overall
					Sawcut, %					
N*	45	13	9	33	45	5	40	15	28	233
Minimum	46.5	48.8	49.1	47.6	46.8	49.1	48.7	48.9	46.4	46.4
Maximum	52.7	53.1	53.1	52.9	53.1	51.7	52.7	52.6	52.0	53.1
Arithmetic mean	49.4	51.2	51.1	50.7	50.1	50.8	50.6	50.8	50.0	50.3
LCI*	48.9	50.5	50.1	50.3	49.7	49.5	50.3	50.2	49.4	50.1
UCL*	49.9	51.9	52.1	51.1	50.6	52.1	51.0	51.4	50.5	50.5
Mean deviation	1.3	1.0	1.1	1.0	1.4	0.8	0.9	1.2	1.2	1.2
Standard deviation	1.6	1.2	1.3	1.2	1.7	1.0	1.1	1.1	1.5	1.5
Variance	2.5	1.4	1.8	1.5	2.8	1.1	1.2	1.3	2.3	2.2
CV*DN**	3.2TN	2.3TN	2.6TN	2.4TN	3.31.6	2.0TN	2.,2TN	2.3TN	3.04,5,6	3.0NN
					Forequarter, %					
N*	46	13	9	31	50	6	40	14	25	234
Minimum	34.3	34.6	357	34.4	34.5	35.0	34.6	34.6	35.6	34.3
Maximum	39.3	39.6	37.8	39.2	40.2	38.3	39.3	38.6	40.4	40.4
Arithmetic mean	36.8	36.5	36.7	36.8	37.8	36.8	37.0	36.9	38.0	37.2
LCI*	36.5	35.6	36.2	36.4	37.5	35,6	36.7	36.1	37.5	37.0
UCL*	37.1	37.5	37.3	37.3	38.2	38.1	37.3	37.6	38.6	37.3
Mean deviation	0.9	1.2	0.6	1.0	1.0	1.0	0.9	1.1	1.1	1.1
Standard deviation	1.2	1.6	0.7	1.2	1.3	1.2	1.1	1.3	1.3	1.3
Variance	1.3	2.5	0.5	1.5	1.7	1.5	1.2	1.7	1.7	1.7
CV*	3.1	4.3	2.0	3.3	3.4	3.3	3.0	3.6	3.5	3.5
DN**	TN	TN	TN	TN	TN	TN	TN	TN	TN	TN
					Sidecut, %					
N*	49	12	9	32	57	6	38	16	27	246
Minimum	11.1	10.4	10.6	10.2	10.1	10.8	10.2	10.8	10.0	10.0
Maximum	15.0	14.3	12.9	14.1	14.2	12.9	14.4	14.1	13.0	15.0
Arithmetic mean	12.9	12.3	11.9	12.2	12.1	12.2	12.3	12.0	11.5	12.2
LCI*	12.7	11.4	11.4	11.9	11.8	11.3	12.0	11.5	11.1	12.1
UCL*	13.2	13.1	12.4	12.6	12.4	13.2	12.7	12.5	11.8	12.4
Mean deviation	0.8	1.1	0.4	0.8	1.1	0.8	1.0	0.7	0.7	1.0
Standard deviation	0.9	1.3	0.6	1.0	1.3	0.9	1.2	0.9	0.9	1.1
Variance	0.9	1.7	0.4	1.0	1.6	0.9	1.4	0.8	0.8	1.3
CV*	7.2	10.6	5.4	8.4	10.4	7.6	9.6	7.4	7.6	9.3
DN**	TN	TN	TN	TN	1,4,6	3.6	TN	4	TN	1,2,4,6

* N = number of observation; LCI = lower confidence limits; UCL = upper confidence limits, CV = coefficient of variation, DN = adherence data.
** The figures follow a normal distribution by Kolmogorov-Smirnov (1), Cramer-von Mises (2), Anderson-Darling (3), Kuiper (4), Watson (5), Lilliefors (6), Shapiro-Wilk (7). NT = normal distribution for all tests, and NN = not present normal distribution for any test.



[Sawcut = 49.21994 + 0.04374 * Zebu - Zebu 0.0003706 *² (r^2 = 0.4333, P = 0.0003), Forequarter = 36.61898 + 0.01108 * zebu (r^2 = 0.25691; P = 0.0004); Sidecut = 13.14567 to 0.0144 * zebu (r^2 = 0.81509, P = 0.001)]

Figure 3 - Relation between the percentage of zebu blood and the percentages of saw cut, forequarter and sidecut in the carcass of steers slaughtered at 24 months.

Hereford, decreased the sidecut percentage linearly. As in this analysis the thickness of subcutaneous fat was not influenced by the degree of blood, it is believed that the second hypothesis is more plausible.

Conclusions

The crossbreeding between European and zebu breeds results in carcasses of steers with greater weight, higher yield and higher percentage of saw cut, compared with purebreds. Zebu steers have higher percentage of forequarter and lower percentage of sidecut compared with steers of European breeds.

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