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ULTRASSONOGRAPHY EVALUATION OF SHEEP CARCASS QUALITY OF SANTA INÊS BREED

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ABSTRACT

Ultrassonography is an important option to evaluate carcass composition and quality, as it is a non-invasive technique which quantifies different tissues in live animals. The objective of this study was to estimate the correlation between measurements taken *in vivo*, using ultrasound and skinfold caliper, in sheep carcasses from Santa Ines breed. Eighty-one male animals, aging 8 to 18 months, and weighting on average 31 kg live weight were used. The measures taken *in vivo* by ultrassonography were longitudinal diagonal length, longitudinal rib eye area, transversal diagonal length, and transversal rib eye area. Hot carcass weight, carcass yield, carcass fat thickness, carcass length, carcass rib eye area and retail cuts weight (leg, loin, shoulder, ribs and neck) were determined. The analyses of variance, main components, polynomial regression and correlation were carried out using SAS® statistical program. There was no difference between castrated and intact animals for carcass quality and components, indicating that castration does not provide better carcass quality. Animals with higher leg, shoulder and rib weights had lower skin weight, wither height and weight of abdominal organs, indicating a more desirable body type for selection. Body weight, body length and rib eye area by ultrasound (*in vivo*) can predict the rib eye area, leg weight, carcass length, hot and half carcass weight. However, loin, neck and rib weights, carcass yield and weight of abdominal organs cannot be predicted by these *in vivo* measurements. The measurements taken with skinfold caliper showed no significant correlations with carcass measures, which indicates that they are not efficient for prediction of carcass components and therefore should not be used.

KEYWORDS: carcass yield; castrated; correlation; regression; rib eye area; skinfold caliper.

AVALIAÇÃO ULTRASONOGRÁFICA DA QUALIDADE DE CARCAÇA DE OVINOS SANTA INÊS

RESUMO

A ultrassonografia pode ser uma importante ferramenta para a avaliação da composição da carcaça por ser uma técnica não invasiva que permite quantificar diferentes tecidos em animais vivos. O objetivo deste trabalho foi estimar as correlações entre medidas tomadas *in vivo*, por meio do ultrassom e do adipômetro, e na carcaça de ovinos da raça Santa Inês. Utilizaram-se 81 machos, entre 8 e 18 meses de idade, com peso médio de 31 kg. As medidas *in vivo* obtidas por ultrassonografia foram medida diagonal longitudinal, área de olho de lombo longitudinal, medida diagonal transversal e área de olho de lombo transversal. Determinou-se o peso de carcaça quente, rendimento da carcaça, gordura de cobertura da carcaça, comprimento de carcaça, área de olho de lombo da carcaça e peso dos cortes comerciais: pernil, lombo, paleta, costela e pescoço. As análises de variância, componentes principais, regressão polinomial e correlação foram realizadas utilizando-se programa estatístico SAS®.

Não houve diferença entre animais castrados e inteiros para qualidade e componentes de carcaça, indicando, portanto, que a castração não proporciona uma carcaça de melhor qualidade. Os animais com os pesos de pernil, paleta e costela maiores apresentam menores peso de pele, altura de cernelha e peso dos órgãos abdominais, caracterizando um biotipo de animal que seria mais desejável a ser selecionado. Peso vivo, comprimento corporal e área de olho de lombo por ultrassom (*in vivo*) podem ser usados para predizer a área do olho de lombo da carcaça, peso do pernil, comprimento da carcaça, peso da carcaça quente e da meia carcaça. No entanto, o peso do lombo, pescoço, costela, rendimento de carcaça e peso dos órgãos abdominais não podem ser preditos por estas medidas *in vivo*. As medidas realizadas com adipômetro não apresentaram correlações significativas com medidas da carcaça, o que indica que não são eficientes para esta predição e, portanto, não devem ser utilizadas.

PALAVRAS-CHAVE: adipômetro; área de olho de lombo; castrado; correlação; regressão; rendimento de carcaça.

INTRODUCTION

In Brazil the majority of sheep meat comes from animals with low quality carcass, which is probably related to genetics and to nutritional and health management. However, it is essential that producers offer high quality sheep meat, for the product to be competitive and meet the demands of the consumer market,

Among the criteria that define carcass quality, two stand out: conformation, which expresses muscle development, and finishing level, which refers to the distribution and amount of subcutaneous fat (OSORIO et al. 2002). Carcasses must have good fat coverage distribution to prevent cold shortening and consequent tenderness loss, besides intramuscular fat at moderate levels, which provides flavor and tenderness.

Research has been conducted to develop non-invasive techniques to evaluate carcass composition and quality, such as ultrasound, considered viable because it allows the quantification of muscle and fat tissues in living animals. Besides the ultrasound, the caliper is a device used to measure skin folds with a high precision level, allowing the estimation of the variations of adipose tissue in body composition.

The carcass composition can be estimated by measuring the rib eye area (REA) and subcutaneous fat thickness (SFT), taken at the insertion of the 12th and 13th ribs, which have high and positive correlation with muscle and fat distribution in the carcass, respectively. These estimates obtained by ultrasonography have also shown high repeatability and high correlations with corresponding measurements taken on the carcass after the slaughter of the animals (WILLIAMS, 2002). The evaluations of REA and SFT along with other characteristics measured on live animals, such as weight and withers height, may assist in the estimation of body composition of animals and hence estimate the carcass yield at slaughter (ROUSE et al., 2000).

The carcass quality may be influenced by breed, age, slaughter weight, and sex among other factors. In general, the carcasses of young animals show better meat quality (MÜLLER, 1993). Furthermore, it is known that consumers prefer carcasses of moderate size, between 12 and 14 kg, which determines that animals have between 28 and 30 kg of live weight at slaughter (SIQUEIRA, 1996).

The aim of this study was to verify the relationship between measurements taken *in vivo* through the use of ultrasound and skinfold caliper, with measures of carcass and retail cuts of Santa Ines sheep, verifying the possibility of using these measurements in genetic improvement programs.

MATERIAL AND METHODS

This study was conducted at the Agricultural College of Brasilia, Planaltina - DF, at Agua Limpa Farm of the University of Brasilia, and at four other private farms located in the Federal District. We used 81 male Santa Ines sheep, being 15 castrated and 66 uncastrated animals, between eight and 18 months of age, with an average weight of 31 ± 8.61 kg. We carried out the measurement of body length (BL) and withers height (WH) on the living animal with the aid of a tape measure.

We performed the *in vivo* ultrasound evaluation with the apparatus Aloka® SSD-500 equipped with a 5 MHz linear transducer. We restrained each animal and carried out the trichotomy of the area to be measured, located approximately at 12 cm from the dorsal median line, at the 12th intercostal space. With the transducer positioned parallel to the dorsal median line (longitudinal direction), we evaluated Longitudinal Diagonal Length (LDL_{US}) and Longitudinal Rib Eye Area ($LREA_{US}$). With the transducer positioned transversely, we evaluated the Transversal Diagonal Length (TDL_{US}) and Transversal Rib Eye Area ($TREA_{US}$), similar to measurements performed by SILVA et al. (2006). The LDL_{US} and the TDL_{US} provide muscle thickness estimate and $LREA_{US}$, and the $TREA_{US}$ determines muscle volume in two different dimensions. In addition to these measures, we obtained the subcutaneous fat thickness (F_{US}) with the transducer placed transversely.

We used a caliper with a tenth millimeter scale to measure the Navel Skin Thickness of the Live animal (NST-L). Before skinning of the animals, we measured the Navel Skin Thickness at Slaughter (NST-S), Right Loin Skin Thickness (RLST), Left Loin Skin Thickness (LLST), Middle Tail Skin Thickness (MTST), Right Shoulder Skin Thickness (RSST), and Left Shoulder Skin Thickness (LSST).

At the end of the experiment, the animals underwent a 24-hour water fast. After that, they were slaughtered, weighed to obtain live weight (LW), and skinned. Subsequently, the head, forelimbs and hindlimbs were withdrawn, the skin was weighed (SW) and the whole carcass was used to obtain hot carcass weight. The carcass was divided and the left half-carcass weight (HCW) was obtained. The actual hot carcass yield (CY) was determined according to methodology of OSÓRIO et al. (1998), where CY=(HCW/LW)x100.

After evisceration, we withdrew the thoracic organs (TO) – lungs, heart, trachea and diaphragm –, and the abdominal organs (AO) – liver and kidneys, which were weighed separately. For the evaluation of carcass characteristics, we used the method adapted from OSORIO's et al. (1998), evaluating carcass fat thickness (CFT) subjectively and the external fat by means of increasing indices, varying from one (lean) to five (very fat). We obtained the measure of carcass length (CL), defined as the distance between the tail and the basis of the neck, with the aid of a tape measure. We determined the carcass rib eye area (CREA) by making a transversal cut of the *longissimus* muscle between the 12^{th} and 13^{th} ribs, using a standard transparent graph template ($1cm^2$). We divided the left half carcass into five retail cuts: leg, loin shoulder, ribs and neck. We weighed each cut separately.

We verified the normality of the data and, when necessary, we transformed them by means of logarithm or arcsin (percentages). We performed analysis of variance considering, as fixed effects, the effect of castration (intact or castrated animal) and the rib eye area (linear and quadratic effect). For analysis of variance of the characteristics measured by ultrasound or caliper, we included the live weight as covariant. We carried out the analysis of main components, correlation and polynomial regression aiming at evaluating the relation between the variables measured on the live animal and on the carcass. We used the GLM, PRINCOMP, CORR and REG procedures of the SAS® statistics package to perform the statistical analyses.

RESULTS AND DISCUSSION

The means we obtained for CY (44.33%) in the present study (Table 1) were similar to the results found by BUENO et al. (2000), CUNHA et al. (2000), GARCIA et al. (2000) and OLIVEIRA et al. (2002), who studied male Santa Ines animals, with similar slaughter weight. Regarding carcass fat thickness (CFT), we obtained higher results than BUENO et al. (2000), CUNHA et al. (2000) and SILVA et al. (2000), who reported values of 1.3; 1.4 and 1.5, respectively. This higher value may be due to the evaluation criteria used by the technician, as it was a subjective evaluation, and all animals belonged to same genetic group and were slaughtered at similar live weight. On the other hand, GARCIA et al. (2000) and OLIVEIRA et al. (2002) reported similar results (2.3 and 2.4), demonstrating once again that this value can only be compared within contemporary groups, because the variation among evaluating technicians is relatively large.

Regarding the analyzed carcass characteristics, only carcass length and skin weight were significantly affected by the effect of castration (Table 1), which agrees with the results found by RIBEIRO et al. (2001) and ROCHA et al. (2010), who analyzed the carcass of Ile de France and Hampshire Down males, slaughtered at 12 months of age. These authors concluded that there were no significant differences between the carcass quality of uncastrated and castrated animals, which agrees with the results we found in this study. Therefore, the studies mentioned as well as the current study agree that sheep production systems can dismiss the use of castration as it does not improve carcass quality.

Table 1. Variance analysis and means obtained for the carcass characteristics of Santa Ines animals

	LW (kg)	Leg (kg)	Shoulder (kg)	Loin (kg)	Ribs (kg)	Neck (kg)	CL (cm)	CFT (mm)	HoCW (kg)	HaCW (kg)	SW (kg)	TO (kg)	AO (kg)	BL (cm)	WH (cm)	CY (%)
SC	ns	ns	ns	ns	ns	ns	***	ns	ns	ns	*	ns	ns	ns	ns	ns
$TREA_{US}$	ns	ns	ns	ns	ns	ns	ns	*	ns	ns	ns	ns	ns	ns	ns	ns
$TREA_{US}^2$	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
CV(%)	21.70	14.44	22.70	55.88	49.87	50.97	4.97	35.04	6.92	8.95	19.75	12.39	36.25	9.70	4.42	7.23
Mean	31.13	2.26	1.38	0.43	0.66	0.60	75.52	2.38	14.24	7.09	1.99	4.40	0.78	65.62	70.45	44.33

* P< 0.05; ** P< 0.01; *** P< 0.001; ns= non-significant; SC: Sexual condition (intact and castrated); $TREA_{US}$: transversal rib eye area measured by ultrasound; $TREA_{US}^2$: quadratic effect of the $TREA_{US}$; CV: coefficient of variation; CL: carcass length; CFT: carcass fat thickness; HoCW: hot carcass weight; HaCW: hot half carcass weight; SW: skin weight; TO: Thoracic organs; AO: abdominal organs; BL: body length; WH: withers height; CY: carcass yield.

The effect of the LW was statistically important for all the characteristics evaluated, except loin and withers height. Therefore, animals with higher live weight presented higher retail cuts weight, longer length and bigger rib eye area, as expected. The transversal rib eye area measured by ultrasound ($TREA_{US}$) did not affect statistically the characteristics evaluated, except carcass fat thickness (CFT), for which only the linear effect was significant. This indicates that this value is not related with the retail cuts weight, carcass weight and abdominal and thoracic organs weight, contradicting previous studies which showed a positive relation among carcass yield, retail cuts weight, carcass weight and rib eye area (HAMLIN et al., 1995; MAY et al., 2000; GREINER et al., 2003).

Linear and quadratic effects of transversal rib eye area measured by ultrasound ($TREA_{US}$) influenced significantly the navel skin thickness measured on the live animal (NST-L), longitudinal diagonal length measured by ultrasound (LDL_{US}) and transversal diagonal length measured by ultrasound (TDL_{US}). Only the linear effect was significant for the longitudinal rib eye area measured by ultrasound ($LREA_{US}$) (Table 2).

Table 2. Variance analysis and means obtained by ultrasound and caliper on Santa Ines animals

	CREA (cm^2)	NST-L (mm)	LDL_{US} (cm)	$LREA_{US}$ (cm^2)	$TREA_{US}$ (cm^2)	TDL_{US} (cm)	F_{US} (mm)	NST-S (mm)	LLST (mm)	RLST (mm)	MTST (mm)	LSST (mm)	RSST (mm)
SC	ns	***	***	***	***	ns	ns	ns	ns	ns	ns	ns	ns
LW	***	ns	***	***	***	***	ns	*	*	ns	ns	ns	*
$TREA_{US}$	ns	***	***	***	-	***	ns	ns	ns	ns	ns	ns	ns
$TREA_{US}^2$	ns	*	*	ns	-	**	ns	ns	ns	ns	ns	ns	ns
CV (%)	16.13	41.65	15.04	20.42	33.12	11.52	37.57	14.69	24.04	24.04	18.73	13.66	12.59
Mean	12.22	2.88	1.91	3.54	2.61	1.89	0.35	3.74	5.57	5.57	5.56	3.92	3.97

* P< 0.05; ** P< 0.01; *** P< 0.001; ns= non-significant; SC: Sexual condition (intact and castrated); $TREA_{US}$: transversal rib eye area measured by ultrasound; $TREA_{US}^2$: quadratic effect of the $TREA_{US}$; CV: coefficient of variation; CREA: carcass rib eye area; NST-L= navel skin thickness of the live animal; LDL_{US}: longitudinal diagonal length measured by ultrasound; $LREA_{US}$: longitudinal rib eye area measured by ultrasound; $TREA_{US}$: transversal rib eye area measured by ultrasound; TDL_{US}= transversal diagonal length measured by ultrasound; F_{US}: fat measured by ultrasound; NST-S: navel skin thickness measured at slaughter by a caliper; LLST: left loin skin thickness measured at slaughter by a caliper; RLST: right loin skin thickness measured at slaughter by a caliper; MTST: middle tail skin thickness measured at slaughter by a caliper; LSST: left shoulder skin thickness measured at slaughter by a caliper; RSST: right shoulder skin thickness measured at slaughter by a caliper.

Regarding the measurements obtained by ultrasound, the effect of castration (intact or castrated animals) was statistically significant for NST-L, LDL_{US}, $LREA_{US}$ and $TREA_{US}$. As for skin weight, we observed significant difference between intact and castrated animals as castrated animals presented heavier skin weight disagreeing with the findings by RIBEIRO et al. (2000), who did not verify difference in the proportion of skin between intact and castrated Ile de France animals.

Table 3 shows the correlations estimated between the characteristics evaluated *in vivo* and *post morten*. The correlations between live weight (LW) and most of the carcass characteristics, measured by ultrasound and caliper, were positive and varied from moderate to high, indicating that heavier animals present higher values of the characteristics evaluated. We obtained a correlation of 0.97 between LW and hot carcass weight (HoCW), agreeing with the results found by BONACINA et al. (2007), who concluded that the live weight of lambs was efficient to estimate hot carcass weight because it presented high correlation coefficient (0.84).

The correlations between the characteristics evaluated by caliper and by ultrasound and the leg were positive and varied from moderate to high. The correlations between the characteristics evaluated by caliper and by ultrasound and loin weight were positive and varied from low to moderate, while the correlations between the measures and carcass fat thickness (CFT), abdominal organs (AO) and navel skin thickness of the live animal (NST-L) were low and negative.

Table 3. Correlations between carcass characteristics evaluated *in vivo* and *post morten* by ultrasound

	CY	Skin	TO	AO	CREA	NST-L	BL	WH	LDL_{US}	$LREA_{US}$	TDL_{US}	$TREA_{US}$
LW	0.40^{***}	0.73^{***}	0.36^{***}	0.20	0.73^{***}	0.27^{*}	0.42^{*}	0.21	0.64^{***}	0.80^{***}	0.91^{***}	0.63^{***}
Leg	0.39^{**}	0.65^{***}	0.36^{**}	0.16	0.51^{***}	0.30^{*}	0.46^{*}	0.03	0.54^{***}	0.68^{***}	0.86^{***}	0.49^{***}
Loin	0.11	0.14	0.36^{*}	-0.05	0.21	-0.15	0.27	-0.00	0.20	0.41^{***}	0.39	0.17
Shoulder	0.34^{**}	0.53^{***}	0.30^{*}	0.17	0.37^{*}	0.32^{*}	0.25	-0.14	0.49^{***}	0.66^{***}	0.85^{***}	0.43^{***}
Ribs	0.23	0.17	0.47^{***}	0.11	0.09	-0.15	-0.19	-0.35	0.28	0.52^{***}	0.36	0.10
Neck	0.27	0.37^{*}	0.20	0.54^{***}	0.51^{***}	-0.13	0.23	0.02	0.44^{**}	0.37^{*}	0.69^{**}	0.28
CL	0.19	0.32^{*}	0.84^{***}	0.26^{*}	0.11	-0.28^{*}	0.46^{*}	0.22	-0.05	0.33^{*}	0.72^{***}	-0.12
CFT	0.36^{**}	0.36^{**}	-0.06	0.03	0.57^{***}	0.20	0.50^{*}	0.17	0.44^{***}	0.28^{*}	0.36^{*}	0.35^{**}
CW	0.59^{***}	0.73^{***}	0.29^{*}	0.24	0.73^{***}	0.46^{***}	0.42^{*}	0.20	0.67^{***}	0.80^{***}	0.91^{***}	0.62^{***}
HaCW	0.50^{***}	0.71^{***}	0.32^{*}	0.24	0.63^{***}	0.42^{***}	0.35	0.06	0.61^{***}	0.79^{***}	0.90^{***}	0.60^{***}
CY		0.34^{**}	-0.03	0.24	0.39^{*}	0.37^{**}	0.22	0.07	0.52^{***}	0.49^{***}	0.50^{**}	0.39^{**}
Skin			-0.01	0.27^{*}	0.59^{***}	0.54^{***}	0.26	0.28	0.59^{***}	0.57^{***}	0.80^{***}	0.59^{***}
OT				-0.07	-0.24	-0.52^{***}	0.26	-0.12	-0.35^{**}	0.03	0.78^{***}	-0.42^{**}
AO					0.23	-0.05	-0.04	0.12	0.12	0.17	0.85^{***}	0.04
CREA						0.36^{*}	0.52^{*}	0.26	0.58^{***}	0.48^{**}	0.37	0.45^{**}
NST-L							0.15	0.22	0.61^{***}	0.38^{***}	0.64^{***}	0.68^{***}

* $P< 0.05$; ** $P< 0.01$; *** $P< 0.001$. LW: live Weight; CY: carcass yield; TO: Thoracic organs weight; AO: abdominal organs weight; CL: carcass length; CFT: carcass fat thickness (visual observation at slaughter, 1-5); CW: carcass weight; HaCW: half carcass weight; BL: body length; WH: withers height; CREA: carcass rib eye area; NST-L: navel skin thickness of the live animal (caliper); LDL_{US}: longitudinal diagonal length measured by ultrasound; $LREA_{US}$: longitudinal rib eye area measured by ultrasound; $TREA_{US}$: transversal rib eye area measured by ultrasound; $TREA_{US}$: transversal rib eye area measured by ultrasound. Measurements by caliper at slaughter and subcutaneous fat thickness measured by ultrasound were not displayed because they did not show statistically significant correlations with the results displayed at the table.

The measures we obtained by ultrasound presented high correlation with hot carcass weight (HoCW) and half carcass weight (HaCW), indicating that heavier animals will present higher measures for the other carcass characteristics. On the other hand, the measures obtained by caliper presented moderate to low correlations for HoCW and HaCW. MARTINS et al. (2004) studied lambs and observed that REA_{US} presented high correlation with carcass characteristics, such as HoCW, HaCW and CL. BONACINA et al. (2007) estimated positive correlations, varying from moderate to high, among measures by ultrasound and hot carcass weight, body weight, conformation and carcass yield.

Generally, measures obtained by ultrasound presented positive correlations between 0.40 and 0.60 and statistically significant with the measures of CREA. CREA was positively and favorably correlated with carcass fat thickness and with valued cuts such as loin and leg, which agrees with the results found by WILLIAMS (2002). Besides, muscle measures by ultrasound presented positive, high and statistically significant correlations with leg and shoulder weight. Therefore, ultrasound measurements can be useful to predict the yield of these retail cuts. These results agree with the findings by WILLIAMS et al. (1997), who concluded that carcass characteristics evaluated by ultrasound along with the live weight (LW) are good to predict carcass and retail cut weights of bovines. SILVA et al. (2003) verified that both subcutaneous fat (F_{US}) as the transversal rib eye area measured by ultrasound ($TREA_{US}$) presented linear growth in function of body weight.

Figure 1 shows two eigenvectors of the analysis of the main components, which explain 63% of the total variation among the characteristics. By observing the first eigenvector, we noticed that one animal with high live weight also presents high retail cuts weight, as expected. This finding agrees with BUENO et al., (2000), who reported a linear growth of hot and cold carcass weight, cuts weight and components weight, indicating the tissue increase in the carcasses due to the increase in live weight of the animals. FERNANDES et al. (2008) verified that lambs slaughtered at higher weight obtained higher hot carcass yield based on empty body weight, which may be explained by the higher proportion of carcass weight related to live weight due to smaller digestive system content.

The second eigenvector revealed that the animals with heavy leg, shoulder and ribs presented smaller skin weight, wither height and abdominal organs weight, characterizing a more desirable biotype of animal for selection. BEZERRA et al. (2010) reported similar results after observing higher commercial yield in undefined breed goats associated to smaller weight of the non-carcass components, specially the lighter weight of the rumen/reticulum set. JENKINS & LEYMASTER (1993) verified that the percentages of liver, lungs and kidneys, in relation with the empty body weight (EBW), are higher at birth and decrease with aging. According to OSÓRIO et al. (2002), the proportion of skin weight in relation to the live weight decreases with aging, which agrees with the findings in this study.

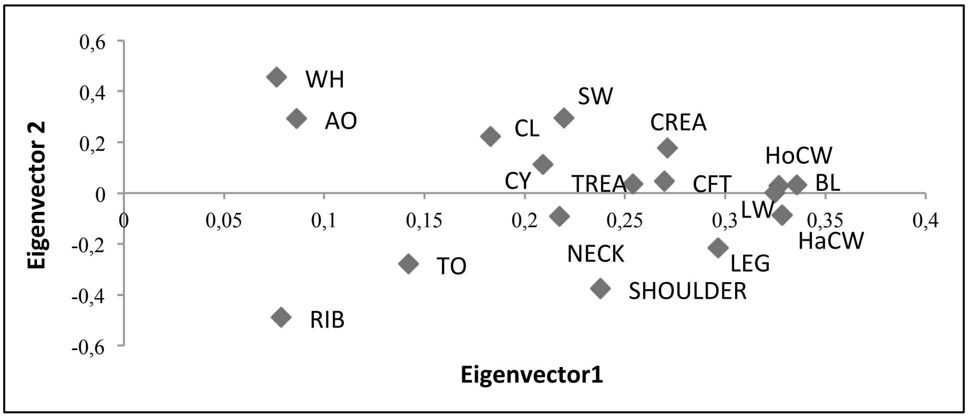

Figure 1. First eigenvectors for the carcass characteristics of Santa Ines in DF.
LW= Live weight; WH= wither height; SW= Skin weight; AO= Abdominal organs; BL= Body length; CREA= Carcass rib eye area; CY= Carcass yield; TREA= Transversal rib eye area; CFT= carcass fat thickness; HoCW= Hot carcass weight; CL= Carcass length; HaCW= hot half carcass length; TO= Thoracic organs.

Table 4 displays the regression equations using the studied carcass characteristics and components as dependent variables, and the measures taken by ultrasound, live weight, withers height and body length as independent variables. Therefore, the objective of these regression equations was to evaluate if the measures obtained in vivo may be used to predict carcass and retail cuts weight obtained after slaughter.

Among the ultrasound measures, only $TREA_{US}$ had a statistically significant effect for the variables CY and CREA. CREA presented regression with high coefficient of determination (R^2=0.70), and had body length and $TREA_{US}$ as independent variables; thus, we could predict CREA with these *in vivo* measures. DELFA et al. (1995)

used ultrasound and observed that from 75 to 95% of the variation in the retail cuts weight were explained by multiple regression models that consider the live weight, the muscle depth and the lumbar and sternal subcutaneous fat thickness in the equation These authors also reported that 59 to 86% of the variation in carcass fat total weight was explained by the variation in live weight and subcutaneous fat thickness at 13th rib and that these equations explained 73 to 83% of the variation in the subcutaneous fat thickness of the carcass.

Table 4. Significant regressions for carcass characteristics measures taken by ultrasound and the live weight

Dependent Variable	R^2	Equation
Leg	0.65	= -0.255+0.0799*LW
Shoulder	0.42	= 2.88-0.0453*WH+0.0532*LW
Loin	ns	
Neck	0.27	= -0.6408+0.0387*LW
Ribs	0.12	= 4.007-0.045*WH
CL	0.77	= 62.4594+0.6049*LW
CFT	0.57	= -1.966+0.124*LW
HoCW	0.92	= $6.298+0.0074*LW^2$
HaCW	0.82	= $3.487+0.0035*LW^2$
CY	0.21	= $39.8248+1.338*TREA_{US}^2$
SW	0.40	= - 0.154+0.060*LW
TO	0.30	= $5.266+0.0031*LW^2$
AO	ns	
CREA	0.70	= $-11.838+0.186*BL+6.154*TREA_{US}$

CL= carcass length; CFT= carcass fat thickness; HoCW= hot carcass weight; HaCW= hot half carcass weight; CY= carcass yield; SW= skin weight; TO= thoracic organs; AO= abdominal organs; CREA= carcass rib eye area; BL= Body length; WH= withers height; LW= live weight; $TREA_{US}$= transversal rib eye area measured by ultrasound; $LREA_{US}$= longitudinal rib eye area measured by ultrasound; ns=non-significant.

The characteristics leg weight, carcass length hot carcass weight and hot carcass weight had regression with coefficient of determination above 0.60; thus, the measures taken *in vivo* are good to predict these carcass measures. Therefore, genetic improvement programs, whose selection objectives are the characteristics rib eye area, leg weight, carcass length and weight may use *in vivo* live weight, body length and $TREA_{US}$ as selection criteria. These measurements are cheaper and can be done in a greater number of animals, because it is not necessary to slaughter the animals in order to obtain the measures.

HASSEN et al. (1998; 1999) verified the viability of using ultrasound measurements to estimate the carcass composition in bovines, and reported that the model which considered LW, REA_{US} and SFT explained up to 81% of the HoCW. Comparatively, the results of the present study showed a higher coefficient of determination for HoCW (92%), using only the LW as independent variable.

For AO and loin weight, the regression equations estimated were not significant. For neck and ribs weight and CY we obtained low coefficients of determination ($R^2<0.30$). Therefore, *in vivo* measurements carried out in this study should not be used to predict these retail cuts, carcass yield and abdominal organs weight.

CONCLUSION

There was no difference between castrated and intact animals regarding carcass quality and components, indicating, thus, that castration does not produce better carcass quality. The animals with higher leg, shoulder and ribs weight presented lower skin weight, withers height and abdominal organs weight, characterizing an animal biotype more desirable for selection. The *in vivo* measures of live weight, body length and rib eye area taken by ultrasound may be used to predict carcass rib eye area, leg weight, carcass length, hot carcass weight and half carcass weight. However, loin, neck and ribs weight, carcass yield and abdominal organs weight cannot be predicted by these *in vivo* measures. The measurements taken by caliper did not present significant correlations with carcass measures, indicating that they are not enough to predict and hence should not be used.

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