ESTIMATION OF CARCASS AND EMPTY BODY COMPOSITION OF ZEBU BULLS USING THE COMPOSITION OF RIB CUTS[1]

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ABSTRACT: Determination of body composition is very important in nutritional and growth regulation studies. However, determination of body composition by grinding and analyzing all tissues is unfeasible as an experimental routine. The objective of this study was to test methodologies for body composition estimation. Linear measurements and chemical composition of the 9-10-11th and 10th rib sections were used to estimate chemical composition of 31 Nellore (Zebu) intact males with an average 333.5 kg body weight (range of 180.5 to 496.0) and 16.1% empty body lipid (range of 10.6 to 22.1). Composition of ribs, carcass and empty body were obtained by quantitatively grinding, homogenizing and sampling all body tissues. The 9-10-11th composition was a good estimator of body composition with r^2 of 0.99; 0.98; 0.98 and 0.91 for estimates of kg water, lipid, protein, and ash; with low standard errors of the estimate. Results with the 10th rib cut were similar (r^2 of 0.98, 0.98, 0.97 and 0.88 for the same regressions). Data are in the range of published results, however coefficients of regression were statistically different from those published for *Bos taurus* populations. Rib cut composition is a good parameter for the estimation of chemical body composition, but specific equations must be used for Zebu animals.
Key Words: bovinos, body composition, rib cut, zebu

ESTIMATIVA DA COMPOSIÇÃO CORPORAL DE TOURINHOS NELORE ATRAVÉS DA COMPOSIÇÃO DE CORTES DE COSTELA

RESUMO: A determinação da composição corporal é fundamental em estudos nutricionais e da regulação do crescimento. Entretanto, a determinação direta é impraticável como rotina experimental. O objetivo deste estudo foi testar metodologias para estimar a composição química corporal. A composição da secções da 9-10-11ª e da 10ª costelas foram empregadas para estimar a composição corporal de 31 tourinhos Nelore com média de 333,5 kg de peso (variação de 180,5-496,0) e 16,1% de lípideo no corpo vazio (variação de 10,6-22,1). A composição dos costelas, carcaça e corpo vazio foram obtidas através de moagem quantitativa de todos os tecidos. A composição da 9-10-11ª costelas foi um bom estimador da composição com r^2 de 0,99; 0,98; 0,98 e 0,91 para as estimativas de kg de água, lipídeo, proteína e cinzas com baixo desvio padrão da estimativa. Os resultados com a secção da 10ª costela foi similar (r^2 de 0;98, 0,98, 0,97 e 0,88 para as mesmas regressões). Dados são consistentes com resultados da literatura, entretanto os coeficientes lineares das regressões foram estatísticamente diferentes daqueles publicados para *Bos taurus*. A composição de secções das costelas é um bom parâmetro para estimar a composição corporal, mas equações específicas devem ser utilizadas para zebuínos.
Descritores: bovinos, composição corporal, cortes das costelas, zebu

INTRODUCTION

The determination of body composition is very important in nutritional investigations as well as in studies that evaluate growth regulation. However, in large animals, direct determination of body composition by grinding and analyzing all body tissues is impossible as an experimental routine. Several methods have been described for the estimation of body composition in cattle. Methodologies for "in vivo" estimation are promising because they allow for repeated

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measurements in a single animal. However linear measurements (TRENKLE, 1986), ultrasound (BAILEY *et al.*, 1986) and urea space (PRESTON e KOCH, 1973) have not been able to accurately predict chemical composition. Dilution techniques using tritium and deuterium have been considered the most hopeful, but its high cost (ROBELIN, 1984) and inconsistent accuracy (ARNOLD *et al.*, 1986) make its use justifiable only under certain experimental conditions.

Several methods that require slaughter of the animals have also been evaluated. Weight and linear measurements taken from the carcass have not shown good precision in estimating carcass or body composition. Carcass specific gravity has been widely used for the estimation of body composition (GARRET & HINMANN, 1969; PRESTON *et al.*, 1974) but poor predictions were obtained when the technique was applied to populations leaner than steers from british breeds fed on grain to high liveweights (KELLY *et al.*, 1968; GIL *et al.*, 1970; LANNA *et al.*, 1988).

Early work established the composition of various rib cuts as good estimators of empty body composition (LUSH, 1926; HOPPER, 1944; HANKINS & HOWE, 1946), and these have been confirmed by more recent reports (GEAY e BERANGER, 1969; ROBELIN *et al.*, 1975). However some studies have shown that the predictive equations do vary between sex (HANKINS & HOWE, 1946) and also between breeds (ALHASSAN *et al.*, 1975). The objective of this work was to test the rib composition as an estimator of body composition and to develop equations for a population of Zebu animals which represent about 80% of the commercial beef herd in Brazil.

MATERIALS AND METHODS

The 31 animals used in this study were purebred Nellore from a research station herd of the Instituto de Zootecnia of São Paulo State. At the start of the experiment sixteen were one year old and fifteen were two years old with all animals being raised exclusively on pasture without supplementation. Individual ages as well as birth, weaning and intermediary weights and heights were recorded. Four animals of the one year old group and three from the two year old group were slaughtered after being fed for 15 days a typical feedlot ration of corn silage and concentrate (60:40 proportion in the dry matter). The rest of the animals were fed the same diet at two levels of intake (ad libitum and 65% of ad libitum) for 3 to 6 months before slaughter, allowing for a wide range of weight and degree of fatness.

Animals were slaughtered at the meat laboratory and rapidly and carefully processed. Shrunk liveweights were obtained after a 16 hour fast of food and water. After cerebral concussion the esophagus and rectum were tied, the blood was quantitatively collected, weighted and sampled. The carcass and head were carefully separated in half, with the kidney and pelvic fat being cut and stored in plastic bags before hot carcass weights were recorded. The left half of the head, the left half of the carcass the two left feet and the visceral organs were also stored in plastic bags and frozen. The digestive tract was immediately cleaned by hand and all tissues stored in plastic bags and frozen. The hide was divided in half and not frozen but stored in a cooler before grinding.

All frozen tissue was cut with an electric saw and ground in a large meat grinder (Herman P-33A-3-789, 15 H.P., São Paulo, SP) five times trough a 30 mm plate and the last two trough a 12 mm plate when a 2 kg sample of the homogenate was taken. The chilled hide was cut in small pieces and ground through the same meat grinder. About 400 grams of the samples were lyophilized in quadruplicate in petri dishes to constant weight and then ground with dry ice through a 2mm screen. Protein was determined by a Macro-Kjedhal procedure and the result multiplied by 6.25. Ether extract percentage was calculated from the weight loss of the sample after 30 hours of extraction in a soxhlet apparatus. Ash was determined after 16 hours in a furnace at 550 degrees celsius.

The 9-10-11th rib cut was obtained from the right side carcass according to HANKINS & HOWE (1946). The 10th rib cut sample was obtained from the left carcass according to LEDGER & HUTCHINSON (1962) and then cut ventrally at the end of the rib bone. The entire rib cut with bones was ground in the same grinder and then chemical analysis performed as for other body tissues. The 9-11th rib cut was obtained from all the 31 animals used in this experiment and the 10th rib cut was obtained from the last 24 animals slaughtered. The means and standard deviations for the variables in the populations used to derive rib cut prediction equations are in table 1.

Statistical analyses and regressions were performed using a standard analysis package

(SISREG, System for Regression Analysis, MATTIOLI & SCAFFI, 1988). The best multiple equations were chosen based on r^2 and the Cp statistic values (MALLOWS, 1973). The equations were tested for the presence of outlyers after the residuals for the equations that estimate body components in kilograms were standardized for body weight, with no values being excluded from any equation. The model and procedures described by ROBELIN *et al.* (1975) were utilized for the estimation of the number of experimental units required to determine significant differences between two groups of animals:

$$D_{(.05)} = t_{.05}\sqrt{\frac{2}{N}(b^2 V_x + S_{xy})}$$

where N is the number of experimental units; $t_{.05}$ is the value of t for two degrees of freedom; D(.05) is the difference between groups that can be shown at 95% probability; V_x is the variance of the predicting variable; and $S_{x.y}$ is the residual error of the estimate.

RESULTS AND DISCUSSION

The best equations chosen to estimate the chemical components in the empty body based on the composition of the 9-11th rib cut and the 10th rib cut are in TABLES 2 and 3 respectively. Results indicated high coefficients of determination and low standard errors of the estimate, confirming that the chemical composition of rib cuts is a good estimator of carcass and empty body chemical composition. Results obtained with both rib cuts were almost identical, specially when comparisons were made only on the 24 animals for which the 10th rib cut was dissected (results not shown).

In TABLES 2 and 3 two different equations predicting amount (in kilograms) of the chemical components were developed, one using carcass weight and the other not. When carcass weight was given to the computer as an independent variable it was always included in the regressions, indicating it increased r^2 and decreased Cp. However, several different treatments can alter the relationship between carcass weight and body composition, among them: concentration of energy in the diet (WOODY *et al.*, 1983), compensatory growth (DREW, 1971) and hormonal treatments such as β-adrenergics (REEDS *et al.*, 1988), estrogenic compounds (TRENKLE & MARPLE, 1983) and somatotropin (BOYD *et al.*, 1991). Thus, the best equations that did not use carcass weight as a parameter were also derived from data.

It has been demonstrated that treatments like β-adrenergic infusion can also alter the relationship between carcass and empty body composition (BOYD *et al.*, 1991). Under these circunstances the precision with which rib cut composition predicts empty body composition should be decreased. Because several techniques including specific gravity and rib cuts composition use carcass measurements, further work should test the hypothesis that different treatments might alter the relationships between carcass and non-carcass tissues.

High precision for the estimates for lipid and water in both the carcass and the empty body have been consistently obtained by several authors (LUSH, 1926; HOPPPER, 1944; HANKINS & HOWE, 1946; ROBELIN & GEAY, 1976), however the linear coefficients of the regressions, as well as the intercepts, have differed for different populations (HANKINS & HOWE, 1946; ALHASSAN *et al.*, 1975). The coefficients for simple and multiple regressions of this work differ from those determined by ALHASSAN *et al.* (1975) for Angus and Hereford steers (TABLE 4). The equations shown in TABLE 4 for Nellore bulls are not the best fit equations, but those using amount of lipid in the rib cut and carcass weight as variables (TABLE 4), allowing a comparison of our results with those of ALHASSAN *et al.* (1975). Even though a direct comparison with another study is complicated by different experimental conditions, it was observed that the values for the linear coefficient of regression for the prediction of empty body fat for both Angus and Hereford (b = 95.4 and 62.1 respectively) are outside the confidence interval found for the coefficient of regression for Nellore animals (b = 58.2) of this work with P<.01 and P<.07 respectively (TABLE 4). It should be noted that large errors would result from the interchangeable use of these equations, nevertheless relationships which had not been validated have been used to estimate body composition and nutrient requirements of Zebu animals.

Although breed differences were demonstrated and that sex differences had been previously reported (HANKINS & HOWE, 1946), some limited observations indicate that equations in this study (TABLE 4) may be applicable to animals on pasture which had lost up to 50 kg of live weight during the dry period (Figure 1). Presumably the relationship between the 9-11th rib cut composition and empty body composition is not altered by nutritional treatments. This indicates that the technique can be used to predict the composition of animals which have gained and lost weight, as is commonly observed under pasture systems in tropical conditions.

As previously reported in the literature (HOPPER, 1944; ROBELIN *et al.*, 1975), equations estimating protein and ash concentration had lower predictive value (TABLE 1 and 2). This lack of precision is more evident in populations with a narrow range of variation in fat-free mass content (ROBELIN *et al.*, 1975; ROBELIN e GEAY, 1976). Already in 1926 Lush had suggest that the amount of ash in an animal should be estimated indirectly using the relationships of the chemical components in the fat-free matter (LUSH, 1926).

Several experiments in the literature tested the effects of nutritional and hormonal treatments using indirect techniques to estimate body composition. Some authors have performed standard statistical analysis to these data as if predictions were equal to the actual body composition. As previously noted by ROBELIN *et al.* (1975) this is statistically incorrect. A more rigorous approach should account for the predictive equation error and also the random error involved in any sampling of a population. In TABLE 5, using a formula that includes both sources of error, the number of experimental units required to detect a difference as significant was determined. This seems to be the most objective way to evaluate the potential of predictive equations developed in this and other work. It is also very helpful in the design of future work.

TABLE 1 - Value for dependent and independent variables including empty body (EB) and rib cut (RC) composition for the 31 animals used to develop the regressions (S, standard error; MAX, maximal value; MIN, smallest value).

VARIABLE	MEAN	S	MAX.	MIN.
Live weight, Kg	333.5	87.5	496.0	180.5
Age, days	622.7	201.9	904.0	302.0
Carcass weight, Kg	193.7	54.1	293.8	103.9
Hip height, cm	139.0	7.2	151.5	122.0
EB water, %	62.1	2.9	66.7	56.5
EB lipid, %	16.1	3.3	22.1	10.6
EB protein, %	19.1	0.7	20.4	17.1
EB ash, %	4.6	0.4	5.4	3.9
9-11th RC weight, kg	3.3	1.0	5.0	1.7
9-11th RC water, %	56.6	3.8	63.8	50.5
9-11th RC lipid, %	20.0	4.9	11.4	27.6
10th RC weight, kg	1.8	0.5	3.0	1.0
10th RC water, %	55.0	3.9	62.8	48.4
10th RC lipid, %	21.6	5.2	30.7	11.9

TABLE 2 - Best equations to estimate empty body composition based on the amount (K, kg of the component) and content (percent, %) of the chemical components (W, water; L, lipid; P, protein; A, ash) of the 9-11th rib cut (RC) and hot carcass weight (HCW). $S_{x,y}$ is the standard error of the estimate.

Empty body component	Intercept	Regression Coefficients								r^2	$S_{x,y}$
		%LRC	%LRC²	KLRC	KWRC	KPRC	%ARC	KARC	HCW		
Water, %	67.3		-0.0136							.93	0.8
Water, kg	6.2			-42.2	13.7				0.935	.99	2.5
Water, kg	21.2	1.74			70.2					.91	13.9
Lipid, %	8.9		0.0161							.95	0.8
Lipid, kg	5.6			46.4	-19.6				0.246	.98	1.1
Lipid, kg	8.1		0.0235	45.5						.95	4.9
Protein, %	-									.46	-
Protein, kg	-2.1			-10.9					0.344	.98	3.8
Protein, kg	64.2					75.4				.89	5.3
Ash, %	-									.22	-
Ash, kg	1.0						13.4		0.053	.91	1.1
Ash, kg	12.9						-1.82	60.3		.87	1.3

TABLE 3 - Best equations to estimate empty body composition based on the amount (K, kg of the component) and content (percent, %) of the chemical components (W, water; L, lipid; P, protein; A, ash) of the 10[th] rib cut (RC) and hot carcass weight (HCW). $S_{x,y}$ is the standard error of the estimate.

Empty body component	Intercept	Regression Coefficients[a]									
		%LRC	KLRC	%WRC	KWRC	%PCR	KPCR	KARC	HCW	r^2	$S_{x,y}$[b]
Water, %	71.7	-0.489								.92	2.48
Water, kg	-82.8			1.75					.874	.98	5.20
Water, kg	151.3			-1.53	127.8					.91	12.4
Lipid, %	3.1	0.595								.93	0.91
Lipid, kg	1.3		78.1		-38.4				.277	.98	3.01
Lipid, kg	4.3	0.676	82.1							.95	4.94
Protein, %	-									.44	-
Protein, kg	-25.5					1.48			.291	.97	2.42
Protein, kg	55.1			-0.66	42.9					.91	4.27
Ash, %	-									.23	-
Ash, kg	1.5							13.76	.050	.88	1.4
Ash, kg	3.3						25.1	32.95		.84	1.4

TABLE 4 - Equations predicting empty body lipid in different breeds of cattle. Equations for Angus and Hereford are from Alhassan *et al.* (1975). Predictive equations abreviations are: KLEB, kg of lipid in the empty body; KLRC, kg of lipid in the 9-10-11[th] rib cut; HCW, hot carcass weight. CVR is the coefficient of variation of the estimate.

BREED	EQUATION	r^2	CVR
Angus	KLEB = - 3.99 + 95.40 KLRC	0.82	16.1
	KLEB = -49.30 + 31.30 KLRC + 0.50 HCW	0.94	9.4
Hereford	KLEB = 15.34 + 62.17 KLRC	0.95	10.8
	KLEB = -11.49 + 44.08 KLRC + 0.22 HCW	0.96	10.1
Nellore	KLEB = 8.77 + 58.23 KLRC	0.95	10.8
	KLEB = - 1.73 + 42.63 KLRC + 0.11 HCW	0.95	10.2

TABLE 5 - Number of experimental units required to observe significant differences (P=.05) between two groups of animals using equations developed in this work. Abreviations: G, grams of the chemical component; RC, 10[th] rib cut; W, water; L, lipid; P, protein; A, ash; $S_{x,y}$, standard error of the estimate; V_x variance of the predicting variable.

Empty body					Experimental units for differences of	
component	Parameter	r^2	$S_{x,y}$	V_x	10%	5%
Water, %	%WRC	0.92	0.8	3.9	-	2
Water, kg	GWRC	0.89	13.1	270	4	15
Lipid, %	%LRC	0.93	0.9	5.3	9	34
Lipid, kg	GLRC	0.94	5.1	196	8	32
Protein, kg	GPRC	0.89	4.5	90	5	19
Ash, kg	GARC	0.77	1.6	28	11	45

CONCLUSION

The rib cut composition was confirmed as a precise estimator of body composition in Zebu intact males. The technique greatly reduces labor and expenses over the direct analysis of all body tissues. The major draw-back from its use is the need to slaughter the animal. The results from this experiment have confirmed that the technique requires the development of specific equations for Zebu animals.

Large errors in the estimation of body composition, nutrient requirements and feed efficiency would result from the use of equations developed for european breeds. Equations were developed for Zebu intact males which can be used in future experiments.

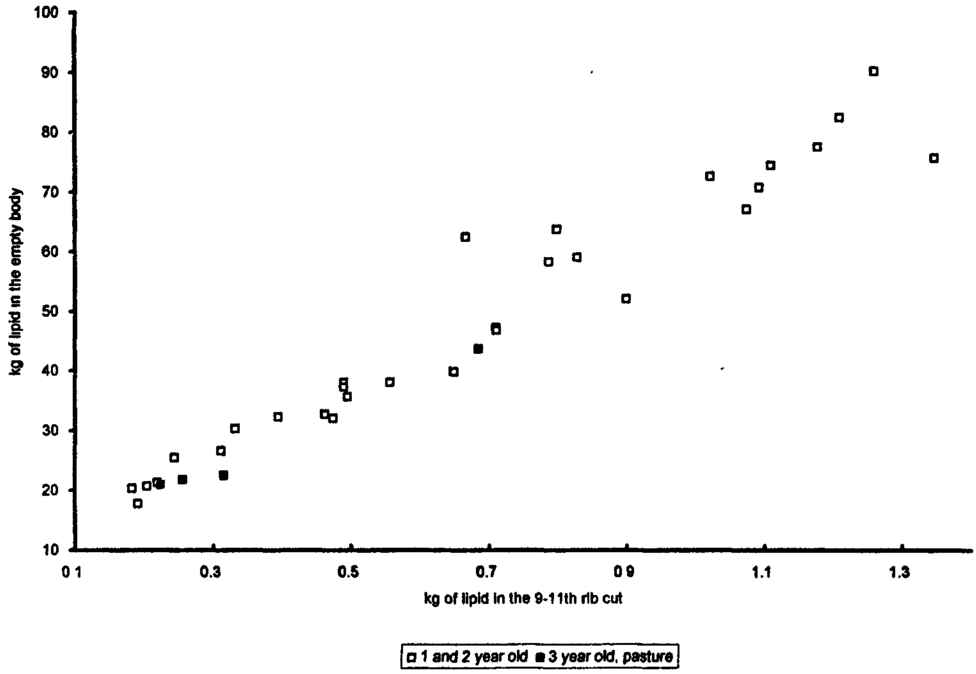

Figure 1. Plot of the individual data points of the regression between amount of lipid in the 9-11th rib cut and amount of lipid in the empty body. Data from 4 bulls, three years old, which had lost an average of 47 kg during the dry period were included.

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