PREDICTION EQUATIONS FOR ESTIMATING CARCASS YIELDS IN NELLORE AND NELLORE CROSSBRED CATTLE[1]

ALBINO LUCHIARI FILHO[2] and DELL M. ALLEN[3]

ABSTRACT - Carcass data were used to develop equations for predicting weights of several cut-out yields for bulls from two experiments conducted at the Instituto de Zootecnia in São Paulo, Brazil. These data of 72 young bulls were obtained from 32 Nellore, 18 1/2 blood Marchigiana-Nellore, 12 1/2 blood Chianina-Nellore and 10 1/4 blood Marchigiana-Nellore. Equation 1, used to predict weight of trimmed total carcass cuts (Y = -6.8074 + 0.8021 (chilled carcass weight in kilograms - 3.1021 (kidney and pelvic fat percentage) + 0.2743 (fat thickness in millimiters)), would seem to be the most useful, since it utilizes three easily obtainable variables and is highly accurate (R^2 = 0.96). Chilled carcass weight was the independent variable with the greatest contribution in all prediction equations. All the models included chilled carcass weight and kidney and pelvic fat percentage as independent variables.

Index terms: Marchigiana, Chianina.

EQUAÇÕES PARA PREVISÃO APROXIMADA DE RENDIMENTO DE CARCAÇA EM GADO NELORE E NELORE MESTIÇO

RESUMO - Foram utilizados os resultados obtidos com dois trabalhos experimentais conduzidos no Instituto de Zootecnia, em São Paulo, no desenvolvimento de equações para estimar várias características de carcaça. Dados de carcaça de 72 tourinhos jovens, sendo 32 Nelore, 18 1/2 sangue Marchigiana-Nelore, 12 1/2 sangue Chianina-Nelore e 10 1/4 Marchigiana-Nelore foram usados no desenvolvimento das equações. A equação 1, usada para estimar o peso da porção comestível da carcaça (Y = -6,8974 + 0,8021 (peso da carcaça resfriada em quilogramas) - 3,1021 (percentagem de gordura renal e pélvica + 0,2743 (espessura de gordura em milímetros), parece ser a mais útil, pois utiliza somente três variáveis, que são facilmente obtidas, alem de ser de grande precisão (R^2 = 0,96). O peso de carcaça resfriada foi a variável que apresentou a maior contribuição no desenvolvimento das equações. Todos os modelos estudados incluíam o peso de carcaça resfriada e a percentagem de gordura renal e pélvica como variáveis independentes.

Termos para indexação: Marchigiana, Chianina.

INTRODUCTION

The development of prediction equations to estimate carcass composition in beef cattle is very important since research is costly and in many cases important growth, breeding and nutritional projects are not carried completely through a final carcass evaluation due to the high cost of accurately determining composition, as well as the non-existence of adequate research facilities. The presence of muscling differences and lower fat percentages in bull carcasses suggest that different cutability equations may be necessary for bulls versus steers versus heifers.

Cole et al. (1960) observed that of all variables investigated, separable round tissues gave the most precise estimate of total carcass muscling. Separable lean of a particular cut of beef was found to be more descriptive of carcass leanness or muscling than either the loin eye area or other carcass measurements. Separable bone weight of the entire carcass was highly correlated with total separable carcass lean (r = 0.75).

Carcass weight alone was more closely related to separable lean (r = 0.75) than were combinations of carcass length and loin eye area or carcass length, loin eye area and 12th rib fat thickness (Cole et al. 1962). The authors concluded that probably the most valuable prediction equation was that which included only 12th rib fat thickness and carcass weight.

Brungardt et al. (1963) observed that percent trimmed round made the largest contribution to the multiple correlation coefficient in predicting

1 Accepted for publication on October 23, 1986.
Part of a Master's thesis submitted to Kansas State University for the degree Master of Science.

2 Seção de Avaliação e Classificação do Gado de Corte, Instituto de Zootecnia, São Paulo, Brasil.

3 Department of Animal Sciences and Industry, Kansas State University, Manhattan, Kansas 66506 - USA.

percent retail yield. When loin eye area was included in the equation with a single 12th rib fat measurement, percent kidney knob and left side weight, it made a significant improvement in the precision of the estimate. All fat measurements studied had highly significant simple correlations with percent retail yield.

All correlations between fat thickness and percent boneless and partially boneless retail cuts were negative and significant (Hedrick et al. 1965). The subcutaneous fat thickness measurement was associated with two to three times as much of the variation in retail yields as were Longissimus dorsi measurements.

Field et al. (1966) used 12th rib fat depth, percent kidney fat, loin eye area and carcass weight to predict weight and percent of muscle, bone and fat in bull carcasses. These four independent variables accurately predicted weight of fat, muscle and bone (R^2 = 0.90, 0.98 and 0.93 respectively). These workers concluded that carcass weight alone was a good indicator of weight of muscle, bone and fat in bull carcasses of varying sizes.

Allen (1968), studying the carcasses of 80 steers equally divided into light and heavy weight groups, and four fat thickness cells, observed that fat thickness was negatively correlated with measurements of muscling and bone and positively correlated with measurements of fat.

Abraham et al. (1968) found that carcass weight was the most important variable in multiple regression equations for predicting weight of boneless closely trimmed loin, rib, rump, cushion round and chuck (boneless steak and roast meat). Fat thickness, kidney fat weight, loin eye area and wholesale round weight also contributed significantly to equations for predicting weight of boneless steak and roast meat. These workers observed that fat thickness was the most important variable in multiple regression equations predicting percent of boneless steak and roast meat.

Epley et al. (1970) studied regression equations predicting total weight of retail cuts using hot carcass weight, loin eye area, fat thickness and kilograms of kidney, pelvic and heart fat as predictors. Variation in hot carcass weight explained more of the variation in total weight of retail cuts than did the other three predictors. When hot carcass weight, fat thickness and kidney pelvic and heart fat were or were not held constant, loin eye area was the least valuable predictor of both percent total and percent primal retail cuts. Hot carcass weight was the single most valuable predictor of total primal retail cut weights (fat thickness least valuable) but fat thickness was equally as valuable as hot carcass weight in predicting percent retail cuts (loin eye area least valuable).

Nelms et al. (1971) observed that carcass weight, percent kidney and pelvic fat and fat depth were the only variables marking a significant contribution in the equation for predicting weight of retail cuts, with weight accounting for most of the variation. Fat depth and percent kidney and pelvic fat were the only variables making a significant contribution to the equation for predicting percent retail cuts. Presented in this paper are several prediction equations to estimate carcass composition in beef cattle which may be utilized in situations where carcass evaluation is needed, but can not be done due to a lack of time, money or facilities.

MATERIALS AND METHODS

Data were obtained from 72 animals raised under similar environmental conditions from birth to slaughter. These data were used to develop some regression equations for estimating cutability and other carcass traits of interest in Nellore and Nellore crossbred cattle. These 72 animals consisted of 32 purebred Nellore bulls, 18 one--half bood Marchigiana-Nellore, 12 one-half blood Chianina-Nellore and 10 one-quarter blood Marchigiana-Nellore crossbred bulls which were part of two experiments conducted at the Instituto de Zootecnia, São Paulo. The range in age and live weight across all treatments at slaughter were from 24 to 28.5 months and from 437.0 kg to 513.5 kg respectively.

Experimental design, rations fed and slaughter procedures have been described in Luchiari Filho et al. (1981) and Luchiari Filho (1981).

After a 24-hour chill period, one half of each carcass was separated into retail cuts, fat trim and bone. All yields obtained from the fabrication of each side were doubled to represent the total amount of product on a carcass basis. Carcass length was measured from the anterior edge of the first rib to the anterior edge of the aitch bone. Loin eye area was measured at the 12th rib and fat thickness over the 12th rib at the three-fourths, the distance from the medial to the lateral end of the Longissimus dorsi muscle. Kidney and pelvic fat was weighed and expressed as a percentage of the chilled carcass weight.

Several prediction equations were developed in which chilled carcass weight kidney, and pelvic fat percentage, loin eye area, fat thickness over the 12th rib and carcass length were used as independent variables to estimate several carcass traits of economic importance.

The dependent variables that were predicted using these equations were: 1) weight of total carcass trimmed retail cuts (Y1); 2) weight of trimmed special hindquarter retail cuts (Y2); 3) weight of forequarter trimmed retail cuts (Y3); 4) weight of total carcass bone (Y4), and 5) weight of trimmed special hindquarter and forequarter cuts (Y5).

The models were built using the Backward Elimination Stepwise Regression procedure on the SAS Institute (1979).

RESULTS AND DISCUSSION

The mean, standard deviation, minimum and maximum values for each trait studied are presented in Table 1.

Equations 1, 2 and 3 (Table 2) predict weight of total carcass trimmed retail cuts. Equation 1 was the most accurate equation developed and used the independent variables chilled carcass weight, kidney and pelvic fat percentage and 12th rib fat thickness. Equation 2 is presented since it includes only chilled weight and kidney and pelvic fat percentage and thus, may be the easiest to be applied. This equation, using only these independent variables, had a very high coefficient of determination ($R^2 = 0.95$). When carcass length and loin eye area were included as independent variables to estimate weight of total carcass trimmed retail cuts, equation 3 had an R^2 value equal to that of equation 1 ($R^2 = 0.96$). Of all independent variables, chilled carcass weight made the greatest contribution in all equations for the prediction of weight of trimmed retail cuts. This should be expected since in predicting the weight of the parts of a carcass, the weight of the whole carcass is a major influencing factor. These results agree with results obtained by Abraham et al. (1968), Epley et al. (1970) and Nelms et al. (1971) who observed carcass weight to be the variable with the greatest contribution in the equation predicting weight of retail cuts. This is not surprising since heavier weight carcasses naturally will have greater weights of retail cuts unless all the additional weight is in the form of excess fat or bone.

Equation 4 predicts weight of trimmed special hindquarter retail cuts and equation 5 predicts weight of trimmed forequarter retail cuts (Table 2). Both equations used chilled carcass weight, kidney and pelvic fat percentage, loin eye area and fat thickness as independent variables with coefficients of determination of 0.90 and 0.87 respectively. Loin eye area and fat thickness in conjunction with chilled carcass weight and kidney and pelvic fat percentage were more important in determining weight of trimmed special hindquarter or forequarter retail cuts than total carcass retail cuts. This is logical since the Longissimus muscle is one of the largest muscles present in the special hindquarter and thus an increase in its size would increase the amount of retail cuts from the special hindquarter. Fat thickness on the other hand is inversely related to amounts of retail cuts from the special hindquarter and thus as fat thickness increases, special hindquarter retail cuts decrease. However, it should be noted that as fat thickness, increases, forequarter retail cut weight increases which would suggest that more fat is included in the retail cuts from the forequarter.

Equation 6 predicts weight of total carcass bone using all independent variables except carcass length (Table 2). When carcass length was included as an independent variable in equation 7, the coefficient of determination was increased considerably (Equation 6, $R^2 = 0.57$ and equation 7, $R^2 = 0.71$). The length of the carcass is a good indicator of its size and its skeleton, so, the inclusion of the carcass length as independent variable made a considerable improvement in its R^2 value. Equation 7 may be useful to estimate the weight of bones and in conjunction with equation 1, 2 or 3 to estimate carcass muscle to bone ratio.

Equation 8 estimates the weight of trimmed special hindquarter plus forequarter retail cuts and has an R^2 value of 0.94. With the exception of equation 6, all equations presented here would be of practical use to measure the carcass yield traits they respectively estimate due their relatively high R^2 values and the ease with which the independent variables can be measured and obtained. If the yields are desired as a percentage of carcass weight, the predicted values need only be converted

TABLE 1. Overall mean, standard deviation and range for dependent and independent variables.

Variables	N	Mean	Standard deviation	Minimum value	Maximum value
Live weight (kg)	70	466.10	39.20	310.00	568.00
Hot carcass weight (kg)	68	267.61	27.56	171.90	332.50
Kidney and pelvic fat weight (kg)	70	8.01	1.88	4.20	12.60
Fat thickness at 12th rib (mm)	70	3.84	2.32	1.00	11.00
Loin eye area (cm^2)	69	72.36	9.96	42.90	95.50
Carcass length (cm)	58	124.98	3.62	113.70	133.50
Total carcass closely trimmed retail cuts (kg)	69	192.01	21.18	120.90	240.44
Total special hindquarter closely trimmed retail cuts (kg)	69	87.58	9.11	56.20	108.32
Total forequarter closely trimmed retail cuts (kg)	70	78.40	10.56	44,40	97.64
Total bone weight (kg)	70	43.97	4.09	31.80	54.46
Chilled carcass weight (kg)	70	259.01	25.71	170.20	318.00
Kidney and pelvic fat percentage	70	3.09	0.66	1.64	4.82
Closely trimmed retail cuts from special hindquarter plus forequarter (kg)	69	165.70	18.29	100.60	205.16

TABLE 2. Prediction equations for estimating carcass traits.

Equation number	Dependent variable	Intercept	Chilled carcass weight (kg)	Kidney and pelvic fat percentage	Loin eye area (cm^2)	Fat thickness (mm)	Carcass length (cm)	Error mean square	R^2
1	Y1	-6.8074	+0.8021	-3.1021		+0.2743		19.1985	0.96
2	Y1	-6.9977	+0.8061	-3.0441				19.2994	0.95
3	Y1	45.1663	+0.8725	-3.6633	-0.1232		-0.4693	18.5376	0.96
4	Y2	6.6075	+0.2731	-1.5499	+0.2273	-0.3374		8.6238	0.90
5	Y3	-8.4971	+0.3956	-2.0771	-0.1531	+0.4964		15.9928	0.87
6	Y4	20.2877	+0.1414	-1.2975	-0.1101	-0.2477		7.8051	0.57
7	Y4	-21.7699	+0.0693	-0.6658			+0.3938	4.1325	0.71
8	Y5	-0.3776	+0.6856	-3.6172				20.2194	0.94

Y1 = Weight of total carcass trimmed retail cuts
Y2 = Weight of trimmed special hindquarter retail cuts
Y3 = Weight of forequarter trimmed retail cuts
Y4 = Weight of total carcass bone
Y5 = Weight of trimmed special hindquarter and forequarter cuts

to a percentage form, since the carcass weight must be known.

Overall, it can be observed that chilled carcass weight and kidney and pelvic fat percentage were used in all models as independent variables. As muscle and fat are the most abundant tissues found in beef carcasses, a positive, relationship between carcass weight and these tissues would be expected. Trimmed retail cuts consist of muscle and fat tissue and heavier carcasses yield greater weights of these cuts. On the other hand, fat proportion has a negative relationship with trimmed retail cuts since with increased fat deposition, the proportion of trimmed retail cuts goes down.

As was explained in Luchiari Filho et al. (1981) and Luchiari Filho (1981), the subcutaneous fat from the retail cuts was trimmed to approximately 5 mm in thickness. It was observed also that the majority of the animals by the time of slaughter presented a fat thickness of less than 5 mm, thus, fat thickness up to 5 mm was in fact a part of carcass edible portion. However, kidney and pelvic fat is never a part of carcass edible portion and is always trimmed and discarded, thus it becomes a potentially important variable in determining carcass edible portion yields.

CONCLUSIONS

1. Chilled carcass weight was observed to be the independent variable with the greatest contribution in all prediction equations.

2. All models studied included chilled carcass weight and kidney and pelvic fat percentage as independent variables.

3. The equation used to predict weight of trimmed retail cuts [Y = -6.8074 + 0.8021 (chilled carcass weight in kilograms) - 3.1021 (kidney and pelvic fat percentage) + 0.2743 (fat thickness in millimeters)], seems to be the most useful, because it utilizes only 3 easily obtainable variables and is highly accurate ($R^2 = 0.96$).

REFERENCES

ABRAHAM, H.C.; CARPENTER, Z.L.; KING, G.T.; BUTLER, O.D. Relationships of carcass weight, conformation and carcass measurements and their use in predicting beef carcass cutability. J. Anim. Sci., 27:604, 1968.

ALLEN, D.M.; MERKEL, R.A.; MAGEE, W.T.; NELSON, R.H. Variation in some beef carcass compositional characteristics within and between selected weight and fat thickness ranges. J. Anim. Sci., 27: 1239, 1968.

BRUNGARDT, V.H. & BRAY, R.W. Estimate of retail yield of the four major cuts in the beef carcass. J. Anim. Sci., 22:177, 1963.

COLE, J.W.; ORME, L.E.; KINCAID, C.M. Relationship of loin eye area, separable lean of various beef cuts and carcass measurements of total carcass lean in beef. J. Anim. Sci., 19:89, 1960.

COLE, J.W.; RAMSEY, C.B.; EPLEY, R.H. Simplified method for predicting pounds of lean in beef carcasses. J. Anim. Sci., 21:355, 1962.

EPLEY, R.J.; HEDRICK, H.B.; STRINGER, W.C.; HUTCHESON, D.P. Prediction of weight and percent retail cuts of beef using five carcass measurements. J. Anim. Sci., 30:872, 1970.

FIELD, R.A.; SCHOONOVER, C.O.; NELMS, G.E. Relationships between carcass weight and muscle, fat and bone in bull carcasses. J. Anim. Sci., 25: 588, 1966.

HEDRICK, H.B.; MILLER, J.C.; THOMPSON, G.B.; FREITAG, R.R. Factors affecting Longissimus dorsi area and fat thickness of beef and relation between these measurements and retail yield. J. Anim. Sci., 24:333, 1965.

LUCHIARI FILHO, A. Carcass evaluation and comparisons of Zebu (Nelore) and European-Nelore crossbred type cattle produced in Brazil. Manhattan, Kansas State University, 1981. 93p. Tese Mestrado.

LUCHIARI FILHO, A.; BOIN, C.; CESAR, S.M.; CORTE, O.O. Estudo comparativo das características quantitativas de carcaças de tourinhos Nelore, meio-sangue Marchigiana-Nelore e meio-sangue Chianina-Nelore. B. Indústr. anim., 38:1, 1981.

NELMS, G.E.; NIMMO, R.A.; RILEY, M.R.; FIELD, R.A.; ROEHRKASSE, G.P. Predicting cutability in bull carcasses. J. Anim. Sci., 31:1078, 1971.

SAS INSTITUTE, Raleigh, EUA. SAS user's guide. Raleigh, 1979. 494p.