The use of non-carcase parts to estimate beef carcase composition

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Ninety-five steers were used to develop a method of estimating the weights or percentages of the four carcase tissues, muscle, bone, fat and connective tissue while the carcases are still on the slaughter floor.

From the investigation of a number of non-carcase parts it was found that three measurements could be used to estimate all four carcase components. The measurements were

/a/ Short-cut tonque weight
/b/ Foreshanks weight
/c/ Hot side weight

Simple and multiple regression equations were developed to estimate the weights of muscle, bone and connective tissue in the chilled side.

The comparative accuracy of the estimates was examined relative to that of recorded methods.

The most useful regression equations employed short-cut tonque weight and hot side weight to estimate total side muscle weight, and foreshanks weight to estimate both total side bone weight and total side connective tissue weight.

Fat weight was estimated from hot side weight and the estimates of the weights of the other three carcase components. This technique was more accurate than the Australian Beef Carcase Appraisal System and Butterfield's /1965/ equation both of which use fat thickness measurement at the tenth rib.

When fat thickness measurement was included in regression equations the estimates of muscle weight and fat weight were slightly improved.

The advantages of using the "non-carcase parts" technique are

/a/ All four major carcase components are predicted
/b/ The carcase components can be recorded as absolute weights or percentages of chilled side weight
/c/ Chilled side components are predicted whilst the hot side is still on the slaughter floor
/d/ No commercial loss occurs in carcase, offals or by-products
/e/ All measurements used in prediction are weights
/f/ Fat thickness measurements may be included in the prediction
/g/ The additional information enables producers to make a more critical assessment of the nutritive performance and generic progress of their herds

Der Gebrauch von nicht-fleischlichen Teilen /"non-carcase parts"/ bei der sofort im Anschluss an den Schlachtvorgang vorgenommenen Abschätzung der Zusammensetzug des Rinderkörpers.

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An Hand von 95 Ochsen ist eine Methode entwickelt worden, wobei das Gewicht und der Prozent satz der vier Tierkörperanteile- Muskel, Knochen, Fett und Bindegewebe - sofort im Anschluss an den Schlachtvorgang abgeschätzt werden können.

Durch die Untersuchung einiger nichtfleischlichen Teile wurde bewiesen, dass alle vier Tierkörperanteile sich durch drei Messungen feststellen lassen. Diese Messungen sind:

/a/ das Gewicht der Zunge nach Trennung des Abfalls/das sogenannte"short-cut tongue weight"/
/b/ das Gewicht des Unterschenkels
/c/ das Gewicht der noch blutwarmen Rinderhälfte.

Einfache und multiple regressive Gleichungen sind erarbeitet worden, damit das Gewicht des Muskelanteils, des Knochenanteils und des Bindegewebes in dem gekühlten Tierkadaver berechnet werden kann.

Die relative Genauigkeit wurde geprüft durch einen Vergleich mit schon erprobten Abschätzmethoden.

Die brauchbarsten regressiven Gleichungen messen /I/ das Gewicht der Zunge nach Trennung des Abfalls und das Gewicht der noch blutwarmen Rinderhälfte, um das gesamte Gewicht der Muskel in der Rinderhalfte abzuschätzen, und /2/ das Gewicht des Oberschenkels, um das Gewicht samtlicher Knochen und das gesamte Gewicht des Bindegewebes in der Rinderhalfte zu errechnen.

Das Gewicht des Fettanteils wurde aus dem Gewicht der noch blutwarmen Rinderhälfte und den geschätzten Gewichten der anderen drei Kadaveranteike berechnet. Es stellte sich heraus,dass mit dieser Methode genauere Ergebnisse erzielt werden können als mit dem sogenannten "Australian Beef Carcase Appraisal System" und Butterfields Gleichung /I965/, zwei Methoden, bei denen die Dicke der Fettschicht an der zehnten Rippe gemessen wird.

Wenn die Dicke der Fettschicht in die regressive Gleichung aufgenommen wird, so erhöht sich ein wenig die Genauigkeit der Abschhätzungen über das Gewicht des Muskelanteils und des Fettanteils.

Die Vorteile dieser Methode, die "nicht-fleischliche" Teile untersucht, werden diskutiert.

Utilisation des organes "hors-carcasse"/n'appartenant pas à la carcasse/en vue de la prédiction de la composition d'une carcasse de boeuf, gisant sur la place d'abattage

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Quatre -vingt quinze bouvillons furent utilisés dans le développement d'une méthode d'estimation de poids ou pourcentage des quatre tissus d'une carcasse, gisant encore sur la place d'abattage. Il s'agit du tissu musculaire du tissu osseux, du tissu graisseux et des tissus cellulaires.

D'après les recherches faites sur un nombre d'organes n'appartenant pas à la carcasse, on découvrit que trois mensurations pouvaient être utilisées dans l'estimation des quatre composants de la carcasse. Ces mensurations sont:

/a/ Le poids de la langue coupée net /short-cut tongue:c.à d.sans les organes annexes/
/b/ le poids des jambes avant /foreshanks weight/
/c/ le poids d'une demi-carcasse chaude

Des équations de régressions simples et multiples furent dévelopées pour estimer le poids des muscles, des os et des tissus cellulaires de la demi-carcasse réfrigérée.

La précision comparative de ces estimations fut examinée par rapport à celle décrite dans des méthodes de prédiction.

Les équations de régression les plus utiles, emploient le poids de la langue coupée net et le poids de la demi-carcasse chaude, pour estimer le poids total des muscles de la demi-carcasse, tandis qu'elles emploient le poids des jambes avant pour estimer le poids total de l'ossature et des tissus cellulaires de la demi-carcasse.

Le poids de la graisse est estimé par le poids de la demi-carcasse chaude et par l'estimation du poids des trois autres composents de la carcasse.

Cette technique est plus précise que le "Système australien d'évaluation de la carcasse du boeuf et que l'Equation de Butterfield/1965/. Ces systèmes utilisaient comme mesure l'épaisseur de la graisse sur la dixième côte.

En incluant la mensuration de l'épaisseur de la graisse dans les équation de régression, on obtient des estimations du poids des muscles et du poids de la graisse, légèrement plus précises.

On délibère actuellement sur les avantages découlant de cette technique/l'utilisation des organes "hors carcasse"/ pour ce qui concerne le producteur, le préparateur et l'industrie de la viande en général.

Оценка состава говяжьей туши по отбросам уже на убойном полу

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Исследуя 95 быков, выработан метод для подсчёта веса или процента четырёх тканей туши - мышц, костей, жира, соединительной ткани - уже до отвоза туши с убойного пола.
Исследование некоторых отбросов показало, что все четыре ткани туши можно оценить на основе следующих трёх измерений:

(а) вес укороченного языка;
(б) вес передних голеней
(в) вес тёплой туши

Были выработаны простые и сложные регрессивные уравнения для подсчёта веса мышц, костей и соединительной ткани в охлажденной туше.
Точность оценок была сравнена с точностью имеющихся методов подсчёта.
В самые полезные регрессивные уравнения входили вес укороченного языка и вес тёплой туши для подсчёта общего веса мышц в туше, а также вес передних голеней для подсчёта как общего веса костей в туше, так и общего веса соединительной ткани в туше.
Вес жира был получен из веса тёплой туши и подсчётов прочих трёх компонентов туши. Такой метод оказался более точным, чем "Австралийская система для оценки говяжьих туш" и управление Биттерфильда (1965), которые, как первая, так и второе, используют тзмерение толщины жира у десятого ребра.
Однако при включении толщины жира в регрессивные уравнения немного улучшилась точность оценки веса мышц и жира. Опимываемый метод имеет следующие преимущества:

(а) оцениваются все четыре главных компонента туши
(б) данные для туши могут быть выражены или в форме абсолютного веса или же в процентах охлажденной туши;
(в) состав охлажденной туши получается уже до отвоза тёплой туши с убойного пола;
(г) исключены коммерческие потери в туше, потрохах, субпродуктах;
(д) все измерения, используемые в подсчётах, являются измеренями веса;
(е) измерения толщины жира можно включить в оценку;
(ж) получаемые дополнительные сведения позволяют агрономам более критически оценивать питательное значение и генетическое развитие животных.

The use of non-carcase parts in the prediction of beef carcase composition on the slaughter floor

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Introduction

A beef carcase classification scheme is currently being implemented in Australian abattoirs. Its aim is to provide a quantitative description of each carcase,hot, before it leaves the slaughter floor. For objective evaluation the Australian Beef Carcase Classification Scheme relies heavily on fat thickness measurement at the 12th rib and on carcase weight, two measurements that have been shown repeatedly to be highly associated with total carcase fat and total muscle. Fat thickness is determined by use of an electrical conductivity probe which has been developed over the last six years. Trial use shows that this probe is not yet accurate or reliable. The fat thickness measurement is further complicated by damage frequently done to the subcutaneous fat layers by mechanised hide-pulling over the area of the caudal ribs and loin.

The Australian Beef Carcase Classification Scheme currently prints out five objective characteristics (sex, weight,dentition, fatness, shape) which give an indication of yield. It is possible, however, that certain non-carcase parts may be used to describe yield more satisfactorily.

In the present study certain non-carcase parts which are easily obtainable from the slaughter floor are utilized either in place of, or together with, currently used measurements for objective carcase description.

Materials and Methods

Ninety-five steers (23 Hereford,25 Angus,30 Friesian,10 Charolais ½bred,5 Murray Grey and 2 crossbred) were lot-fed on high grain,low roughage commercial feedlot pellets(12% protein). These animals were slaughtered at various weights and dressed according to commercial procedures used in Australian abattoirs. The chilled right side of each carcase was totally dissected into its constituent muscle, bone, fat and connective tissue.

A number of non-carcase parts were removed at dressing, weighed and used in simple and multiple regression equations in an attempt to predict the weights or percentages of total carcase tissues. Two proved most useful:

(i) Foreshanks disarticulated at the carpo-metacarpal junction,unskinned, cleansed of impacted faecal material and earth from sole and interdigital areas.

(ii) Short-cut tongue which is the tongue trimmed of the tongue "roots" by incising immediately rostral to, and along, each greater cornu of the hyoid bone. Mm.genioglossi were removed at their ventral entry into the substance of the tongue.

Hot side weight, chilled side weight and fat thickness over m.longissimus thoracis et lumborum at the 10th rib were recorded for each side.

The study was made in two stages.In the first,predictions of muscle and bone utilized chilled side weight thus enabling the predictive accuracy of the methods to be compared with those of other recorded prediction methods using chilled carcase and chilled muscle weights.In the second stage,predictions of muscle and fat were made using hot side weight which allowed the non-carcase parts technique to be developed for use on the slaughter floor.

Results

Table 1. Regression analyses of total side muscle weight(Y)over a number of carcase and non-carcase variables(X)

Independent variable	X mean(g)	b	SEb	Probability	SEE(g)	R
N= 63, Y mean = 60463 grams						
Short-cut tongue wt.	906	81.149	3.544	**	7676	.95
Chilled side wt.	106232	0.498	0.011	**	4083	.99
Short-cut tongue +		21.598	4.067	**		
chilled side wt.		0.381	0.024	**	3396	.99
Short-cut tongue +		14.950	3.868	**		
chilled side wt. +		0.462	0.028	**		
fat thickness		-437.100	99.539	**	2973	.99
Shin muscle group wt.	1585	44.484	1.068	**	4382	.98
Shin muscle group wt. +		21.414	2.310	**		
chilled side wt.		0.268	0.026	**	2639	.99
Shin muscle group wt. +		17.590	2.667	**		
chilled side wt. +		0.334	0.036	**		
fat thickness		-240.069	93.978	**	2526	.99
N= 80, Y mean = 58916 grams						
Hot side wt.	108843	0.461	0.013	**	4852	.97
Hot side wt. +		0.313	0.021	**		
short-cut tongue wt.		30.303	3.895	**	3654	.98
Hot side wt. +		0.461	0.031	**		
short-cut tongue wt. +		13.919	4.316	**		
fat thickness		-506.066	87.240	**	3062	.99

** $p < .01$

(a) Muscle

Total side muscle weight was predicted most accurately from multiple regression equations involving shin muscle group weight and less accurately from those equations utilizing short-cut tongue weight (Table 1). The most accurate predictor was shin muscle group weight together with chilled side weight and fat thickness (SEE=2526g) with short-cut tongue plus hot side weight less accurate (SEE=3654g). In the case of shin muscle group weight and short-cut tongue, the progressive addition of side weight and fat thickness resulted in an improved prediction with all variables contributing.

Table 2. Regression analyses of total side bone weight(Y_1) and total side bone plus connective tissue weight(Y_2) over carcase and non-carcase variables (X)

Independent variable	X mean (g)	b	SEb	Probability	SEE(g)	R
N= 80, Y_1mean = 14404 grams						
Foreshanks wt.	3643	4.099	0.118	**	978	.97
Hot side wt.	108843	0.082	0.005	**	1936	.87
Foreshanks wt. +		3.726	0.242	**		
hot side wt.		0.009	0.005	NS	966	.97
Hot side wt. +		0.123	0.005	**		
fat thickness		-298.454	24.616	**	1143	.96
Hot side wt. +		0.052	0.009	**		
foreshanks wt. +		2.545	0.032	**		
fat thickness		-139.557	25.954	**	827	.98
Foreshanks wt. +		4.143	0.130	**		
fat thickness		-12.933	15.678	NS	980	.97
N= 48θ, Y_1mean = 13667 grams						
Radius/ulna wt. +		13.948	0.832	**		
chilled side wt.		0.018	0.004	**	573	.99
N= 80, Y_2mean = 16761 grams						
Foreshanks wt.	3643	4.493	0.015	**	1098	.94

θ In 32 of the 80 carcases, radius/ulna weight was not recorded

** $p < .01$

NS Not significant

(b) Bone and connective tissue

Three measurements available on the slaughter floor, foreshanks weight, hot side weight and fat thickness were used alone or in combination to predict total side bone weight (Table 2). Comparisons were made with radius/ulna weight plus chilled side weight, which predicted total side bone weight most accurately. Foreshanks weight was the best single predictor and its standard error of estimate (SEE) of 978g was not improved by the addition of other variables, except in the case where foreshanks weight plus hot side weight plus fat thickness gave a SEE of 827g.

Foreshanks weight predicted bone plus connective tissue weight with virtually the same accuracy that it predicted bone weight.

(c) Fat

The weight of the fourth carcase tissue, fat, was calculated by difference, using the predicted weights of the other three side components and side recovery weight (total weight of the dissected components of the side) according to the equation:

Side fat wt. = Side recovery wt. - (predicted side muscle wt. + predicted side bone wt. + predicted side connective tissue wt.)

After side fat weight was calculated, the results were compared with dissected fat weight and with two estimates, both based on fat thickness measurements, one using the Australian Beef Carcase Appraisal System (Anonymous, 1971) and the other from Butterfield's (1965) equation. The results are shown in Figure 1.

Since chilled side weight was not available on the slaughter floor 98% of hot side weight was used in calculations. This "shrinkage" factor was based on studies of 57 sides (total dissected fat 17.7% - 32.1%) chilled at 2° Celsius for 48, 72, 96 or 120 hours which lost 2.0% (mean) of hot side weight.

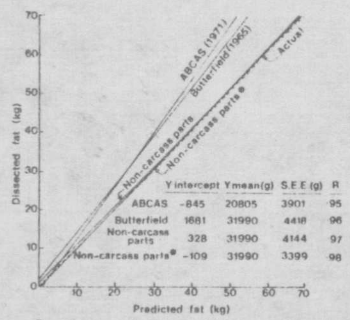
Table 3. Equations for the prediction of side muscle, bone, connective tissue and fat

Side component (Y) (grams)	Predictor (X) (grams or mm)	Equation
Total side muscle wt.	Hot side^{X_1}wt. + short-cut^{X_2} tongue wt.^{X_3}	$Y=-998.22+0.3126X_1+30.30X_2$
Total side muscle wt.	Hot side wt.+short-cut tongue wt.+fat thickness	$Y=1771.28+0.4613X_1+13.92X_2-506.07X_3$
Total side bone wt.	Foreshanks wt.	$Y=-528.23+4.10X_1$
Total side bone wt. + connective tissue wt.	Foreshanks wt.	$Y=393.15+4.4932X_1$
Total side fat wt.		Y=0.98(hot side wt.)-(predicted side muscle wt.+predicted side bone wt+ predicted side connective tissue wt)

Discussion

Although shin muscle weight in combination with chilled side weight gave the best estimates of total side muscle weight (SEE=2526,2639) the method is unlikely to be useful in the commercial situation since it is time consuming,involves the chilled side and causes carcase devaluation.On the other hand hot side weight combined with short-cut tongue weight, may be used on the slaughter floor to predict side muscle weight although a loss in accuracy of prediction occurs (SEE=3654g). The difference in accuracy between the two methods however, represents a loss between a potentially rapid "slaughter floor" technique and a relatively accurate chilled carcase technique (Callow,1962;Hinks and Prescott,1974), used primarily for research purposes.

Foreshanks weight predicted side bone weight(SEE=978g)and side bone plus connective tissue weight relatively accurately. Multiple regression equations combining a variety of other measurements with foreshanks weight failed to improve side bone weight prediction,except in the case where foreshanks weight, hot side weight and fat thickness all contributed to an improved prediction(SEE=827g). This, however,did not represent a large improvement over foreshanks weight alone.



	Y intercept	Ymean(g)	S.E.E (g)	R
ABCAS	-845	20805	3901	·95
Butterfield	1681	31990	4418	·96
Non-carcass parts	328	31990	4144	·97
Non-carcass parts*	-109	31990	3399	·98

Fig. 1. Comparative accuracy of the non-carcass parts method of estimating total side dissected fat weight.

*Fat thickness included

A comparison of foreshanks weight with radius/ulna weight plus chilled side weight, showed the latter combination of measurements to be the better predictor(SEE=573g,Ymean=13667g) of side bone weight. However for the same reasons as stated for muscle prediction,the shin bone technique is not adaptable to slaughter floor procedures.Callow(1962),Hinks and Prescott (1974) and Kempster et al.(1977) found that shin bone was among the most accurate of the carcase bones in predicting total side bone weight. It is,therefore,a very useful technique and the comparison serves to indicate a relatively small error associated with the simple foreshanks approach of this study.

The most practical approach seems to be to use foreshanks weight to predict side bone plus connective tissue weight since these are tissues of similar derivation and commercial value. When this was done the magnitude of the standard error of estimate (1098g,Y mean=16761g) was not very different from that for the prediction of bone weight.

The non-carcase parts method predicts the weights of muscle,bone and connective tissue in the chilled side. Therefore the subtraction of these weights from the chilled side weight equivalent (98% of hot side weight) was necessary to yield side fat weight. Comparisons of the accuracy of the estimation of fat-by-difference showed that the non-carcase parts techniques were more highly correlated with total side fat weight than the chilled carcase techniques and furthermore they showed no tendency towards increased under-prediction of fat weight with increasing level of carcase fatness, as did the latter techniques. The non-carcase parts methods were, therefore, more accurate predictors of side fat weight over a wide fatness range.

This study shows that with or without fat thickness, short-cut tongue weight, foreshanks weight and hot side weight give a comparatively accurate estimate of the weight of the carcase components. In addition other benefits are evident:

(i) The technique allows all four major carcase tissues to be predicted. This provides valuable information for processor and butcher, who have a much clearer indication of yield than that presently implied; for the grower the information should provide a useful selection tool.

(ii) The carcase components are recorded as absolute weights or percentages of the chilled side, which is probably the information that the processor and butcher would prefer.

(iii) Chilled side components are predicted on the slaughter floor. The hot side, therefore, can be ticketed with estimates relevant to shrunken weight before it has left the slaughter floor.

(iv) The carcase measurement and the non-carcase parts used in prediction cause no commercial loss of carcase, offals or by-products.

(v) All recorded measurements for the prediction of carcase composition are weights, the simplest and potentially the most accurate method of data recording. No new technology is required.

(vi) Fat thickness measurements may be included in the prediction if warranted. In the event of a reliable fat thickness measurement not being available for use, the method is only marginally less accurate.

If quantitative carcase details, as proposed by this method, become available to the producer he should be better equipped to assess the nutritive performance and genetic progress of his herd. Consignments of cattle could become virtual progeny tests. The premium carcase categories that will probably arise under objective classification should be easier to achieve. Knowledge of muscle and bone content provides muscle/bone ratio, a highly heritable factor (Hankins et al.,1943;Berg and Butterfield,1966) which may be used for genetic improvement. For over 35 years,muscle/bone ratio has been identified as a valuable selection tool (Hankins et al., 1943;Carroll et al., 1964;Berg and Butterfield,1966,1968)but to date,because it has been difficult to assess, it has been of limited practical value.

Details of side composition, determined by this method, may be applied to the hot side ticket, either as weights of the chilled side, or as percentages. Each would seem to have advantages. The percentage form would overcome anomalies resulting from differential carcase shrinkage.

Australia's initiative in attempting to implement a totally objective form of beef carcase classification represents an important development in the beef industry. However the move appears to be faltering because of technological problems associated with the measurement of fat thickness and because of strong criticism from within the industry that the increased benefits are marginal relative to the costs involved. The non-carcase parts technique is a simple method of obviating the problems associated with the measurement of fat thickness while providing additional objective information of commercial importance to both producer and processor. Since the measurements used are weights, the initial and recurrent costs involved appear likely to be less than those associated with the more complex electrical conductivity probe.

The beef carcase consists of three major components. An accurate prediction of any two should provide an estimate of the third. For this reason, lines of research directed at the development of a simple, accurate means of measuring fatness, and the identification of sites or techniques producing higher correlations with total carcase fatness, must continue. It is possible that further research could result in a better objective description of carcases by combining various measurements. Foreshanks weight, for example, might be profitably combined with an accurate fat thickness measurement. Nineteen years of carcase growth investigations have generally failed to improve the correlations between fat measurements and total carcase fat. This may be because of the great variability in fat growth and deposition, or it may be that such improved correlations do not exist. It is important therefore,to appreciate that if the technological problems associated with the measurement of fat thickness were solved immediately, the direct calculation of carcase fatness from fat thickness measurements would still produce an estimate less accurate than that from the indirect calculation of the non-carcase parts technique. It seems paradoxial that the non-carcase parts method which gives a less accurate prediction of carcase muscle and carcase bone than part-carcase dissection techniques, should result in a more accurate estimation of carcase fat than that from fat thickness measurement. The answer probably lies in the marked variation that exists in the growth and deposition of fat in beef cattle, or alternatively,scientists' lack of knowledge of these patterns of growth. Whichever is true perhaps the time has come to review current prediction techniques. The accuracy of the indirect prediction of carcase fatness, already more accurate than direct prediction methods, can probably be improved. If so it will be done by improving the accuracy of prediction of muscle and bone, thus contributing to the totality of improvement of objective carcase measurement.

The use of carcase parts to predict total carcase components is a well established principle. In the light of this study there seems every reason to extend research into the field of non-carcase parts. The head, which gave a reasonably accurate estimation of bone in preliminary studies, may prove particularly useful. It is located on a moving chain, co-ordinated with its carcase, and contains discreet muscles and bone.

This study shows that beef carcase classification could provide more objective data than presently proposed with perhaps less technology and fewer costs. The approach is potentially simpler than that currently used and may enhance the industry's confidence in the scheme.

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