CONTRACT REVIEW

BEEF CARCASE DESCRIPTION - HAVE WE SUCCEEDED OVER THE LAST 30 YEARS AND HOW DO WE SATISFY THE INCREASINGLY COMPLEX SPECIFICATIONS?

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The foundations of beef carcase description were laid in the USA when Murphey *et al.* (1960) noted that 12th rib fat thickness was closely associated with the important commercial trait, cutability (saleable beef yield). In Australia a few years later, Charles (1964) proposed that beef be marketed by specifications, and his "beef carcase classification" as it became known, used 4 descriptive measurements; sex, age (dentition), carcase weight and subcutaneous fat thickness (at either the 10th or 12th rib). Charles' proposed system lay fallow for some 10 years before the Australian Meat Board began a lengthy series of measurement trials. The development of "over-the-hooks" trading by State agencies mainly in Western Australia, Queensland and Tasmania in the early 1980's led to carcase branding schemes. These required the application of post slaughter treatments to prevent cold toughening, and were designed to indicate for consumers, meat with consistently high tenderness. Such State schemes were largely unchanged when implemented in 1987 by AUS-MEAT (Authority for Uniform Specifications Meat and Livestock), the Australian Meat and Live-stock Corporation body appointed to develop a descriptive "language" and a set of National Standards appropriate for marketing cattle and carcases.

AUS-MEAT began with Charles' 4 measurements, but in a rapidly developing and increasingly complex marketing arena it found it necessary to add further quantitative and qualitative measurements. This stimulated a flood of technological development and methodology with which producers, processors, scientists and marketing bodies are currently involved.

AUS-MEAT has undoubtedly had a large and positive impact on the marketing of cattle and carcases, but not all of its initiatives have been universally accepted. Now, the increasingly complex specifications of Australia's customers, both local and overseas, are imposing new demands on the country's developing technology. The challenge lies at both ends of the beef production spectrum - to satisfy marketing requirements and to feed back information that will promote more efficient beef production.

CARCASE MEASUREMENTS AND TREATMENTS

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The characteristics included in a carcase description system should reflect the quantity and quality of meat that is obtainable from the carcase. In this section, the relationships of the measurements, assessments and treatments to commercial value will be described.

Carcase weight

Carcase weight is a measure of the quantity of the product. It is the basis for payment in several methods of marketing cattle and in subsequent trading of carcases from wholesalers to retailers. Carcase weight also influences value per unit of weight. Almost all markets indicate preferences for specific weight ranges, and carcases which fall outside these can be severely discounted. For example, some supermarkets may accept only carcases within a weight range of 190-220 kg. These limits are set according to consumer preferences.

The development of the "hot standard carcase weight" and its incorporation into the AUS-MEAT language has been a major contribution to beef marketing systems. Prior to its introduction the range in allowance for carcase "shrink" and variations in the dressing procedures were a marketing nightmare, and a source of continuing mistrust between cattle producers and abattoir operators.

Fat thickness

Fat thickness is measured primarily to indicate the composition of the carcase and in particular, the percentage yield of saleable meat. Traditionally, fatness has also been associated with meat quality. Increasing fatness can provide some protection against cold toughening by reducing the rate of chilling of the carcase (Bowling *et al.* 1978). However, where cold toughening is prevented by electrical stimulation, the effect of fatness is much reduced. Some fat cover is necessary to prevent drying out of meat during chiller storage, and a minimum requirement is specified in the AUS-MEAT branding scheme. Consumer perceptions of an association between dietary fat and blood cholesterol levels have led to demands for leaner meat.

Studies by Butterfield (1965), Charles (1977), Johnson and Vidyadaran (1981) and McIntyre and Ryan (1983) have shown close relationships between fat thickness and percentage fat content of the carcase. However, relationships between fat thickness and percentage yield of saleable meat have been variable. In some cases fat thickness has accounted for over 50% of the variation in yield (McIntyre and Frapple 1988) while in others it has accounted for less than 20% of the variation (Johnson 1987). The degree of relationship depends on factors such as the range in carcases included (fatness, weight and muscling), the degree of trimming and the consistency of trimming and cutting procedures.

The fat measurement site has been the subject of some change and continuing debate. In most of the research work in the 1970's, fatness was measured at the 10th rib. When carcase classification was introduced, the 12th rib was preferred because the fat cover was more uniform at that location. Following problems in some areas of Australia with hide-puller damage to the fat layer, the 12th rib measurement was replaced by the rump (P8) site (Moon 1980). Although the P8 measurement has been shown to be as closely related to composition (Johnson and Vidyadaran 1981) and yield (McIntyre and Frapple 1988) as the 12th rib measurement, dissatisfaction with the P8 measurement is frequently expressed. This may be partially attributable to the fact that the final assessment of a carcase is made visually after quartering. Since the rib measurement is made at or close to the quartering position it will clearly be more reflective of the visual appraisal.

The second issue concerns an apparent increase in complaints about the accuracy and reliability of fat thickness measurements. Whether this is due to a decline in standards of the operators, increased dressing damage or inadequate supervision and checking procedures, is unknown. It may also be due to greater awareness and attention being paid to fat thickness measurements. The availability of real time ultrasound scanners has meant that more animals with live fat thickness measurements have been followed through slaughter and some problems have been experienced in the correlation between the 2 measurements. Differences at first were attributed to errors in scanner measurements, but as confidence in these has grown, doubts have focussed on the carcase measurements.

Dentition

Dentition is assessed to provide a measure of the age of the animal. As animals age there is an increase in the strength of the connective tissue component of muscle and a decrease in tenderness. Although toughness does not become a problem until at least 3-4 years, only carcases up to 2 tooth are eligible to receive AUS-MEAT carcase brands.

Sex

Sex is very simple to assess but has very little relationship to either carcase composition or meat quality characteristics that are not accounted for by other measurements. It is relevant in the case of bulls which have greater susceptibly to dark cutting and are more suited for some manufacturing purposes. The recording of sex is also useful from a statistical point of view to identify the structure of the cattle slaughter and enable forecasts of population trends.

Carcase shapefconformation

Carcase shape or conformation has traditionally been regarded as a desirable characteristic. In the development of the classification system, a measure of conformation was considered for inclusion but was rejected because no consistent relationship with commercially important characteristics could be found. However, an assessment of butt profile was included by AUS-MEAT as an indication of muscle to bone ratio (Hall 1988), and therefore of yield of saleable meat. Initially in the carcase branding scheme a minimum butt profile was required to qualify for a brand. Following a reappraisal of the data and some further studies, butt profile was dropped as a requirement and remains an optional characteristic.

The continued belief that conformation is an indicator of carcase muscling is undoubtedly due to the aesthetic appeal of a carcase with a bulging outline compared with one with an angular appearance. As a result much research on conformation has been conducted over many years. Various assessments of shape or conformation have proved to be poorly related to measures of muscling or yield of saleable meat (Johnson 1988; Taylor *et al.* 1990). Often the more desirable shape has been associated with increased fatness which tends to round the outline of the carcase while contributing to reduced yield of meat. Even where comparisons have been made at equal levels of fatness, the benefits of a more desirable shape have been relatively small over a very wide range in conformation (Kauffman *et al.* 1970; Fredeen *et al. 1974).* It can only be concluded that conformation is not sufficiently related to yield or composition to be of predictive value.

Eye muscle area

Measurement of eye muscle area has been introduced recently in the Chiller Assessment scheme. It is used along with carcase weight and fat thickness as a factor in the prediction of weight of lean meat yield. Although eye muscle area does not accurately predict muscling (muscle weight, muscle percentage or muscle to bone ratio), it is at least as accurate as assessments of shape or conformation and has the advantage of objectivity. For some markets, minimum requirements for eye muscle area may be specified.

Meat colour, fat colour and marbling

The other Chiller Assessment characteristics of meat colour, fat colour and marbling are all related to consumer acceptability and their importance cannot be underestimated. For example, poor meat colour can have a disastrous effect on the value of the carcase. Marbling is not important on most Australian markets but was introduced specifically to cater for Japanese requirements. All 3 characteristics are assessed visually with reference to standard photographs or colour chips.

Post slaughter treatments

Post slaughter electrical stimulation or "tenderstretch" hanging to prevent cold toughening is the central feature of the carcase branding scheme. Of the 2 techniques, electrical stimulation has been by far the most widely used. In order to further refine the prediction of tenderness, recent research has been directed at developing methods of objective measurement on the chilled carcase.

THE UTILISATION OF CARCASE DESCRIPTION IN CATTLE PRODUCTION AND BEEF MARKETING

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There have been numerous claims, particularly over the last 5 years, that the future of the livestock industry will depend on the ability of the industry to meet the requirements of the consumer (eg. Donald *et al.* 1993). It has been emphasised that consumer requirements should be described in a manner that is able to be utilised throughout the industry and particularly back to the animal producer (Hall 1988). It is obvious then that the need for improved methods of carcase description will continue to be a high priority, particularly with the current trend to directly link quality attributes and price. This trend is illustrated by the calls for the development of value based marketing systems in Australia (Whan and Johnson 1990) and the USA (Cross and Savell 1992). Value based marketing may be presented as a new concept but in effect it is simply applying price differentials to the measured characteristics of individual animals or carcases.

In this contract, the previous speaker has outlined the development and current state of carcase measurement and description in Australia. We need to now look at how well this system meets the needs of cattle producers and the beef marketing system to provide a ready flow of signals (including price signals) from consumer to producer.

Carcase weight is arguably the most important characteristic in the current system of carcase description as most trading systems operate on a price per kilogram basis. With some markets having quite a small range in carcase weight specifications (eg. domestic supermarket) and others having a very wide range (eg. USA manufacturing beef), there is an obvious need for the cattle producer to have a knowledge of these requirements and of the financial consequences of meeting or not meeting specifications. While carcase weight is directly available and of substantial value to meat processors and retailers, it requires some modification to be useful for producers. McIntyre (1982) reviewed the methods of estimating carcase weight in the live animal and concluded that the most accurate method involved measuring liveweight and applying some knowledge of the factors which influence dressing percentage. Of course, liveweight itself is very important to the producer, particularly through growth rate, with a steadily increasing number of seed-stock producers utilising Estimated Breeding Values for 200,400 and

600 day weight for selection purposes.

Fat thickness is the second major criterion in carcase description for production and marketing purposes. The challenge for the beef producer is to turn off animals with the required combination of carcase weight and fat thickness. As with carcase weight, the range in fat thickness for some markets is quite small and for others quite large and a knowledge of the requirement and the methods of assessing it in the live animal is vital. Substantial reviews of the estimation of fat thickness in the live animal have been presented, from the technical point of view (eg. Allan 1990) or the cost-benefit analysis perspective (Kempster 1984). Apart from visual appraisal and in the case of Computer Aided Livestock Marketing (CALM) assessment, manual palpation, the fat thickness assessment of live cattle is not widely practised in commercial beef production. However, if value based marketing systems were introduced, precise assessment of fat thickness in the live animal would be necessary to more closely meet retailer and consumer requirements.

As discussed in the previous paper, carcase weight and fat thickness are the principal determinants of carcase composition and saleable or lean meat yield. Australian cattle producers have a wide range of genetic, nutritional, hormonal and managerial options available to them to manipulate both of these factors. Many producers have made use of some or all of these factors in developing a production system to meet the required specifications. However, it should be acknowledged that within the optimum carcase weight and fat thickness ranges for many of the markets there is still a significant range in final yield and "price averaging" is often applied to account for this variation. In the short term, price schedules based on narrow bands for carcase weight and fat thickness could be utilised and value based marketing with prices related to individual carcase specifications should be the ultimate goal.

The age of the animal at slaughter, and its sex, are specified for a limited number of markets. In an effort to improve the efficiency of production there has been a trend to reduce the age of animals at slaughter, except for the USA market, and also calls from within the industry for more attention to be paid to the use of entire males and to females for beef production.

The parameters measured in the Chiller Assessment procedure, muscle colour, fat colour, marbling score and estimated lean meat yield, were introduced to augment the information provided by the standard carcase description and to cater for the requirements of particular markets, initially for the Japanese higher quality beef market. Recently, Chiller Assessment has been adapted to other export markets and also to the domestic market (Anon 1993). Chiller Assessment has significant implications for the future of beef marketing, especially if value based marketing utilising all or some of the parameters is introduced. This move could also have major consequences for the producer through consideration of the influence of animal age and pre-slaughter stress on muscle colour, the effect of diet on fat colour and the genetic and nutritional influences on marbling scores. The assessment of these characteristics in the live animal provides an interesting challenge for the future.

It may be concluded that the introduction of a standard carcase description in 1987 produced a sound basis for further developments. The introduction of Chiller Assessment and its possible extension to other markets has significantly broadened the possibilities of linking carcase description to modern marketing proposals. A considerable amount of communication and extension work will be necessary to make these new initiatives useful to, and useable by, the cattle producer.

NEW TECHNOLOGIES - ULTRASONICS

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The race to develop better measurement technologies for beef carcase description has intensified over the last 5 years both in Australia and overseas. Much of this can be attributed to the increased industry demand for greater accuracy and objectivity in beef carcase description. One of the early favourites in this race was the non-invasive technology of ultrasonics.

Ultrasonics refers to the use of high frequency sound waves (≥ 1 MHz) which are pulsed through tissue to provide information about anatomical structure and composition. Its application for the evaluation of livestock was first described in the late 1950's and since then has been well documented (see reviews by Thwaites 1984; Allan 1990). However, the use of ultrasonics in carcase evaluation has, until recently, not received the same amount of attention.

Interest in pulse-echo ultrasound systems for beef carcase description arose because the technology offered a non-invasive alternative for measuring yield predictors such as fat depth and *M. longissimus* dimensions. Because it is non-invasive, carcase measurement can be achieved before the hide is removed, thus obviating the effect of hide-puller damage to the subcutaneous fat layer. Damage caused by hide-pullers in commercial abattoirs is still one of the primary causes of inaccurate fat depth measurements.

Results from 2 separate investigations (Ferguson 1991; Ferguson *et al.* 1992b), indicate that hide-on ultrasound measurements of P8 fat depth (Aloka 210DX; Aloka 500V - 3.5 MHz transducer, Medtel Australia Pty. Ltd.) are comparable in terms of accuracy in predicting side muscle percentage (Table 1) to those taken using the cut-and-measure (CM) technique. In both these investigations, mechanical hide-pullers were not used and great care was taken to preserve the integrity of the subcutaneous fat layer during dressing. In a more recent comparison conducted in a commercial abattoir, hide-on measurements were shown to be more reliable indicators of fat depth than corresponding dressed carcase CM measurements, particularly in fatter carcases (P. Cabassi pers. comm.). This suggests that the hide-on advantage will be more evident under commercial conditions where mechanical hide-pullers are in use.

Table 1. Residual standard deviations for the prediction of muscle percentage from P8 fat thickness (hide-on versus hide-off) and carcase weight in 2 studies

Predictors	Study	
	Ferguson (1991) Muscle % sd = 3.8	Ferguson *et al.* (1992b) Muscle % sd = 2.6
CWT + P8 FT (hide-on)	2.34	1.63
CWT + P8 FT (hide-off)	2.23	1.56

CWT = carcase weight (kg); FT - fat thickness (mm).

Currently, the commercial adoption of hide-on fat thickness measurements is hampered by the lack of a suitable ultrasound device for use in abattoirs.

Estimates of carcase composition can also be obtained using another ultrasonic technique which is based on the measurement of velocity of sound (VOS) through tissues. This technique employs the principal that sound waves travel at different speeds through muscle (1580 m/s) and fat (1480 m/s) tissue. Thus for a known distance, the time required for an ultrasound pulse to travel the distance will be directly influenced by the proportions of fat and muscle present within the pathway.

The technique which was developed in Britain (Miles and Fursey 1977; Miles *et al.* 1984) was originally intended for beef cattle assessment but was later modified for carcase evaluation. A summary of the results regarding the accuracy of VOS in beef carcase yield investigations conducted in Britain (Miles *et al.* 1987; Miles *et al.* 1990) and Australia (Ferguson 1991; Ferguson *et al.* 1992a) are presented in Table 2.

Velocity of sound measurements were shown to be better correlated with muscle percentage than either fat thickness or visual fat score. Its superior predictive accuracy stems from its ability to quantify total fatness better, because unlike fat thickness, sound velocity is equally responsive to all fat depots (ie. subcutaneous + intermuscular) present at each site. Moreover, the predictive advantage of VOS was more apparent in mixed breed samples (studies I, II and III) where genotypic differences in fat partitioning between the major depots are likely to occur. Such differences will limit the predictive accuracy of subcutaneous fat thickness measurements (Kempster *et al.* 1982).

Unfortunately, these encouraging results, conducted under “ideal” conditions, have not been matched by the performance of VOS in commercial environments (Wood *et al.* 1991). This disparity can largely be attributed to the fact that the technology currently uses only prototype equipment and until it is suitably designed and packaged so that it can perform accurately within abattoirs, the full potential of VOS will not be realised.

Table 2. Residual standard deviations for the prediction of muscle percentage from velocity of sound measurements, fat thickness and visual fat scores in various studies

Predictors	Study I	Study II	Study III	Study IV
RV sites 3, 4	1.97			1.48[A]
RV sites 4, 6				
RV sites 3, 4, 6		1.89	2.59	
P8 FT			2.83	1.49[A]
12/13 rib FT	2.20	3.46		
Visual fat score (1-5)	2.18	2.39		

I - Miles *et al.* (1987), muscle % sd = 3.4; II - Miles *et al.* (1990), muscle % sd = 4.5;
III - Ferguson (1991), muscle % sd = 3.5; IV - Ferguson *et al.* (1992a), muscle % sd = 2.6.
RV = reciprocal velocity (μs/cm); FT = fat thickness (mm).
Site 3 -RV measured in a medio-lateral direction immediately cranial to the first rib.
Site 4 -RV measured in a dorso-ventral direction between the tenth and eleventh ribs.
Site 6 -RV measured in a dorso-ventral direction between the seventh and eighth ribs.
[A]Carcase weight included in the model.

NEW TECHNOLOGIES - VIDEO IMAGE ANALYSIS

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The Australian meat industry has been searching for an objective carcase classification technique with a high degree of prediction to enhance a value based trading system that is acceptable to all participants in the industry. Video image analysis (VIA) has the potential to increase the level of precision of currently accepted techniques for assessing carcase value.

Video image analysis is a computer based system that objectively measures a variety of physical attributes that may be captured as images by a video camera. Depending on the VIA processor and software, VIA can measure with a high degree of repeatability infinite ranges of colour, shapes and dimensions of an object by digitising and analysing the image data. Consequently, VIA has the potential to supply a further dimension to carcase assessment for value based trading by objectively measuring meat and fat colour, eye muscle area and fat depth on a quartered carcase and such factors as fat cover and conformation on the intact carcase.

The measurement of eye muscle area and subjective assessment of conformation, eg. AUS-MEAT muscle score (Anon 1986), have been used as additional regressors to predict meat yield. However, these techniques have not gained widespread acceptance by researchers, producers and processors because of either real or perceived variations between assessors, techniques and breeds of animal. Although eye muscle area is not always well related to percentage meat yield, when it is combined with fat depth and/or carcase weight, it markedly improves the prediction of meat yield (O'Rourke 1990; Eldridge 1994). Eye muscle area has been used as an additional regressor for meat yield in the USA (Cross *et al.* 1988) and more recently in Australia in the Chiller Assessment program, however the need to accurately quarter the carcase post-chilling for measurement, limits the usefulness of this technique. Taylor *et al.* (1990) and Eldridge (1994) found that the AUS-MEAT muscle score for conformation contributed little to the prediction of meat yield, while other subjective techniques to assess conformation, such as those described by Colomer-Rocher *et al.* (1986) and Eldridge (1994), have enhanced the prediction of yield.

Providing problems associated with the standardisation of VIA measurement techniques can be overcome in the commercial environment, carcase evaluation by VIA is highly repeatable. Research overseas and in Australia has shown that VIA measurement of conformation can markedly improve the accuracy of prediction of meat yield. Danish workers have developed a beef carcase classification system based on VIA and they are using these measurements in conjunction with other regressors, to significantly improve the accuracy of predicting meat yield with residual standard deviations (RSD) of 1.5% (Petersen *et al.* 1989). In Australia, Eldridge (1994) used VIA measurements on 295 carcases ranging in weight from 169-376 kg and fat thickness l-25 mm at the 12th rib to predict meat yield. Video image analysis measurement improved ($P < 0.05$) the prediction of both percentage and kg of meat yield when the VIA measurement of conformation was used as an additional regressor with fat depth, and fat depth plus carcase weight respectively (% meat yield, $R^2 = 0.61$, RSD = 1.68; and kg meat yield, $R^2 = 0.98$, RSD = 4.39).

A Chiller Assessment and a whole carcase assessment VIA system has been developed by Systems Intellect in Western Australia. The Chiller Assessment system measures eye muscle area, subcutaneous and intra-muscular fat, meat and fat colour and levels of marbling on the quartered carcase. The whole carcase assessment system is used on the slaughter floor to evaluate fat cover/thickness and distribution, and assess carcase bruising and conformation. These systems are currently undergoing evaluation trials for calibration and accuracy of predicting meat yield.

The Danish beef carcase classification system not only estimates yield of carcase but also applies a value index based on carcase composition and muscularity for use in a value trading system (Petersen *et al.* 1989). The development of the VIA assessment system in Australia for the prediction of yield will also allow for the development of a payment system that reflects the value of individual carcases. Trials are currently being undertaken in selected abattoirs in Australia to evaluate a chiller VIA assessment. Preliminary results indicate that this system can identify real differences in economic value between carcases of the same weight and fatness class. The chiller VIA assessment will also allow retailers to more closely specify the product required for their consumers in relation to quality (meat colour) and level of fatness and so improve product consistency and consumer satisfaction.

The ability to accurately predict yield will rapidly lead to the development of a value based trading system that will send to producers the right signals that will enable them to better target their preferred markets. Yes, VIA has the ability to add a further dimension to the assessment of carcase yield and improve estimates of carcase value that will advantage producer, processor and consumer alike.

UTILISING OLD TECHNIQUES

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With the exception of VOS technology, most efforts to improve the accuracy of predicting commercial beef yield (or carcase composition) have been directed at the third regressor in the equation:
Commercial beef yield (Carcase composition) = Carcase weight + Fat thickness + 3rd regressor

Scientists have been primarily concerned with identifying and accurately measuring a third factor which, when added to carcase weight and fat thickness, will significantly and consistently improve prediction. Many third regressors have been investigated including butt profile, muscle score and eye muscle area.

Why the Australian beef industry has pursued a third regressor so vigorously is not clear. Certainly there arose a perception, about 2 years after the advent of AUS-MEAT, that carcase weight and fat thickness together did not give an accurate enough prediction of commercial beef yield even though these 2 measurements were predicting satisfactorily elsewhere in the world. The "official" recording by some AUS-MEAT Assessors of P8 measurements that were up to 100% in error (Johnson 1991) would not have enhanced the credibility of the measurement as a predictor in Australia.

The pursuit of technology to measure possible third regressors has been expensive and the identification of a consistently useful third regressor, largely unrewarding. In relation to butt profile R.F. Thornton (pers. comm.) concluded that "there is no indication of a useful role for butt profile in the estimation of saleable beef yield", while eye muscle area has performed poorly in the quantification of muscle (Cole *et al.* 1960; Johnson *et al. 1992)* and muscle score, under commercial test, failed badly in quantifying saleable beef yield (E.R. Johnson unpub. data).

Using another approach to prediction, Priyanto (1994) ignored the third regressor and set about maximising the value of the 2 proven contributors. He used carcase weight and fat thickness categories

Table 3. Regression equations for predicting percentage side muscle and percentage side fat from P8 fat thickness (from Priyanto 1993)

Equation	No. carcases	a	b (P8FT)	RSD	R^2	Sig. of regression
Carcase muscle (%)						
General	68	66.720**	-0.412**	2.28	0.52	**
Breed-ignored						
WG1	35	67.277**	-0.456**	1.70	0.47	**
WG2	33	63.823**	-0.222*	2.65	0.12	**
Carcase fat (%)						
General	68	12.305**	0.830**	2.89	0.71	**
[illegible]eed-ignored						
FG1	43	11.202**	1.031**	2.28	0.69	**
FG2	25	18.696**	0.395^{NS}	3.52	0.09	NS

a = intercept; b = regression coefficient; RSD = residual standard deviation.
WG1, WG2 = carcase weight groups, 152.6-266.8 kg and 276.6-381.8 kg respectively;
FG1, FG2 = fat depth (P8) groups, 0-11 mm and 12-23 mm respectively.
*P < 0.05; **P < 0.01; NS not significant.

in specific equations and found that the accuracy of prediction in lightweight carcases (153-267kg) was greatly enhanced by this approach (Table 3).

The homogeneity of the regression slopes among breeds for lightweight carcases (WG1), and for the lighter fat thickness group (FG1, O-11 mm), indicated that both percentage side muscle and percentage side fat could be estimated from specific breed-ignored regression equations, using carcase weight and fat thickness. This has important commercial implications since lightweight, low-fat, domestic carcases make up about half of Australia's beef production.

Table 3 shows also that if breed-ignored equations are used in the heavyweight carcases (WG2) or the fatter carcases (FG2), the prediction of percentage side muscle and percentage side fat accounts for a low level of variance with relatively high prediction errors. In these heavier and fatter carcases, Priyanto (1994) found it necessary to include eye muscle area to obtain reasonable prediction. Even so, the use of the 3 regressors in the heavyweight carcases did not predict as accurately as carcase weight and fat thickness in the lightweight carcases.

Since the common frustration of general prediction equations in commerce revolves around maturity type differences (nutrition, grass-grain; sex, heifer-steer; genetic, early-late maturity) the value of using carcase weight and fat thickness in categories, apart from being simple and inexpensive, appears to address the very crux of the differences.

One half of Australia's beef production, the domestic carcases, can be quantified accurately by simple, inexpensive measurements without the need to confront the problems associated with the pursuit of a third regressor.

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