

# 13. Measurement of Carcase Characteristics

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## Learning objectives

By the end of this section you should be able to:

- describe the various measurements taken on carcases
- explain the purpose of these measurements in terms of product description, marketing, quality assurance and meat quality
- debate the advantages and disadvantages of the various measurements, in terms of accuracy, reliability, repeatability and usefulness
- discuss the impact on the industry of the introduction of new measurement technology

## 13.1 Introduction

This lecture examines a range of subjective and objective carcase measurements and their relationship to carcase composition and meat quality. Usefulness of measurement techniques for predicting composition in both the live animal and its carcase should be judged on the following:

- accuracy
- precision (repeatability)
- cost
- practicability

There is a range of new technologies available for the measurement or estimation of some traits. The implementation and usefulness of technologies such as VIA (virtual image analysis) are also covered here. Many measurements taken on the carcase are used in the trading of carcases or primals. They are used to assign the meat to different trading specifications. In some instances they are also used for grading the meat.

**Figure 13.1 Lamb VIAScan being used to collect carcasses images which are then analysed and used to estimate carcass yield. Photograph supplied by J. Thompson.**



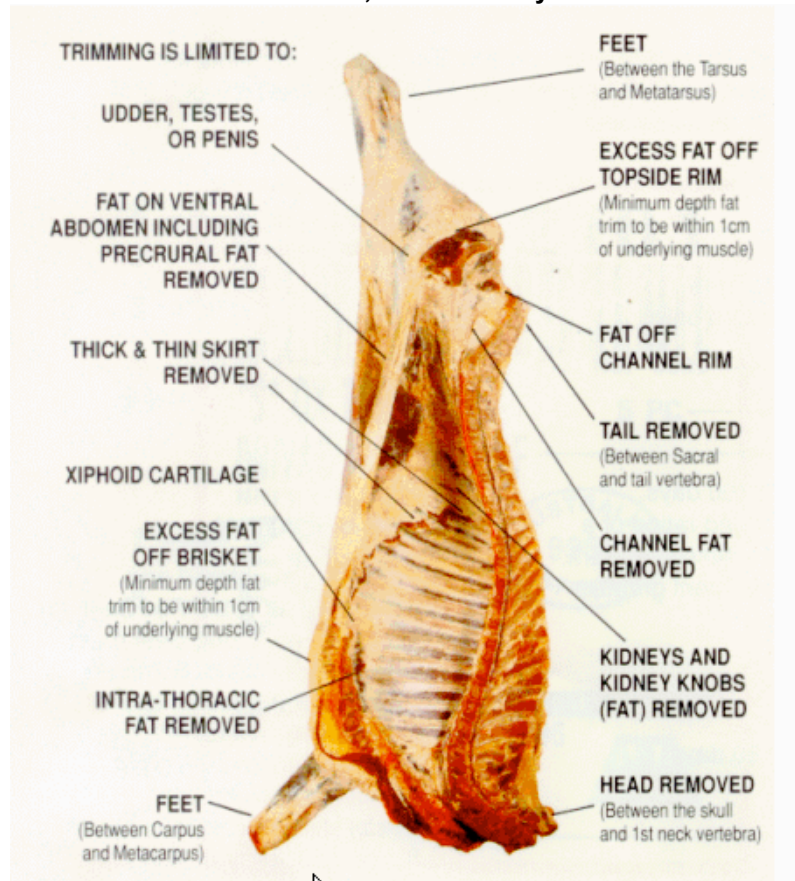
## 13.2 Traditional carcass measurements

### **Carcass weight (kg)**

Under AUS-Meat, carcasses are dressed and trimmed according to a standard carcass definition for all major meat species. This standard carcass is then weighed hot (Hot Standard Carcass Weight—HSCW) at the end of the slaughter chain, before being transferred to the chillers.

The weight of a carcass is reflected not only in kilograms meat yield, but also in the size of individual cuts, and therefore impacts on consumer requirements. Carcass weight also affects slaughter and processing costs. Heavier carcasses are more efficient for the abattoir as unit processing costs can be offset against increased kilograms of red meat yield in the boning room.

**Figure 13.2 Hot standard beef carcass, as defined by AUS-Meat Source: AUS-Meat.**



### **Carcass fat depth (mm)**

A one-dimensional measurement of the subcutaneous fat depot is often used as a measure of carcass fatness.

The composition of the carcass, particularly the amount of fat, has become more important in recent years due to the demand by domestic consumers for less fat in the meat they consume. As fat is the most variable of the carcass tissues, it is also closely related to meat yield. Once the level or amount of fat in the carcass has been estimated it is then possible to indirectly determine the yield of saleable meat.

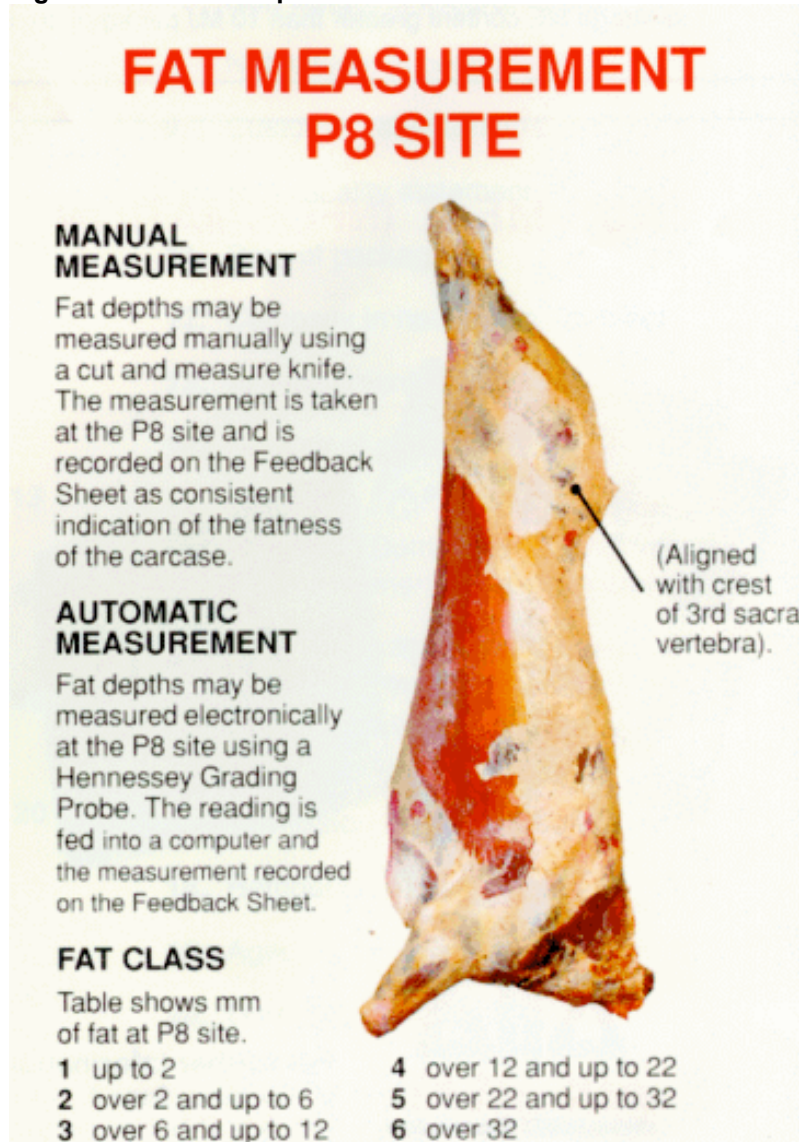
The functional relationship between fat depth or fat coverage and the proportion of muscle or saleable yield in the carcass has been studied extensively for the three major meat species. The measurement sites and devices used in abattoirs to measure fatness have largely been predicated on the results and outcomes of these research studies. Unlike some countries where fat coverage is assessed visually, fat depth is measured objectively in all AUS-Meat accredited abattoirs, using either cut and measure, or a probe.

## Notes – Lecture 13 – Measurement of Carcass Characteristics

Most measurement sites have some predictive power, although some are better than others. Those normally used in cattle are the P8 rump site, and the 12/13th rib site, midway over the longissimus dorsi. Both of these sites can be damaged by hide removal (ie fat is removed with the hide, so that fat depth measured is less than it should be). In Australia the use of downward hide pullers on cattle often tears fat over the loin. Based on a small amount of evidence Australia now bases its fat depth measurement on the P8 site, which is usually measured on the dressed carcass at the end of the slaughter chain. Where a rib fat measurement is taken, it is usually taken on the quartered carcass in the chiller.

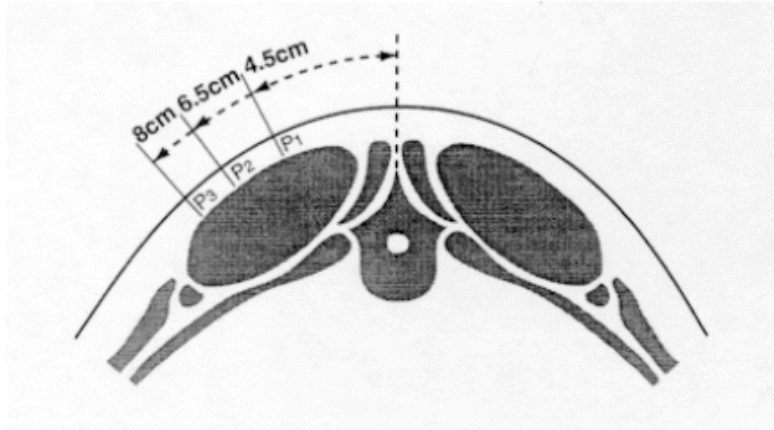
In sheep the most usual measurement is taken at the GR site, and measures all tissue from skin to bone at the ventral edge of m. longissimus dorsi.

**Figure 13.3 P8 fat depth in a beef carcass. Source: AUS-Meat.**



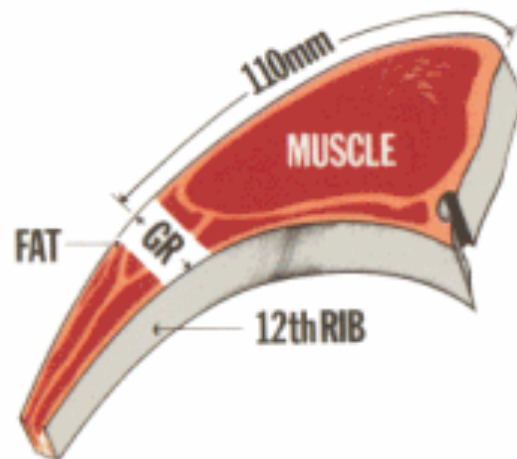
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**Figure 13.4 Point of measurement on the rib site for cattle. Source: AUS-Meat.**



The point of measurement taken with an optical probe (intrascope) at the level of the head of the last rib. P1 and P3 apply to split or unsplit carcasses and P2 to split carcasses.

**Figure 13.5 The GR site on lamb where the fat depth is measured. Source: AUS-Meat.**



### **Conformation scores**

Subjective appraisal of carcass shape tries to segregate carcasses that appear blocky, with good development of the loin and hind leg, as this is associated with greater saleable meat yield and improved shape of the primal cuts.

Subjective appraisal of carcass shape, can take three forms:

1. Conformation - appraisal of muscle thickness and subcutaneous fat relative to the skeletal dimensions.
2. Fleshiness - assessment of muscle thickness and intermuscular fat relative to the skeletal dimensions.
3. Muscularity - appraisal of muscle relative to the skeletal dimensions.

Traditional conformation scores are based on the appraisal of muscle proportion and the covering subcutaneous fat, making no allowance for fat cover. As a consequence, these scores tend to have a negative relationship with yield and a positive relationship with fat cover. When corrected for the percentage of fat cover, conformation scores describe the fleshiness of the carcass, and therefore adjusted scores have a strong positive relationship with lean meat yield.

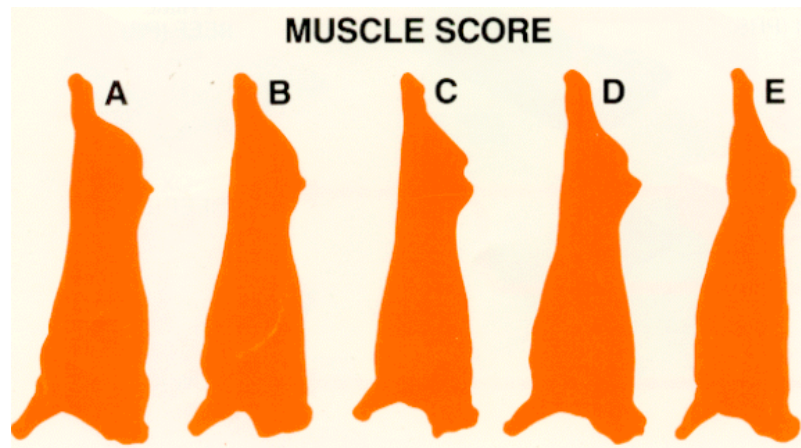


### **Traditional conformation score—butt shape**

The visual assessment of butt shape has been by far the most contentious of all carcass characteristics included in the AUS-MEAT language. Butt shape is assessed by observing the lateral profile of the butt. The shape is then assigned a score from A (most convex) to E (most concave). Assessment is done on the dressed carcass at the end of the slaughter chain.

Its inclusion within the AUS-meat language was predicated on the basis that it provides additional information about carcass yield. Unfortunately, this has never been supported by scientific evidence and this has given rise to the contention surrounding the value of butt shape as a descriptor. There is scientific evidence showing a relationship between “muscle score”, as defined by NSW Agriculture, and yield, but the experience needed to score this with any degree of accuracy has meant that it has not been adopted for general use.

**Figure 13.6 The subjective assessment of butt shape in beef carcasses . Source: AUS-Meat.**



### **Disadvantages**

- it is difficult to standardise between assessors.
- no account is taken of whether shape is due to fatness or muscle
- there is therefore considerable variation in fatness, and consequently yield, within each score, and overlaps between scores.

### **Breed bias**

- The ‘fat corrected’ conformation score under-estimates the yield of European breeds and over-estimates the yield for dairy breeds. This bias highlights differences between breeds in fat partitioning and lean muscle to bone ratio.
- Replacement of conformation score with breed improves precision in prediction equations. However breed specific equations are not practical for processors who buy cattle and carcass of unknown history.

### **Eye muscle area (EMA)**

The area of the rib eye muscle at the quartering site can be measured in the chiller on the quartered carcass. Expressed in square cm, it is an additional variable used in conjunction with HSCW and fat depth to improve the accuracy of yield estimates. It is interchangeable with conformation score, but has the advantage of being an objective rather than a subjective measurement. If an objective measurement of the eye muscle area is possible, then there is little value using subjective conformation scores when cattle are processed.

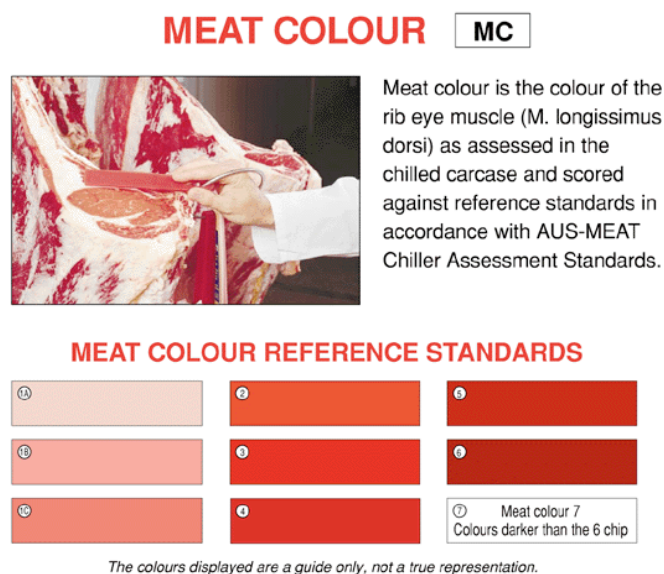
### **Chiller assessment**

AUS meat and MSA chiller assessment includes assessment of meat colour, fat colour, and marbling, using standard reference chips and a halogen light source. MSA also assesses ossification and muscle pH. Eye muscle area can also be measured.

### **Meat colour**

Meat colour is the colour of the rib eye muscle (m longissimus dorsi) assessed on the quartered, chilled carcass, at least 40 mins after quartering. This enables the cut muscle surface to bloom. Colour is scored against reference standards, which range from 1a to 6.

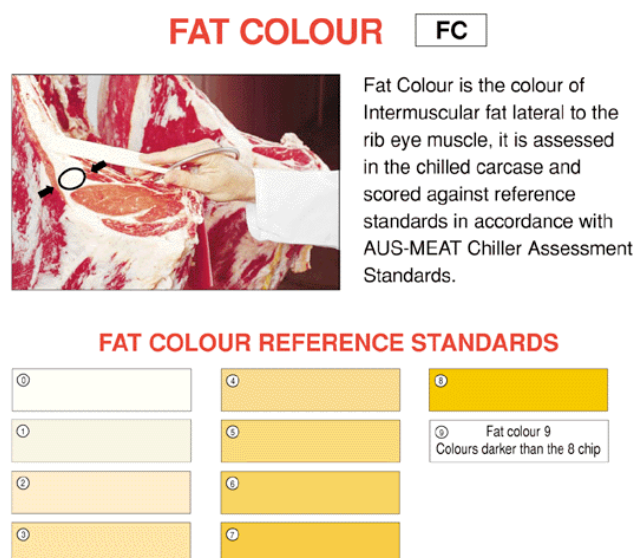
**Figure 13.7 Assessment of meat colour using AUS-Meat standard reference chips**  
Source: AUS-Meat.



## Fat colour

Fat colour is the colour of the intermuscular fat lateral to the rib eye muscle on the chilled, quartered carcass. It is scored from 0 (white) to 9 (bright yellow).

**Figure 13.8. Assessment of fat colour using AUS-meat standard reference chips**  
Source: AUS-Meat.



## Marbling

Marbling is an assessment of the amount of intramuscular fat (fat that is deposited between individual muscle fibres) in the m. longissimus dorsi. It is assessed on the chilled carcass, against reference standards. AUS-meat standards (Fig. 14.8 **Error! Reference source not found.**) range from 0 (no marbling) to 6 (heavy marbling). MSA graders use US marbling standards, which have more gradations.

**Figure 13.9 Assessment of marbling using AUS-meat reference standards.**

Source: AUS-Meat.

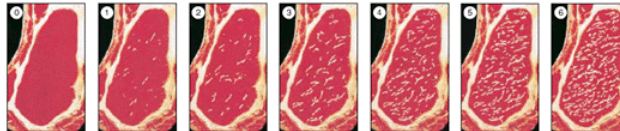
**MARBLING (Intramuscular fat)**

**MB**



Marbling is the fat that is deposited between individual muscle fibres of the M. longissimus Dorsi. It is assessed in the chilled carcass and scored against reference standards in accordance with AUS-MEAT Chiller Assessment Standards.

**BEEF MARBLING REFERENCE STANDARDS**



**Ossification**

Ossification is a measure of the maturity of a carcass. It is based on a visual score of the degree of ossification, size and shape of the bones and cartilage in the carcass, particularly the split chine bones. The scoring system follows the guidelines used by the USDA. The MSA scale of ossification goes from 100 to 200 in 10 point increments.

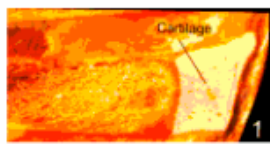
**Table 13.1 Ossification Description Table. Source: Thompson, (2005).**

MSA score	Age (mths)	Sacral vertebrae	Lumbar vertebrae	Thoracic vertebrae
100	9	No ossification	No ossification	No ossification
110	10	Capping starts	No ossification	No ossification
130	15	Advanced capping, separate still visible	No ossification	No ossification
150	20	Capping completed but some cartilage still visible	No ossification	No ossification
170	24	Capping completed, sacral closing	Some ossification	No ossification
200	30	Completely fused	Nearly completely ossified	Some evidence of ossification, 25% in first 3 vertebrae
300	42	Completely fused	Completely ossified	Partially ossified
400	72	Completely fused	Completely ossified	Outlines plainly visible
500	96	Completely fused	Completely ossified	Outlines barely visible

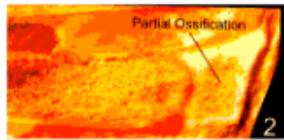
MSA graders refer to three sites along the backbone – the sacral, lumbar and thoracic vertebrae. The sacral vertebrae are the last five vertebrae on an AUS-MEAT standard carcass, taken from the tail end following the removal of the tail at the junction between the sacral and coccygeal vertebrae. The lumbar vertebrae are the six vertebrae in the loin region of the carcass. The thoracic vertebrae are the 13 vertebrae to which the ribs are attached. The above table shows the ossification that occurs at the three sites, as the animal matures. Age in months shown is only approximate.

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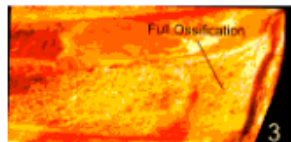
**Figure 13.10 Appearance of spinous process of the vertebrae as ossification increases.**  
Source: USDA



1) An image of a spinous process showing no ossification



2) An image of a spinous process showing partial ossification



3) An image of a fully ossified spinous process

### Ultimate pH

Ultimate pH (pHu) is that pH reached when glycogen reserves are depleted in the course of ATP production, or when temperature and pH levels prevent further build of hydrogen ions to cause further increase in acidity. Normally pHu will be about 5.4 to 5.6 — this is the level of acidity at which pH decline halts even if further glycogen substrate is available. Higher pHu levels result where there are insufficient glycogen levels to reach this pH. This is discussed in detail in other lectures. In normal animals pHu is not attained until after rigor, and the time to reach pHu depends on the rate at which ATP is depleted. This in turn depends on factors such as temperature, electrical inputs to the carcass, species, and initial glycogen reserves. In cattle it can take as long as 24-36 hours. Therefore the earliest time that the ultimate pH can be measured needs to be determined for each plant.

pHu is measured using a pH probe. There are numerous types available for measurement of pH in the laboratory. Measurement of pH of meat in an abattoir is obviously a very different proposition, and the probe needs to be robust. The most commonly used has a spear probe with a combination electrode, connected to a standard digital pH meter. In beef carcasses pH is measured in the longissimus muscle. In sheep it may be measured in the shoulder muscles.

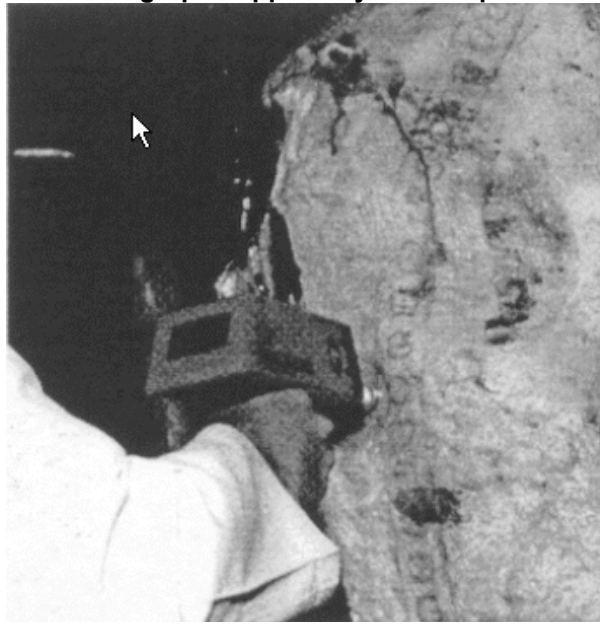
## 13.3 Technologies to Estimate Carcass Composition

### Optical probes

Optical probes were developed to measure fat depth on the carcass in place of the cut and measure techniques. They are equipped with a photoelectric cell that measures the thickness of the subcutaneous fat. The photoelectric cell is sensitive to the differences in the colour of fat and muscle, permitting the machine to measure the fat thickness when the probe penetrates the fat-muscle interface.



**Figure 13.11 The Hennessy Grading Probe used to measure the P8 fat depth on a beef carcass. Photograph supplied by J. Thompson.**



#### **Advantages**

- probes are easier and quicker to operate.
- they can be connected to an electronic data capturing system.
- they reduce operator error.

#### **Disadvantages**

- although optical probes measure fat depth objectively, the way they are used is partly subjective.
- it is essential operators are trained to identify damaged carcasses that can not be measured.
- operators must override obvious mistakes made by the probe.

#### **Accuracy of prediction**

The probe developed for cattle and sheep in 1984 was called the Hennessy Grading Probe.

- The Hennessy probe HGP measured fat depth consistently lower than the cut and measure technique.
- This was caused by the compression of the soft warm fatty tissue by the probe base plate.

#### **Video image analysis (VIA) systems**

Over the last eight years in Australia, there has been an ongoing program of development of new technologies for beef carcass description. Several different technologies including ultrasound and electromagnetic scanning have been evaluated. Of these, the most promising technology to emerge has been Video Image Analysis, or VIASCAN® as it is now commercially known. In Australia, there are three VIASCAN® systems now available. VIA systems have also been developed by Denmark, Germany, France and Canada.

##### **1. Whole carcass VIASCAN**

This system provides slaughter floor measurements of carcass dimensions, bruise score and subcutaneous fat distribution, coverage and colour on beef and lamb carcasses. Using combinations of these measurements, predictions of percentage saleable yield are achieved.

##### **2. Chiller assessment VIASCAN**

Applied in the chiller on the ribbed forequarter to measure eye muscle area, fat coverage over the eye muscle, fat colour and meat colour. The measurements of fat coverage and eye muscle area allow determination of percentage saleable yield.

##### **3. Portion assessment VIASCAN**

Applied by the food services sector, this system provides measurements of meat colour, fat colour and area on meat portions or sliced retail cuts.

## Notes – Lecture 13 – Measurement of Carcass Characteristics

### Whole carcass VIA

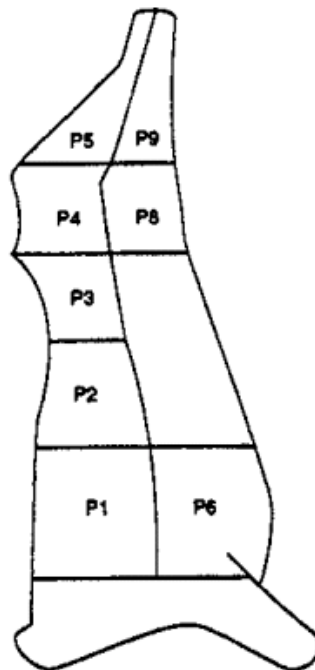
The whole carcass VIA is installed between the slaughter floor and the chiller. Images are taken as the carcass pass along the chain. The carcass needs to be stationary for only a very short time. This system removes the subjectivity associated with visual fatness and conformation classification. Specialised software extracts the data from the images (such as lengths, areas, colours). This data is then further processed to predict carcass composition.

### Colour parameters

- Average red, green and blue colour is measured over eight regions of the carcass.
- Camera is calibrated using 12 colour chips.
- Colour parameters assess the fat coverage over the carcass.
- The Danish systems (Beef Classification Centre) measure colour over 60 areas of the carcass.

**Figure 13.12 The patches over the lateral view of the carcass which the average red, green and blue values are measured by the WC-VIA (System Intellect, Australia).**

**Source: System Intellect Australia.**



### Carcass dimensions

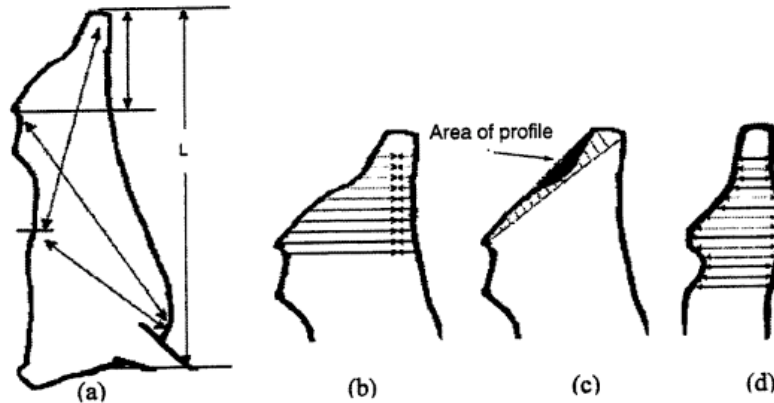
Dimensions are measured on the lateral and dorsal view.

Measures overall conformation of the carcass on the lateral view.

Measures the width of the hindquarter and the curvature of the butt region.

Measures the width of the hindquarter from the dorsal view.

**Figure 13.13. WC-VIA measurement (System Intellect, Australia).** The dimensions measured by the WC-VIA (System Intellect, Australia) (a) over the lateral view of the whole carcase, (b) across the width of the hindquarter, (c) the description of butt profile, and (d) the dorsal width of the hindquarter. Source: System Intellect Australia.



#### **Advantages**

- No possibility of cross contamination between carcasses, as there is no contact or penetration of carcass.
- The capturing and processing of an image is extremely quick.

#### **Disadvantages**

- Shadow effects of irregularities on the subcutaneous fat surface.
- Carcass blemishes (*i.e.* bruising, contamination of blood).
- Calibration of camera.
- Irregular lighting.
- Colour parameters are highly correlated.
- Dimension parameters are highly correlated.

#### **Prediction of carcass composition**

- when applied to very fat carcasses (grain finished Japanese ox), the WC-VIA equations lose predictive accuracy.
- with light or leaner carcasses the WC-VIA performs better than the HSCW and P8FD model.

#### **VIA chiller assessment system**

The chiller VIA is manually positioned over the cut surface of the quartered carcass. It automatically measures the loin fat depth, the area of the eye muscle, and the colour of meat and fat.

**Figure 13.14. The video image chiller assessor capturing an image of the quartered site.** Photograph supplied by J. Thompson.



## Notes – Lecture 13 – Measurement of Carcass Characteristics

### Advantages

- objective assessment.
- removes human error.
- fast.
- little training required.

### Disadvantages

- reflectance off meat.
- meat surface must be cut smoothly.
- has some difficulty tracing the outline of the eye muscle area.

### Portion assessment VIA

The portion assessment VIA is available for use by the food services sector (meat wholesalers, retail butchers, caterers), although their use is not widespread. The system gives them an objective measurement of meat colour, fat colour and area on meat portions or sliced retail cuts. This helps them estimate yield at the retail level, and keep track of what does — and does not — fit within their specifications.

**Figure 13.15. Portion cut assessment VIASCAN, measuring size and colour of individual steaks. Photograph supplied by J. Thompson.**



### *Electromagnetic scanning*

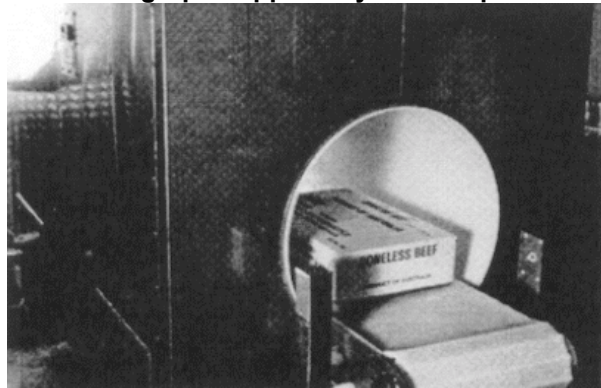
Electromagnetic scanners estimate the quantity of lean muscle in a carcass by measuring the different conductivity and dielectric properties of muscle, fat and bone. Muscle tissue is 20 times more conductive than fat tissue due to the greater concentration of aqueous sodium and potassium in and around muscle cells. The scanner measures the different absorption of energy of lean and fat in the presence of an electro magnetic field. The energy absorbed by the carcass is proportional to the quantity and composition of the conductive fat free mass.

Other factors that influence conductivity are the geometry of the tissue mass, and meat temperature.

To optimise the application positioning of samples must be consistent, sample temperature needs to be constant or measured, and sample geometry needs to be measured.



**Figure 13.16. An electromagnetic scanner used to predict the lean percentage of boxed beef. Photograph supplied by J. Thompson.**



#### **Advantages**

- Objective estimate of carcass composition.
- Non-invasive.
- Reliable.
- Predictive accuracy is not dependent on the stability of relationships between measurements at specific sites in the carcass and carcass composition.

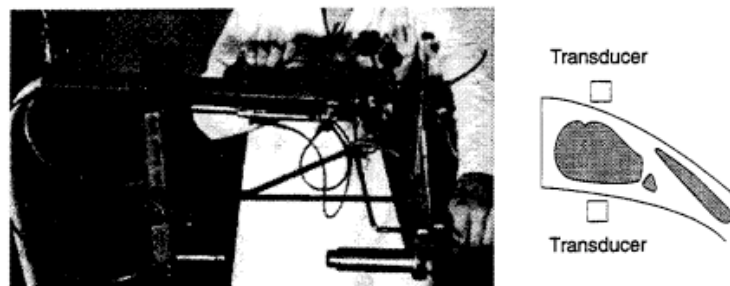
#### **Velocity of sound (VOS)**

Ultrasound waves are sound waves with frequencies above the range of the human ear (i.e. above 16-18,000 cycles/second). Sound travels through an homogenous material such as water at a constant speed. VOS through solid material varies directly with the bulk modulus and inversely with density of the material. Greater bonding force between molecules increases the bulk modulus, therefore sound will travel faster through a solid than a liquid or gas (bone transmits sound faster than muscle). With increased density of the molecules the speed of sound is reduced (i.e. sound travelling from muscle to fat). Sound transmitted through a material excites the molecules causing them to oscillate. The frequency of oscillation is determined by the density of the molecules.

#### **Prediction of carcass composition**

Averaging VOS measurement across three sites improves accuracy when predicting the percentage of lean tissue. Accuracy of predicting yield is similar to the HSCW and P8 FD equation. Precision is improved by including conformation scores, breed or sex effects, helping to describe the variation in lean mass between bulls and steers.

**Figure 13.17. An ultrasonic device that measures the velocity of sound through tissues at anatomical sites on the carcass. Photograph supplied by J. Thompson.**



#### **Advantages**

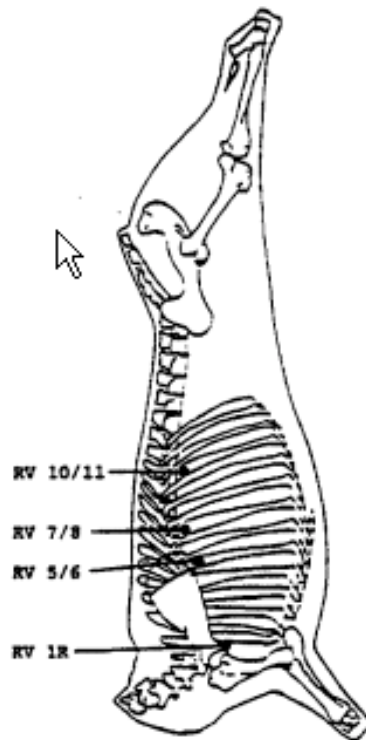
Lean mass directly affects the velocity at a given fat content, unlike fat thickness which is indirectly related to the lean muscle content of a carcass.

#### **Disadvantages**

VOS measurements tend to have poor repeatability, as it is difficult to reposition the transducer at exactly the same point of the carcass. Error may also be caused by tissue heterogeneity and variation in the distance between the transducers.

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**Figure 13.18. Anatomical sites on the carcass where the velocity of sound has been measured as predictors of yield. Source: Thompson, (2006).**



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**Readings** There are no readings for this topic.

### Summary

Summary Slides are available on web learning management systems

- carcass measurements cover the full range from subjective assessment to objective measurement by either humans or machines.
- modern technology is being increasingly used
- measurements are used in a variety of ways, from enhancing accurate description of product for marketing purposes, to monitoring post-slaughter systems for quality assurance, to predicting the yield and eating quality of the product.
- there are advantages and disadvantages for most measurement systems

### References

Anon 1998. Handbook of Australian Meat 6<sup>th</sup> Edition AusMeat Ltd, Brisbane.

System Intellect Australia - WD - VIA Carcase measurement system and beef carcase description system.

United States Department of Agriculture (USDA). Scoring system and guidelines to measure carcase maturity. Washington, D.C., USA.