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Bone-out for MSA Quality Index

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Executive Summary

Meat Standards Australia (MSA) is a cuts based grading system which grades individual cuts in the beef carcass using commercial inputs. By necessity the outputs of MSA are complex but this complexity is warranted in carcasses where muscles differ widely in form and function and hence eating quality.

There is a need to provide a simple feedback tool by which producers can monitor changes in eating quality of the carcass. Boning groups were set up as a tool to help processors sort carcasses into like groups to facilitate the harvesting of cuts of different eating quality grades. Initially they were intended to be customised to the type of carcasses processed within each plant. However as the system evolved boning groups were applied as a national standard across the country on all types of cattle. As a national system they were inefficient in separating the carcasses into like groups for boning. At the producer level they were difficult to interpret or to use to monitor progress in eating quality.

The concept of a MSA index to describe eating quality of the carcass was proposed as a tool to allow producers to better understand changes in the predicted eating quality of their carcasses. It was proposed that the MSA Index be calculated as a weighted eating quality score for the whole carcass. This required assumptions as to the cooking procedure used for each cut and a base muscle distribution pattern in the carcass. A weighted MSA index could be calculated as the sum of the MQ4 for each muscle multiplied by the weight of the muscle as a proportion of total muscle in the carcass. This approach assumed that muscle distribution patterns were relatively constant across the carcass of different breeds, sexes and weight classes of cattle.

There has been considerable research undertaken on factors that influence muscle distribution in beef carcasses. The conclusion from these studies was that muscle distribution in the carcass was a result of the functional stresses placed on the musculature. As all cattle undertake similar activities by walking, standing and lying down it was therefore not surprising that between breed differences in muscle distribution were small.

This project examined the distribution of trimmed MSA cuts in the carcasses of steers from three muscling lines. The muscling line were part of a long term project managed by the NSW DPI where replacement animals had been selected for low and high live animal muscling scores. The base cows were from the Hereford breed which were mated to Angus bulls. Inadvertently the mysotatin gene was introduced into the high muscling line in 2005 and this presented an opportunity to create another muscling selection line where the cows had one copy of the myostatin gene.

The range in muscling between these lines was similar if not greater than the between breed difference in muscling that exist in industry. Carcasses from these lines presented an ideal opportunity to firstly develop a base on which to calculate the MSA Index, but also to investigate the effect of extremes in muscling on muscle distribution. The inclusion of a line which carried one copy of the myostatin gene provided an extreme in muscling caused by a single gene effect.

The results showed little difference in muscle distribution of trimmed MSA cuts between carcasses from the high and low muscling lines. The muscle distribution did differ slightly for the myostatin muscling carcasses so they were excluded from the base muscle distribution pattern used to calculate the MSA Index.

A dissection guide was provided to allow the muscle distribution data base to be added to in the future. This would only occur if producers were concerned that their carcasses differed enough in muscle distribution to warrant a different base distribution pattern to calculate the MSA Index.

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1.0 Background

The MSA beef grading model provides a tool to predict the eating quality of individual cuts in the beef carcass from commercial inputs available at grading. The output from the MSA model is an eating quality score for individual cuts for a range of cooking methods. Based on consumer responses the eating quality scores are then allocated to one of 4 grades being unsatisfactory (fail), good every day (3 star), better then every day (4 star) and premium (5 star).

Compared to other grading systems around the world an MSA eating quality score for every muscle and cook combination can appear unnecessarily complex and difficult to integrate into a commercial environment. However this complexity is rewarded by a vastly improved accuracy of the MSA model to describe the consumer response to eating that particular cut cooked in a specific manner. The complexity is necessary because of the effects of the different model inputs vary with cut.

There is however a need to provide a simple feedback tool by which producers can monitor changes in carcass eating quality. The current array of scores by cook methods is useful for the processor but is not a realistic option for feedback to producers. Unfortunately muscles in the carcass respond differently to the input factors in the MSA model and so it is not possible to use the eating quality score of a single muscle or group of muscles as a simple indicator of carcass quality. An example would be the effect of increasing *Bos indicus* content which has a large effect on the striploin and only a small change in the eating quality of the eye round. Similarly inputs such as marbling and ossification scores, which are used by other grading systems around the world, have a differential effect on eating quality across the carcass musculature. The net result is that carcass is a collection of muscles which will vary enormously in eating quality as a function of the animal, the grading inputs and value adding effects. A consequence of this complexity is that no single muscle that could be used to simply describe quality of the carcass (Polkinghorne, 2005).

Boning groups were set up as a means to implement the complex output of the MSA model into the commercial environment to harvest cuts of different quality. Boning groups historically provided a basic tool to sort carcasses for processors to harvest cuts of varying quality. However when they were applied as a national standard there were significant deficiencies in their efficiency to segregate cuts of different qualities. The variable efficiency of boning groups to harvest cuts of different qualities in a commercial boning room has recently been highlighted by in work undertaken by Murdoch University (Peter McGilchrist pers comm) . They concluded that boning groups did not provide an efficient means of harvesting cuts of different eating quality and therefore the value of the boning groups as a feedback tool for producers was questionable.

The fact that boning groups describe the eating quality of the cut relative to the worst cut in the group also makes it an insensitive measure to describe carcass quality. The production sector would benefit from a simple figure that describes eating quality of the cuts within the carcass. This lead to an MLA initiative to develop an MSA index which can be used to describe changes in cut quality both over time and between production systems.

The concept behind the MSA index was to develop a single score that would be indicative of overall carcass eating quality. This would provide producers a tool that was sensitive to small changes in eating quality and allow progress to be monitored over time. Such an index would also be a sound basis to evaluate both on-farm genetic progress over time and also to compare the impact of different management strategies.

An overall index could be calculated by taking a weighted average of all MQ4 scores in the carcass. This requires an assumption as to the cooking procedure used for each cut. In addition a muscle distribution pattern is required to weight the eating quality scores from the different cuts. A weighted MSA index could be calculated as the sum of the MQ4 for each muscle multiplied by the weight of the muscle as a proportion of total muscle in the carcass. This approach assumes that the muscle distribution is relatively constant across the carcass of different breeds, sexes and weight classes of cattle.

The potential impact of breed or sex on muscle distribution have been the focus of a great deal of research over the past 50 years. The conclusion from these studies was that whilst cattle breeds differ widely in size and shape there is little difference between breeds in muscle distribution (see review by Berg and Butterfield 1976). The major changes in muscle distribution occur soon after birth when the functional demands of adjusting to a new environment are substantial. From about weaning the muscle distribution is relatively stable with only small changes occurring with further increases in carcass weight. Berg and Butterfield (1976) concluded that muscle distribution in a carcass was a result of the functional stresses placed on the musculature of the live animal. As all cattle undertake similar activities by walking, standing and lying down it was therefore not surprising that between breed differences in muscle distribution were small.

Previous studies on muscle distribution have either dissected whole muscles or dissected primal cuts. The results from dissection studies were not suitable to develop the MSA Index because the MSA cuts often have portions of the same muscle in different MSA cuts, (eg the *M. longissimus* dorsi forms part of the CUB045 and STR045 cuts) and also not all of a muscle is necessarily dissected when preparing some MSA cuts. In those studies where commercial cuts were used, generally the primals were simply separated into muscle, fat and bone which was not suitable for quantifying the weight of individual muscles within the primal. Therefore it was essential that the distribution of trimmed MSA cuts in the carcass be determined for a sample of carcasses.

Whereas previous studies concluded that breed and sex effects on muscle distribution were relatively small there was evidence that the double muscling gene can impact on muscle distribution. Slightly different variants tend to occur in most beef breeds (Arthur 1995). Muscle hypertrophy in the homozygote carriers of the gene tend to have several gradients operating with more pronounced muscle development in the hindquarter compared to the forequarter and more muscle in the proximal compared with the distal muscles of the limbs. Finally there is more pronounced development of the superficial muscles compared to those which are deep in the musculature (Shahin and Berg 1971, Arthur 1995). In the heterozygote animal the differences in muscle distribution are still evident but less pronounced than for the homozygote.

Whilst the research clearly showed that breed differences in muscle distribution were small to there is still an industry perception that muscle distribution in cattle was a function of body conformation. The perception was that the higher conformation animals had a greater proportion of muscle in the high priced hindquarter cuts.

There was an opportunity to address the base line muscle distribution pattern to be used to calculate the MSA Index and also the industry concerns that muscling impacted on muscle distribution by boning out carcasses from the NSW DPI high and low muscling lines. The cattle comprised 40 pasture finished steers from 3 lines. The low muscling line where male and female replacements had been selected for low muscle score. The high muscle line where male and female replacements had been selected for high muscle score. These high and low muscling lines were established in 1992. In 1996 the double muscling mutation was inadvertently introduced into the high muscling line and it continued as a separate myostatin line with females having one copy of the myostatin gene. The same bulls were used in both the high muscling and myostatin lines.

The following dissection protocol was set up to record the weights of trimmed MSA cuts from the three lines. Results are presented on the distribution pattern which was then used in conjunction with the output from the MSA model to generate MSA Index scores.

2.0 Bone-out Protocol for MSA cuts

Carcasses are quartered at the 12th/13th rib site with a square cut across the eye.

Hindquarter boning

The hindquarter is boned into 8 primals according to the AUSMeat specifications (Anon 1998)

1. 1 rib striploin
2. Full thin flank
3. Rump with entire tri-tip intact (don't leave tail on the thick flank)
4. Thick flank with no tri tip – Patella removed
5. Topside with no trim
6. Silverside
7. HQ shin
8. Tenderloin (full tenderloin)

Forequarter boning

The forequarter is broken into primal without sawing any bones, ie the rib cage is left intact. From the inside surface of the forequarter the inside skirt (M. transversus abdominis) is removed along with the diaphragm. The *M. intercostals* are removed from the ribs after all primals have been removed.

The forequarter is boned into 7 primals according to AUSMeat specifications (Anon 1998).

1. Brisket primal is defined caudally by a cut 100mm dorsal from the junction of the 12th rib and the costal cartilage to the cranial junction of the first rib with the sterum.
2. The ribset and chuck are separated by a cut between the 5th and 6th rib hard up against the 6th rib.
3. Foreshank with no bone
4. Blade (leave the *M. subscapularis* or CHK084 which is the muscle on the bottom side of scapula on the chuck). The scapula bone is removed.
5. Chuck tender (CHK085, *M. supraspinatus*) is separated from the blade (bolar and oyster together)
6. Intercostals are trimmed from the rib vertebrae

The primals are weighed and after trimming the MSA cuts are also weighed using the spreadsheet shown in Appendix A1 and A2. Much of the description of cuts and there dissection made use of the Australian Handbook of Meat (1998) and Butterfield and May (1966).

2.1 Hindquarter Primals

Striploin

The striploin comprises a major portion of the *M. longissimus dorsi* which runs the length of the lumbar vertebrae in the hindquarter. In the hindquarter this muscle is termed the *M. longissimus dorsi et lumborum.*

The caudal boundary of the striploin is a cut across the lumbar sacral junction and the cranial boundary the junction of the 12/13th rub. The *M. longissimus dorsi* is dissected from the dorsal vertebrae and lateral spines. Subcutaneous fat is removed from the dorsal surface and the intercostal muscles from the ventral surface. The *M. mutifidius* is removed, as is the *M. iliocostalis*. The cranial portion of the *M. gluteus medius* which overlies the caudual portion of the striploin is removed (see Figure 2). The silverskin or epyimysium is left intact on the trimmed primal.

The trimmed striploin is then divided into anterior (STA045) and posterior (STP045) portions. Typically the anterior (STA045) and caudal (STP045) portions of the striploin comprises 2.3% and 2.1% of the trimmed weight of MSA cuts in the carcass, respectively.

Anterior striploin piece (STA045, *M. longissimus dorsi et lumborum*)

Figure 1 The trimmed STA045 (*M. longissimus dorsi et lumborum.*

Posterior striploin piece (STP045, *M. longissimus dorsi et lumborum*)

Figure 2 The trimmed STP045, (*M. longissimus dorsi et lumborum).*

Tenderloin

The tenderloin primal is removed from inside the hindquarter. Generally the *Mm. psoas major, psoas minor* and *iliacus* are removed as one piece with the *M. iliacus* being dissected from the shaft of the ileum. The side strap muscle (*M. psoas minor*) is removed, as is the *M. iliacus,* leaving the *M. psoas major* (TDR062).

Typically the TDR062 (*M. psoas major*) comprises 1.9% of the trimmed MSA cuts, whilst the TDR034 (*M. iliacus*) comprises 0.8% of the total trimmed MSA cuts.

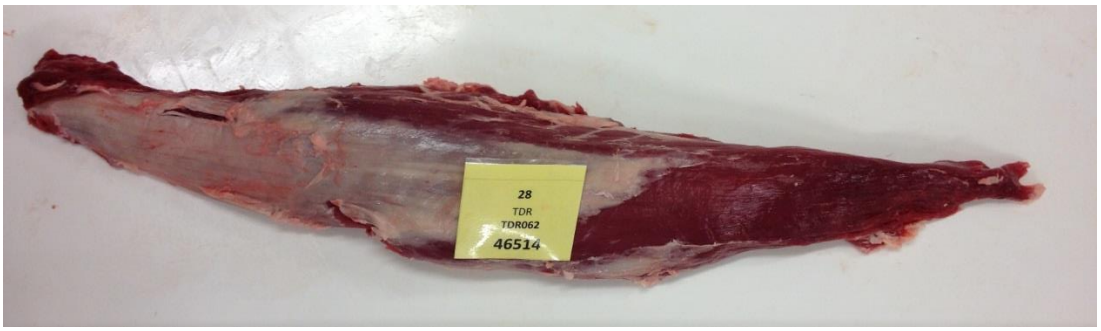


Figure 3 The trimmed TDR062 (*M. psoas major)*. The side strap (*M. psoas minor*) and *M. iliacus* have been removed.

Figure 4 The trimmed TDR034 (*M. iliacus)*.

RUMP

The full rump primal is removed from the carcass by separating the flank and ensuring that the tritip (*M. tensor fascia latae,* RMP087) is left intact on the rump cut. The caudal border is a straight cut from the subiliac lymph node to a point cranial to the acetabulum (or cup joint). The cranial end is separated by a cut at the lumbo sacral junction in a straight line to the tube coxae of the flank. The rump primal can be removed bone-in and subsequently the os coxae bone removed on the table, or it can be boned out from the hanging hindquarter.

The rump primal comprises 5 MSA cuts. The tritip (RMP087), the rump cap (RMP005), two portions of the *M. gluteus medius* (RMP131 and RMP231) and the *M. gluteus profundus* (RMP032).

Tri tip, RMP087 *(M. tensor fasia latae*)

The tri tip and D rump are prepared from the full rump by separating the natural seam between the *M. gluteus medius* and the *M. tensor fascia latae* (RMP087). Typically the tri tip (*M. tensor fasia latae,* RMP087) comprises 1.3% of trimmed MSA cuts.

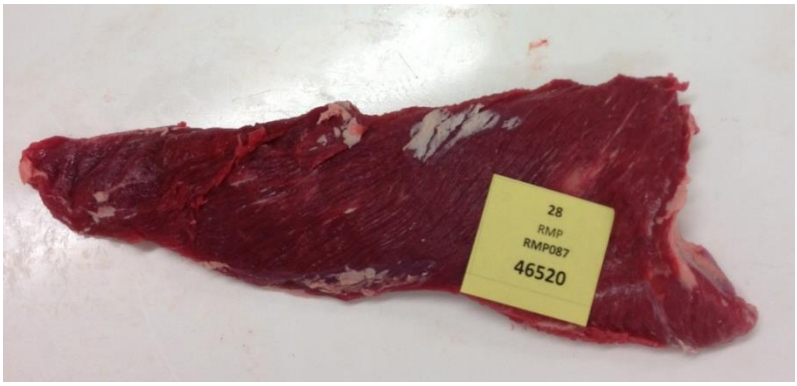


Figure 5 The trimmed tri tip, RMP087 (*M. tensor fascia latae*).

Rump cap, RMP005 (*M. biceps femoris*,)

The D rump is then dissected into the rostbiff (RMP131 and RMP231) and the cap of the rump (RMP005). The latter comprises the dorsal portion of the *M. biceps femoris* which overlies the D rump. The muscle is trimmed of subcutaneous fat. Typically the RMP005 *(M. biceps femoris)* comprises 1.5% of trimmed MSA cuts.

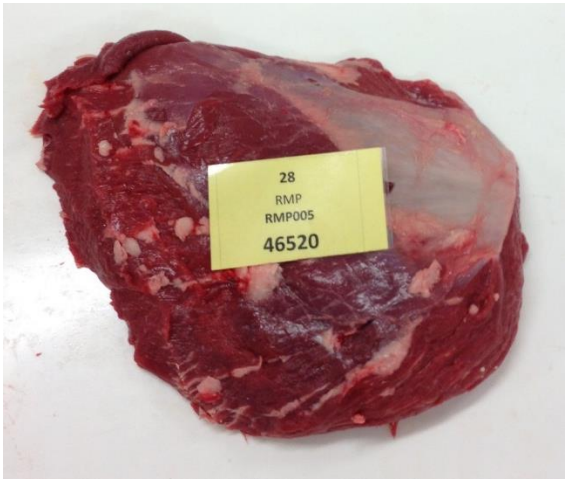


Figure 6 The trimmed rump cap RMP005 (*M. biceps femoris)*. This muscle has been dissected from the D rump.

M. gluteus profundus, RMP032

The rostbiff is further trimmed by removal of the *M. gluteus profundus* from the ventral surface of the rostbiff. This is a thin fan shaped muscle which needs to be dissected from the os coxae. Typically the RMP032 comprises 0.3% of the trimmed MSA cuts.

Figure 7 The trimmed RMP032 (*M. gluteus profundus)*.

Rostbiff, RMP131 and RMP231 (*M. gluteus medius*,)

The trimmed rostbiff is then separated along the seam into two portions, the body and head of the *M. gluteus medius*.

The larger portion or body of the *M. gluteus medius* is termed the RMP131 and typically comprises 2.6% of the trimmed MSA cuts.

Figure 8 The trimmed body of RMP131 (*M. gluteus medius*).

The head of the muscle which lies underneath the *M. biceps femoris* is termed the RMP231 and typically comprises 1.4% of trimmed MSA cuts.

Figure 9 The trimmed head of RMP231 (*M. gluteus medius*).

THIN FLANK

The think flank is prepared by a cut commencing at the superficial inguinal lymph node following the contour of the hip and then the ventral border of the striploin. The thin flank comprises 3 MSA cuts being FLK064 (*M. rectus abdominis),* TFL051 *(M. obliquus externus abdominis)* and TFL052 (*M*. *obliquus internus abdominis*)

Flank steak, TFL064 (*M. rectus abdominis*)

From the think flank primal the FLK064 (*M. rectus abdominis*) is dissected from the ventral portion of the flank and trimmed of fat. The FLK064 runs the length of the abdominal cavity from the sternum to the pubis. The serous membrane and connective tissue are easily stripped from this muscle. Typically TFL064 comprises 1.7% of the trimmed MSA cuts.

Figure 10 The trimmed TFL064 (*M. rectus abdominis*).

Flank plate steak tip TFL051 (*M. obliquus externus abdominis) and* TFL052 (M. *obliquus internus abdominis*)

The remaining flank plate steak tip comprises the *M. obliquus externus abdominis* (TFL051) and *M. obliquus internus abdominis* (TFL052). These muscles are trimmed of external fat and trimmed of easily accessible pockets of fat. Typically the TFL051 (*M. obliquus externus abdominis)* and TFL052 (*M. obliquus internus abdominis)* comprises 1.2 and 2.6% of trimmed MSA cuts, respectively.

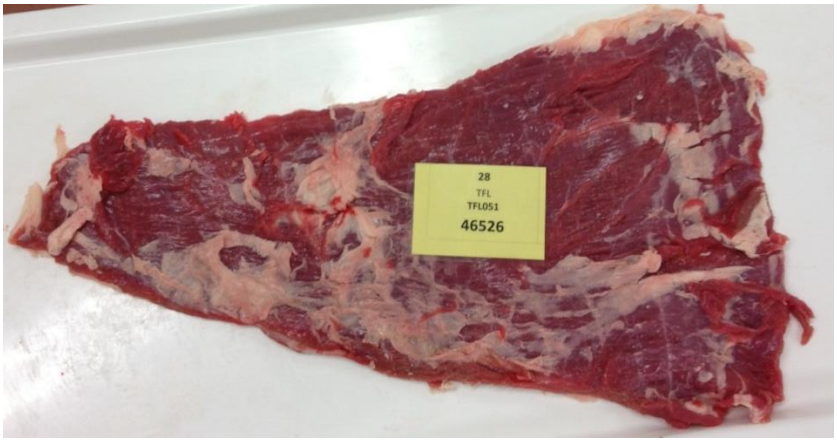


Figure 11 The trimmed TFL051 (*M. obliquus externus abdominis)*

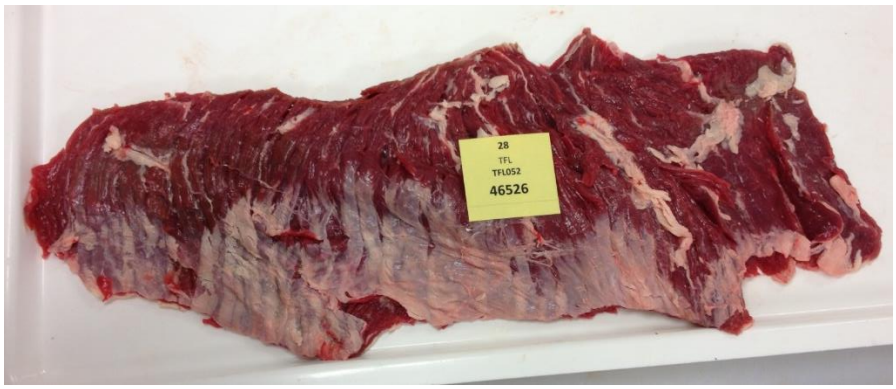


Figure 12 The trimmed TFL052 (*M. obliquus internus abdominis*)

TOPSIDE

The topside primal comprises 3 MSA cuts and is removed from the butt by following the natural seam between the thin flank and the silverside. The 3 MSA cuts comprise the TOP033 (*M. gracilis*), the TOP001 (*M. adductor femoris*) and TOP073 (*M. semimembraneous*) being separated.

Topside Cap, TOP033 (*M. gracilis)*

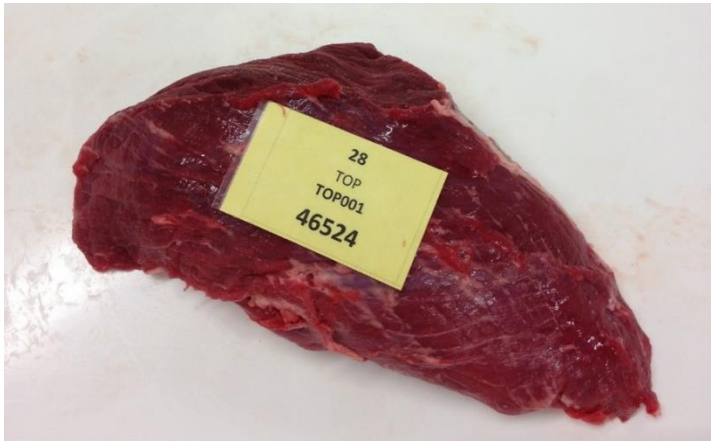
The topside cap (TOP033, *M. gracilis*) is on the external surface of the topside primal and removed along the natural seam and trimmed of all subcutaneous fat. Typically the TOP033 (*M. gracilis*) comprises 2.6% of trimmed MSA cuts.

.Figure 13. The trimmed topside cap TOP033 (*M. gracilis*)

The remaining portion of the cap off topside primal is separated into the TOP001 (*M. adductor*) and TOP073 (*M. semimembranosus*). This separation is achieved by inserting the fingers into the veins which indicate the junction of the *Mm*. *adductor* and *semimembranosus* and tearing the 2 muscles apart.

TOP001 *(M. adductor)*

Typically the TOP001 (*M. adductor)* muscle comprises 2.1% of the total MSA cuts.



.Figure 14. The trimmed TOP001, (*M. adductor*)

TOP073 (*M. semimembranosus)*

This is the largest of the MSA cuts being a large fleshy muscle and would typically comprise 6.3% of the total MSA cuts.

Figure 15. The trimmed TOP073, (*M. semimembranosus*)

KNUCKLE

The knuckle comprises 4 MSA cuts being the KNU066 (*m. rectus femoris*), KNU098 (M. vastus intermedius), KNU099 (*M. vastus lateralis*) and KNU100 (*M. vastus medialis*).

The knuckle side (KNU099, *M. vastus lateralis*) if the first muscle to be removed from the knuckle. This muscle overlies the knuckle centre (KNU066, *M. rectus femoris)* and the KNU100 (*M. vastus intermedius).* The KNU100 *(M. vastus medialis)* is the deepest muscle in the quadriceps group and has been separated from the shaft of the femur.

<u>Knuckle side KNU099 (*M. vastus lateralis)*</u>

The knuckle side is removed first from the knuckle primal. Typically it comprises 2.6% of the trimmed MSA cuts.

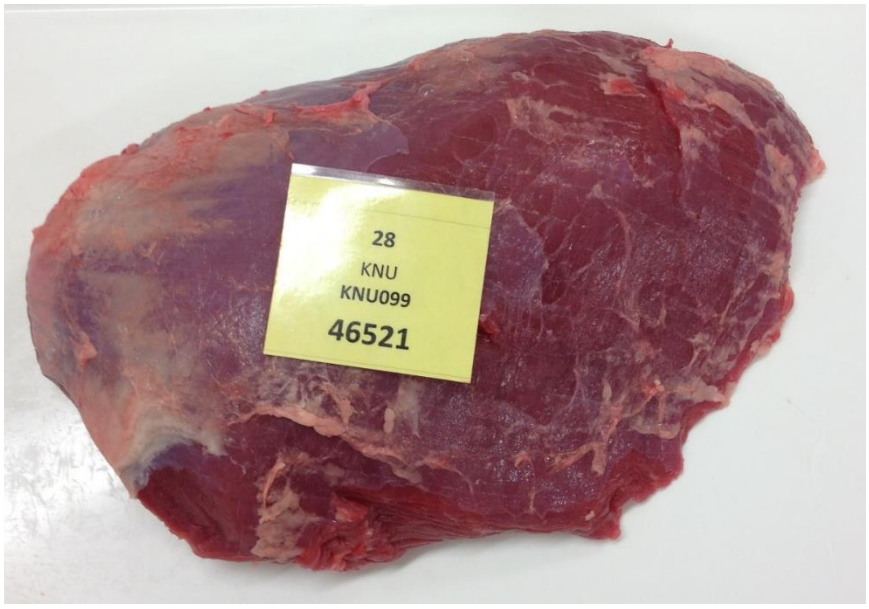


Figure 16 The trimmed KNU099 (*M. vastus lateralis*)

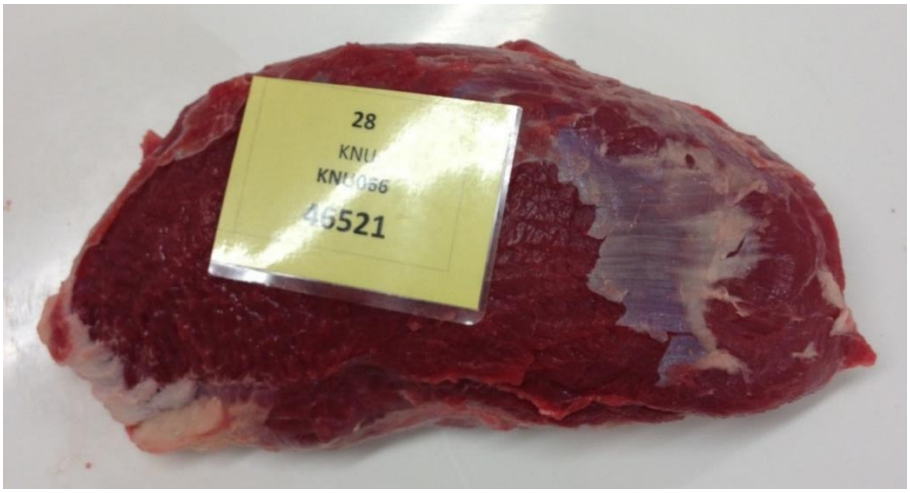


Figure 17 The trimmed KNU066, (*M. rectus femoris)*

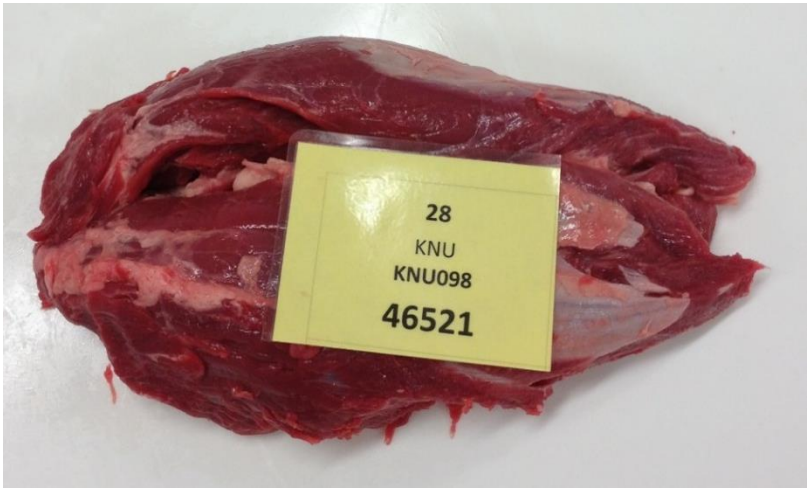


Figure 18 The trimmed KNU098 (*M. vastus intermedius*)

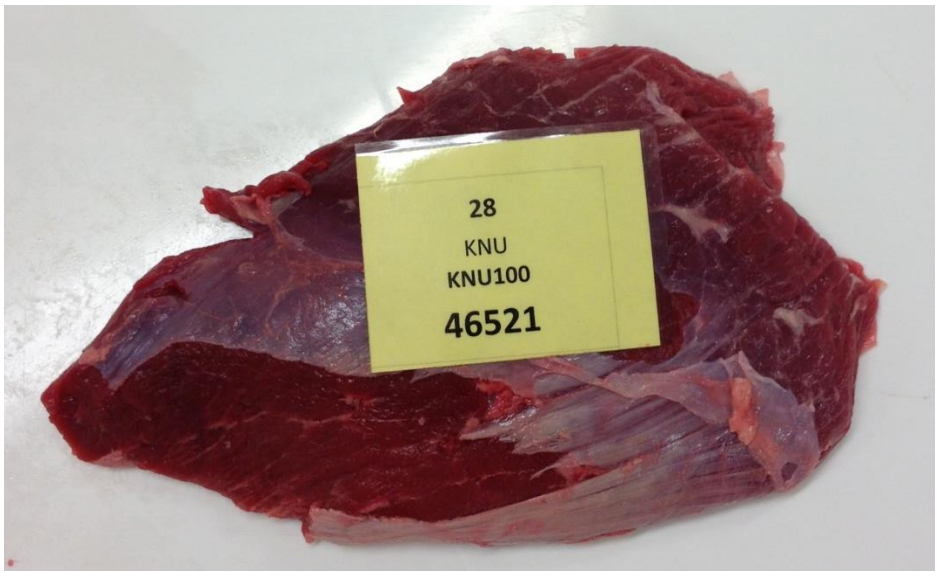


Figure 19 The trimmed KNU100 *(M. vastus medialis)*

Silverside

The silverside comprises 3 MSA cuts comprising the eye round (EYE075), outside (OUT005) and the heel muscle (OUT029). This large cut is separated from the thick flank and topside primals along natural seams.

Eye round, EYE075 (*M. semitendinosus*)

The EYE075 (*M. semitendinosus*)is a long muscle which is usually lighter in colour than the surrounding muscles. It is separated along natural seams from the outside and trimmed of subcutaneous fat. Typically the EYE075 comprises 3.3% of the trimmed MSA cuts.

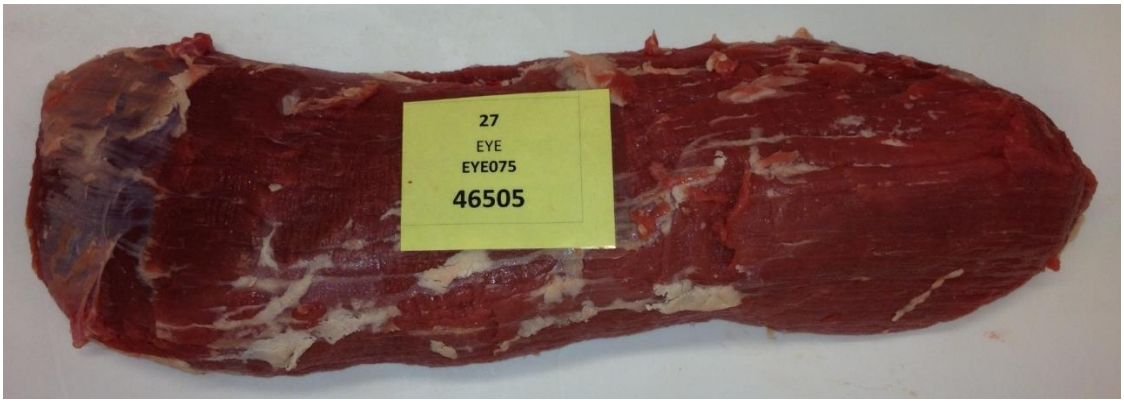


Figure 20. The trimmed eye round (EYE075, M. semitendinosus)

Heel Muscle, OUT029 (*M. gastronemius)*

The heel muscle (OUT029, *M. gastronemius)* is a broad two headed muscle occupying the inside surface of the thigh. The external surface is trimmed of subcutaneous fat. Typically the OUT029 comprises 3.3% of the trimmed MSA cuts.

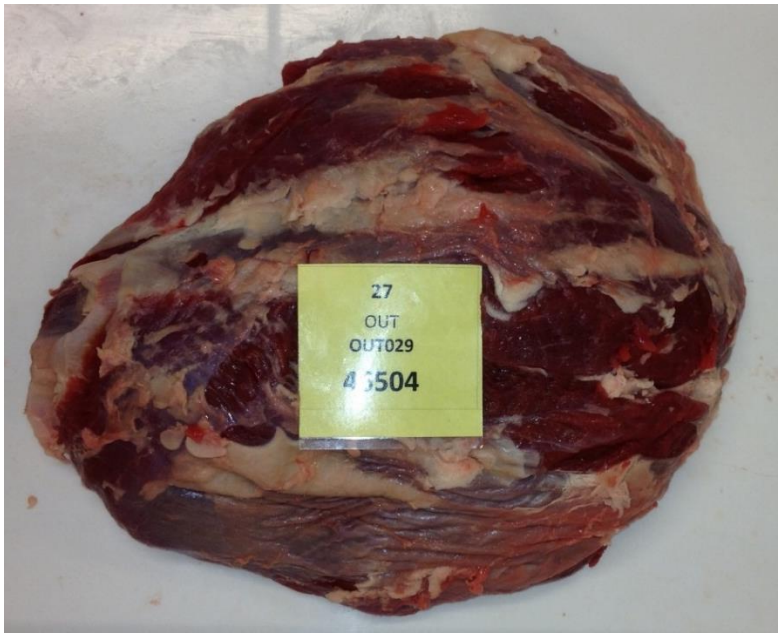


Figure 21. The trimmed heel muscle OUT029 (M. gastronemious)

Outside OUT005 (*M. biceps femoris*)

The outside is a large muscle on the outside of the thigh. The ventral portion overlies the rump and is called the rump cap. The muscle appears to comprise two portions because of the muscle fibre orientation, although technically it is one muscle. The larger cranial portion is separated from the caudal portion by a fat filled groove. Typically the OUT005 comprises 7.4% of the trimmed MSA cuts.

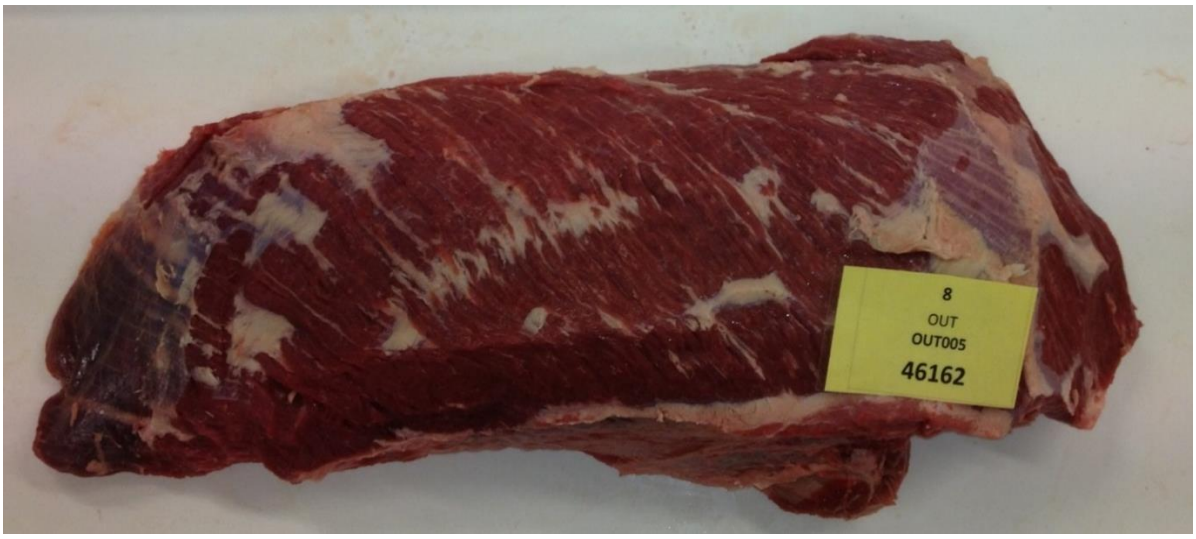


Figure 22 The trimmed outside muscle (*M. biceps femoris*, OUT005)

Hindquarter shin (HQshin)

The hindquarter shin comprises a collection of individual extensor and flexor muscles in the hindshin. The AUSMEAT definition includes the heel muscle (OUT029, *M. gastrocnemius*) but for MSA definition this has been removed and is included in the outside. The MSA trim removes excess subcutaneous fat, but sinews and tendons are left on the cut.

Figure 23 The trimmed HQshin (*Mm. extensor muscles)*

2.2 Forequarter

The 7 forequarter cuts comprise, brisket, ribset, blade, chuck tender, chuck, foreshin and intercostal group.

Brisket

The ventral boundary of the brisket primal is scored using a knife and the primal boned from the forequarter. The brisket primal comprises 2 MSA cuts being the BRI056 (*M. pectoralis profundus*) and BRI057 (*M. pectorlis superficialis*). The brisket primal is not divided into naval and point end portions as is done in most commercial boning rooms.

BRI056 (*M. pectoralis profundus*)

This is the deep pectoral muscle which runs the length of the brisket primal. Typically the BRI056 comprises 4.5% of the total MSA trimmed cuts.

Figure 24 The trimmed BRI056 (*M. pectorlis profundus*)

BRI057 (*M. pectorlis superficialis*).

This is the superficial pectoral muscle which is confined to the caudal portion of the brisket primal. It is trimmed of subcutanmeous and intermuscular fat. Typically the BRI057 comprises 1.9% of the total MSA trimmed cuts.

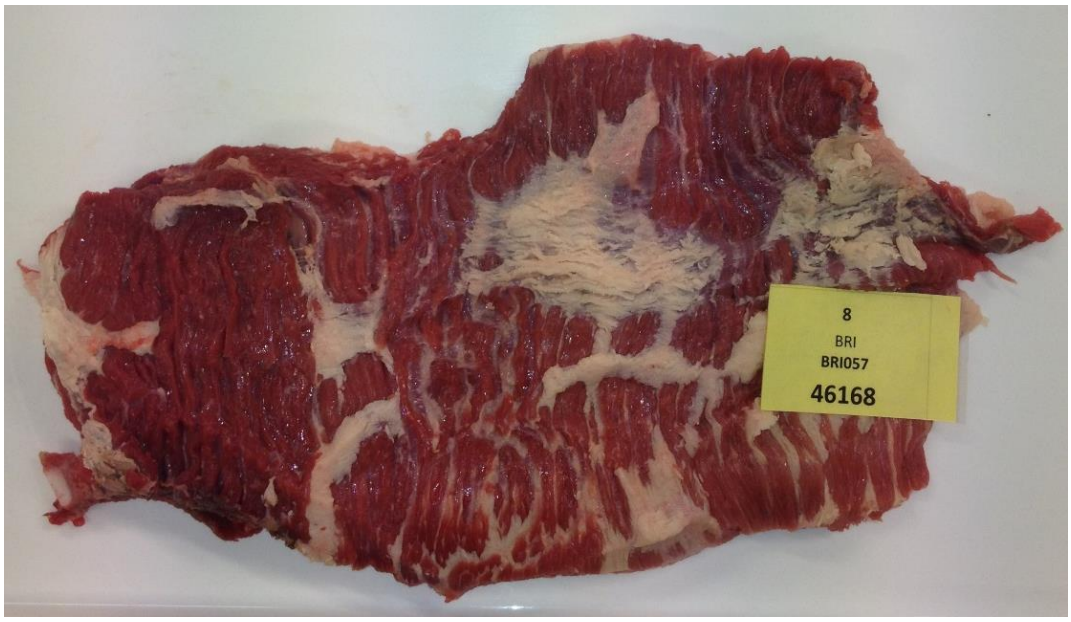


Figure 25 The trimmed BRI057 (*M. pectorlis superficialis*)

Ribset

The boundaries of the ribset primal are defined cranially by the anterior edge of the 6th rib, ventrally by the junction with the brisket and caudally by a square cut across the eye muscle and caudally by the posterior edge of the 12th rib. The primal is boned from the forequarter and the cube roll removed. This cut is then separated into the CUB045 (*M. longissimus dorsi et thoracics*) and SPN081 (*M. spinalis dorsi*)

SPN081 (*M. spinalis dorsi*)

The SPN081 (M. spinalis dorsi) is a broad strap like muscle extending from the lumbar region to the neck. It is trimmed of all intermuscular fat and the connective tissue is retained. Typically the SPN081 comprises 2.1% of the total MSA trimmed cuts.

Figure 26 The trimmed SPN081 (*M. spinalis dorsi*)

CUB045 (*M. longissimus dorsi et thoracics)*

The CUB045 (*M. longissimus dorsi et thoracics*) is trimmed of the *M. multifidius dorsi.* Intermuscular fat is trimmed, whilst the connective tissue sheath is left intact. Typically the CUB045 comprises 3.4% of the trimmed MSA cuts.

Figure 27 The trimmed cube roll muscle (*M. longissimis dorsi et thoraicics*, CUB045)

RIB041 (M. latissimus dorsi)

The RIB041 *(M. latissimus dorsi)* lies in the ribset and blade primals. It is a flat triangular muscle that lies over the thorax. Intermuscular fat is trimmed but this is often difficult and some fat will remain with the cut.

Figure 28 The trimmed RIB041 (*M. lattissimus dorsi*)

Blade

The blade is removed from the forequarter following the natural seam between the ribs and the scapular bone. This requires reflecting back the *M. trapezius* and reflecting back a port of the RIB041 (*M. lattismus dorsi*). The blade primal is separated from the CHK078 (M. serratus ventralis). The humerus is then dissected from the BLD096 *(M. triceps brachii)*.

Oyster Blade, OYS036 (*M. infraspinatus)*

The oyster blade is separated from the blade primal by separating from the scapula bone. The *M. deltoideus* is a small 2 headed muscle which sits on top of the OYS036 (*M. infraspinatus*) with its insertion at the acromial head of the scapula is removed from the oyster blade.

The seam of connective tissue is not removed for the purpose of preparing the MSA cuts but would generally be removed if preparing retail cuts from the oyster blade. Typcially the osdter blade (OYS036, *M. infraspinatus*) comprises 2.7% of the trimmed MSA cuts.

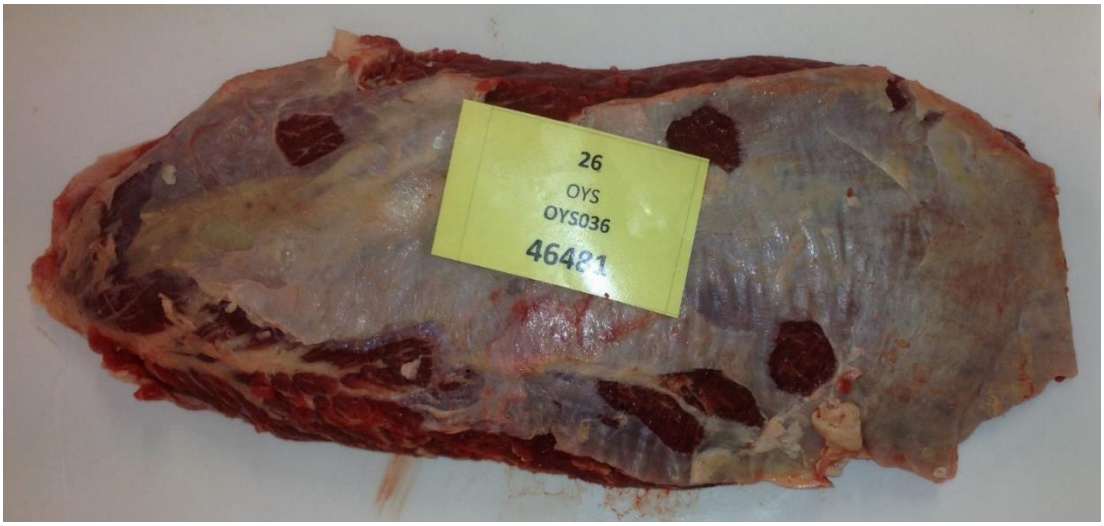


Figure 29 The trimmed oyster blade (OYS036, *M. infraspinatus*)

BLD096, (*M triceps brachii caput longum)*

The BLD096 (*M. triceps brachii caput longum)* is a large triangular muscle which is connected to the scapula and humerus. It is posterior to the other main triceps muscle (BLD084). The *M. trapezius* is dissected as is the attachment to the oyster blade. The BLD096 comprises most of the triceps muscle group. Typically the bolar blade (BLD096, *M triceps brachii caput longum)* comprises 4.4% of the trimmed MSA cuts.

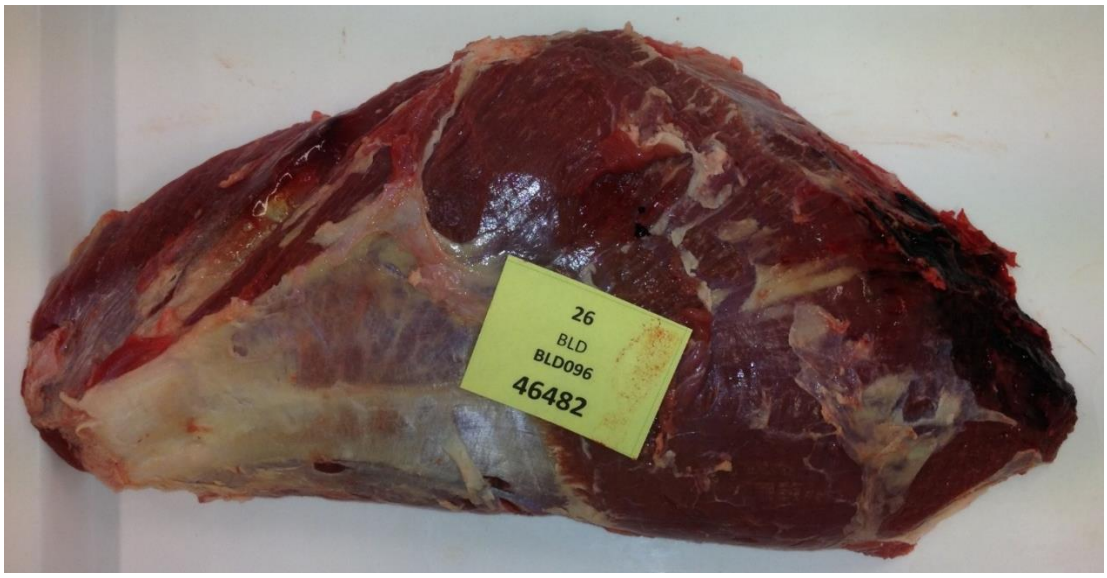


Figure 30 The trimmed BDL096, *M. triceps brachii catput longum*

BLD084 (*M. subscapularis)*

The BLD084 (*M. subscapularis*) is a flat triangular muscle associated with the underside of the scapula. Typically the BLD084, *M subscapularis)* comprises 1.3% of the trimmed MSA cuts.

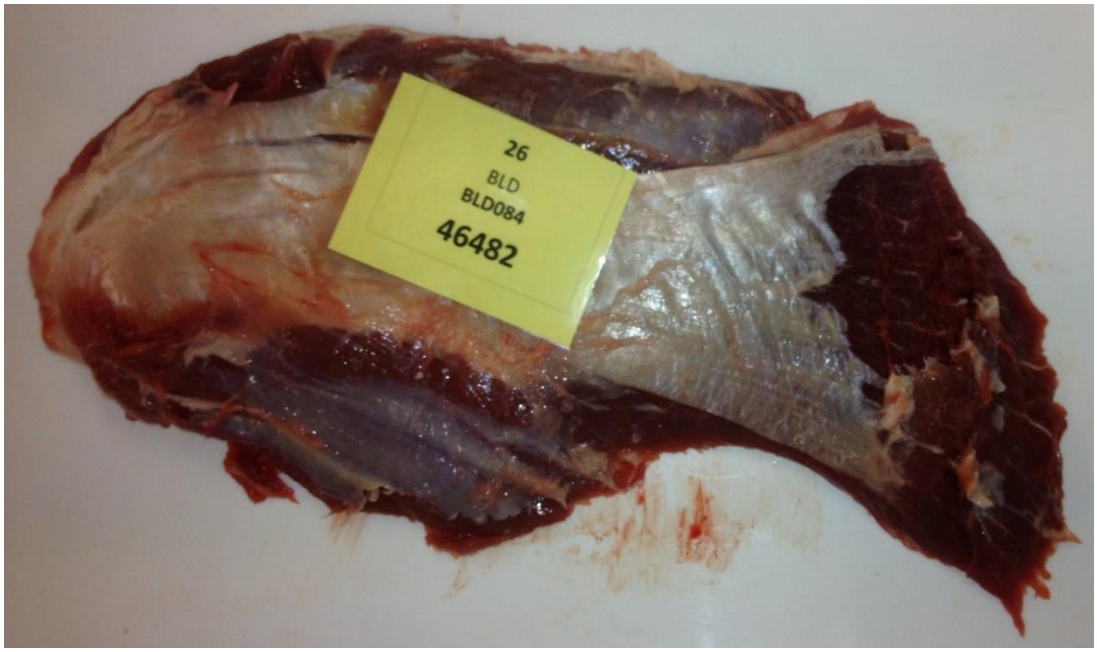


Figure 31 The trimmed BLD084 (*M. subscapularis)*

Chuck

The chuck is the remaining port of the forequarter after the brisket, ribset, blade and chuck tender are removed. There are 5 MSA cuts in chuck comprising CHK068 (*M. rhomboideus*), CHK074 (*M. semispinalis),* CHK078 (*M. serratus ventralis cervicis), CHK081 (M. spinalis dorsi) and* CHK082 (*M. splenius).*

CHK068 (*M. rhomboideus*)

The CHK068 (M. rhomboideus) lies on the dorsal portion of the chuck mostly above the scapula. In many dissection guides the CHK068 (*M. rhomboideus*) is divided into cervical (ie neck) and thoracic portions although MSA treats the muscle as a single cut. The full muscle is a long muscle. The cervical portion is a rounded muscle which lies deep to the cervical trapezius muscle, whilst the thoracic portion lies deep to the scapular cartilage.

Typically the CHK068 comprises 1.0% of the trimmed MSA cuts.

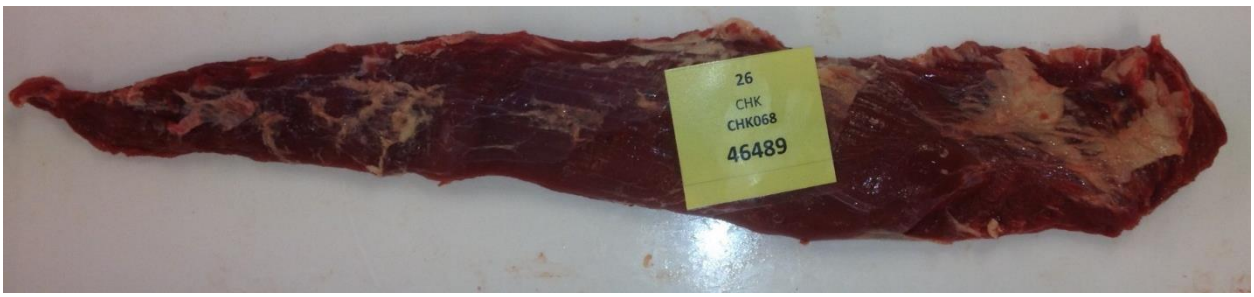


Figure 32 The trimmed CHK068 (*M. rhomboideus*)

CHK074 (*M. semispinalis)*

The CHK074 is mostly referenced as the *M. semispinalis* although some dissection guides refer to it as the *M. complexus.* As can be seen in Figure x the CHK074 is an extensive triangular muscle. Typically the CHK074 comprises 2.0% of the trimmed MSA cuts.

Figure 33 The trimmed CHK074 (*M. semispinalis*)

CHK078 (*M. serratus ventralis cervicis*)

The CHK078 is a large fan shaped muscle which lies deep on the cranial part of the thorax. It is trimmed of intermuscular fat which is trimmed from the grooves on the muscle. Typically the CHK078 (*M. serratus ventralis cervicis*) comprises 2.0% of the trimmed MSA cuts.

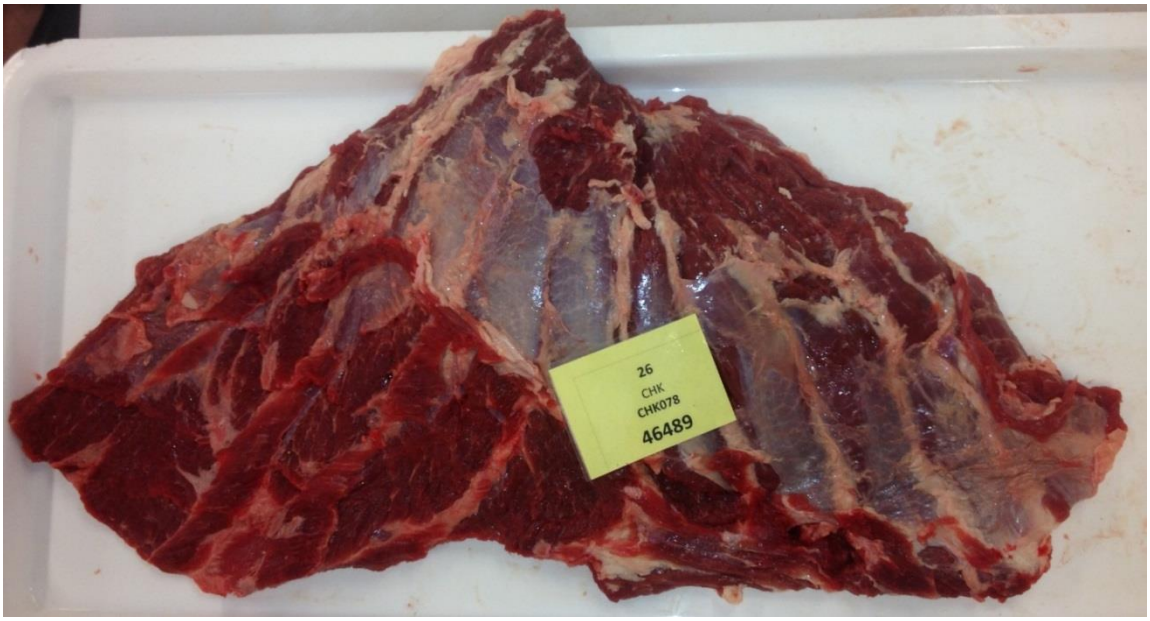


Figure 34 The trimmed CHK078 (M. serratus ventralis cervicis)

CHK081 (M. spinalis dorsi)

This is the continuation of the SPN081 (*M. spinalis dorsi)* from the Ribset primal. Therefore in the chuck this muscle extends from the 5/6th rib junction to the neck. Typically it comprises 1.4% of trimmed MSA cuts.

Figure 35 The trimmed CHK081 *(M. spinalis dorsi)*

CHK082 (*M. splenius)*

The splenius is a thin oval shaped muscle which sits in the cervical region. Typcially it comprises 1.0% of the timmed MSA cuts.

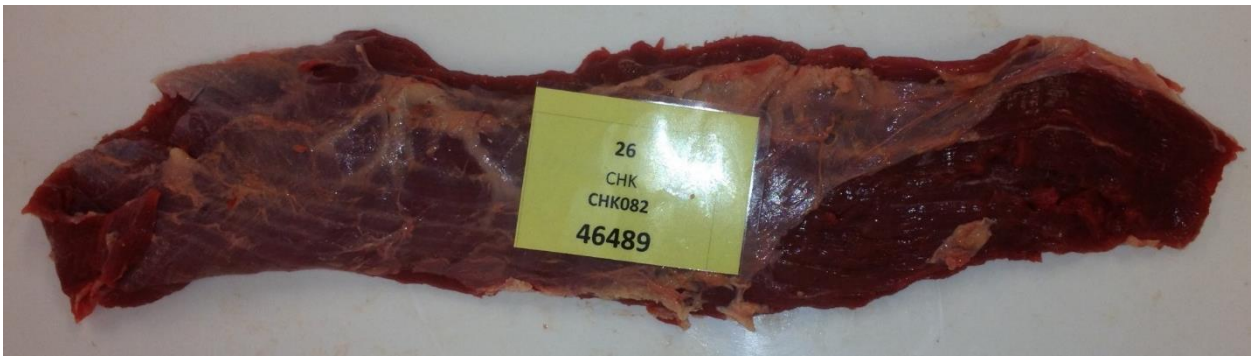


Figure 36 The trimmed CHK082 *(M. splenius)*

Foreshin FQshin

The flexor muscles of the foreshin comprise 4 separate muscles which are dissected as one MSA cut. There is generally very little subcutaneous fat that requires trimming. Similarly there is very little trimming of the epimysium. Typically these flexor muscles comprise 6.4% of the trimmed MSA cuts.

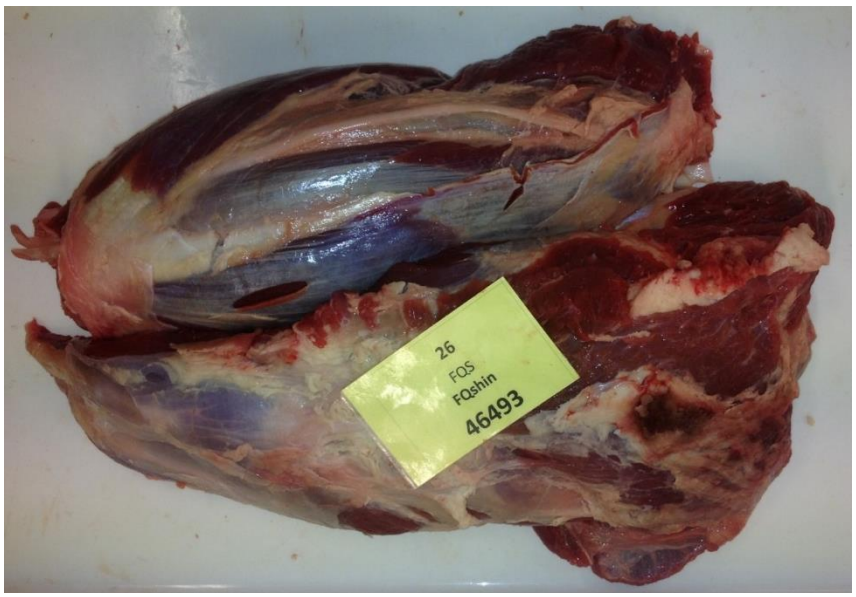


Figure 37 The trimmed Foreshin

Intercostals INT037 *Mm. intercostales externus* and *internus*

The intercostales muscles comprise 2 muscle types being the *M. intercostales externi* and *M. intercostales interni*. These 2 muscles lie in the spaces between the vertebrae and are dissected as one MSA cut. In heavier fatter carcasses these have a very high

fat content. The intercostales muscles do not extend past the vertebrae into the interchrondral spaces (ie the cartilage at the end of the vertebrae into the costal arch). This MSA cut is not trimmed of epyimysium or fat. Typically the INT037 comprises 3.3% of the trimmed MSD cuts.

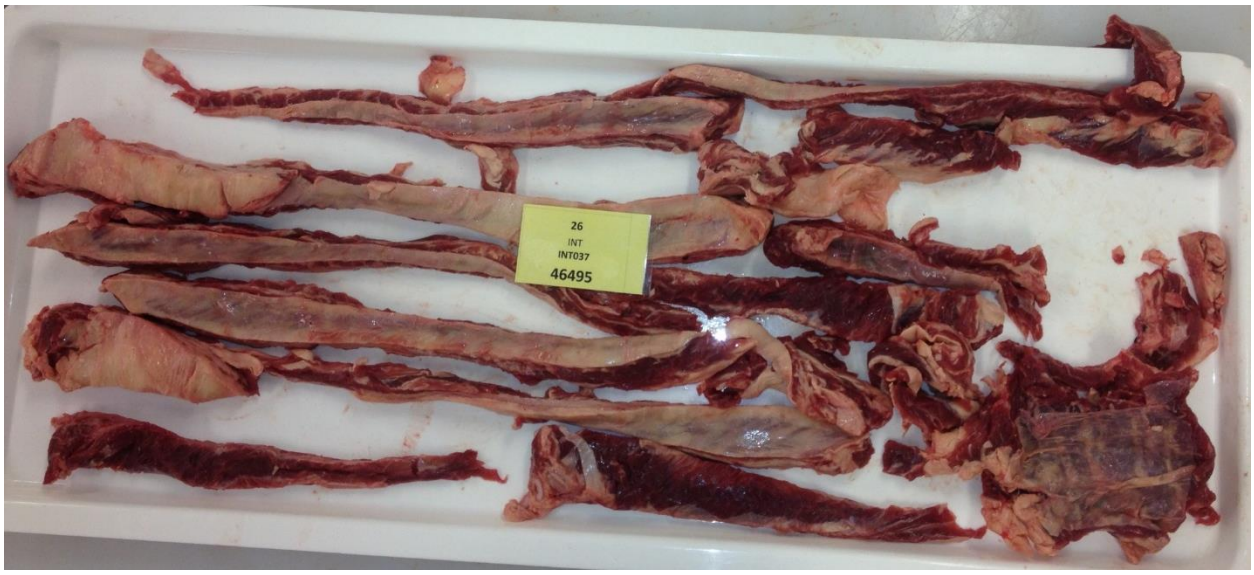


Figure 38 The trimmed INT037 *Mm intercostales externus and internus*

Chuck tender CTR085 *(M. supraspinatus)*

The chuck tender is located on the ventral portion of the scapula. It can be easily excised from the scapula. As shown in Figure X it is covered with a glistening fascial sheet. Typically it comprises 2.% of the timed MSA cuts.

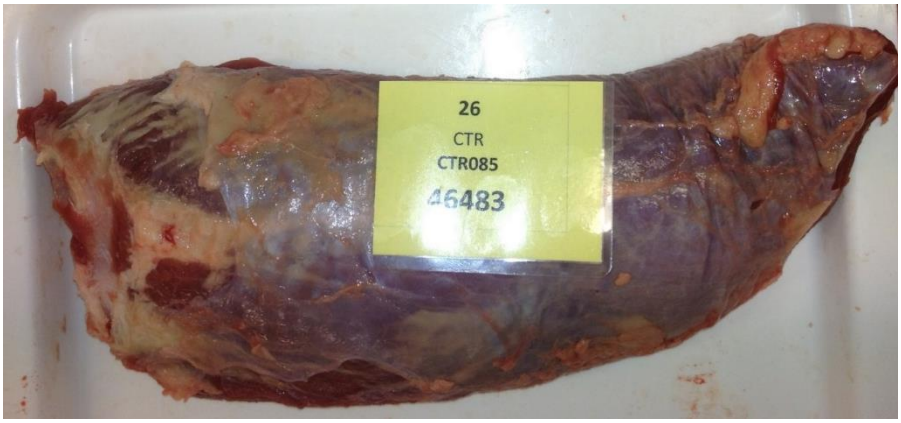


Figure 39 The trimmed CTR085 *M. supraspinatus*

3.0 The NSW DPI Muscling lines

3.1 The muscling lines

The steer sides used in this experiment were a draft of contempory steers which had been finished on pasture and slaughtered at domestic weights. The muscling lines were originally established by NSW DPI in 1992. The high and low muscling lines began with unselected Hereford cows and heifers mated to high- and low-muscled Angus bulls. In 1997, the females were allocated into Low and High muscle lines on the basis of muscle score. Muscle score is a visual assessment of the thickness and convexity of the animal, relative to skeletal size and adjusted for fatness (McKiernan 2007). A 15-point scale from E– (1) to A+ (15) was used, where E animals display the lightest muscling and A the heaviest. In subsequent years, the cow lines continued to be mated to Angus bulls selected from industry on the basis of their muscularity.

In 2005, following the segregation of a *myostatin* mutation (821 del11, Grobet *et al*. 1997) in the High line, a third group of females carrying one copy of the *myostatin* mutation was established (HighHet line). High-muscled progeny were allocated to either the High or HighHet line on the basis of their *myostatin* genotype. Hence, High and HighHet animals share common sires and dams within the herd, while the Lows were separate.

The range in muscling between the lines ranged from E- to A which was considered to be sufficient to cover the between breed range in muscling which exists in the Australian beef industry.

The cattle were slaughtered at a commercial works. Carcasses were not trimmed on line. The following day the left side was boned into primals again without any fat trimming. The primals were vacuum packed and transported to UNE where they were CT scanned to estimate muscle and fat composition of the primals. The primals were then boned into the trimmed MSA cuts using the protocol outlined above.

Weights of trimmed MSA primals expressed as percentages of the total trimmed weight of MSA cuts were analysed in a GLM model which contained terms for muscling line.

3.2 Results

Carcass trait means and variance for the three muscling lines are shown in Table 1. The three muscling lines had similar liveweights and carcass weights.

The live muscle score demonstrate the divergence in the lines with the lows having a mean live muscle score of 4.6, the highs 9.0 on a 15 point scale. The range within the high and low muscling line groups was large from 2 to 1 (which is equivalent to a E to a B muscling score). The mean muscling score of the myostatin steers was slightly higher than the high muscling group with a score 10 (equivalent to a B- score). From this aspect the muscling line steers provided a range in live muscling scores which would be as great or greater than exists in the commercial mix of breeds produced in Australia.

There was also little difference between lines in ossification and marbling scores, ribfat and ultimate pH. The low muscling line had the highest muscle colour score followed by the high muscling line with the lowest muscle colour in the myostatin line.

The distribution of trimmed MSA cuts between the three lines is shown in Table 2. There were 9 MSA cuts out of the 39 where line had a significant effect on distribution pattern. In every instance the significance of the between line effect was a result of the Myostatin line differing from either the high or low line or in some cases both lines. Therefore if the myostatin steers were excluded the muscling line carcasses had very similar MSA cut distribution patterns for the 39 MSA cuts.

The myostatin line which carried at least one copy of the myostatin gene showed small differences in some cuts. When the distribution of the hindquarter cuts were summed the myostatin line had a similar proportion of MSA cuts in the hindquarter to the high muscling line and only 1.5% more than the low muscling line.

3.3 Discussion

These bone out of the muscling lines carcasses clearly showed that lines of cattle that had been selected for high and low muscling since the early 90s had similar patterns of distribution for trimmed MSA cuts. This similarity was evident despite large differences in muscling scores

Given that there were small differences between the muscling selection lines and the myostatin muscling line which carried one copy of the myostatin gene it was proposed that the distribution pattern for calculating the MSA be based on the mean distribution of MSA cuts from the high and low muscling lines. The mean distribution is shown in Table 3. It is proposed that this distribution be used to calculate the MSA Index for cattle graded using the MSA grading scheme.

Table 1 Live weight and carcass traits means and variance for the three muscling lines

	Low		High		Myo	
	Mean	Std	Mean	Std	Mean	Std
Number	13		14		14	
LWT	465	30	459	26	452	37
Mus score	4.5	1.5	9.6	2.0	9.8	3.2
CWT	256	21	262	18	258	22
Oss	132	6	131	12	127	9
Marb	353	46	335	52	295	53
Rib	5.4	1.3	5	2	4	1.7
pHu	5.64	0.10	5.62	0.11	5.64	0.08
Meat col	3.3	1.3	2.9	1.1	2.3	0.9

Table 2 MSA percentage cut distribution in the low, high and myostatin muscling lines

	Low Muscling	High Muscling	Myostatin	Average se	Sign-ificance
No of sides	13	14	13		
MSA Cut					
STA045	2.27	2.31	2.40	0.057	NS
STP045	2.02	2.16	2.09	0.046	NS
TDR034	0.77	0.77	0.68	0.048	NS
TDR062	1.93	1.91	1.94	0.040	NS
RMP131	2.52	2.64	2.59	0.037	NS
RMP231	1.40	1.43	1.41	0.034	NS
RMP005	1.50	1.52	1.50	0.057	NS
RMP032	0.36	0.33	0.31	0.013	NS
RMP087	1.30^{ab}	1.28^{a}	1.38^{b}	0.027	*
TFL051	1.15^{a}	1.22^{a}	1.44^{b}	0.065	*
TFL052	2.59^{ab}	2.67^{a}	2.41^{b}	0.064	*
TFL064	1.19	1.16	1.17	0.027	NS
TOP001	2.05^{a}	2.17^{ab}	2.26^{b}	0.040	*
TOP033	1.64	1.66	1.74	0.034	NS
TOP073	6.38	6.22	6.52	0.100	NS
KNU066	2.60	2.64	2.70	0.038	NS
KNU098	1.02^{a}	1.03^{a}	0.92^{b}	0.031	*
KNU099	3.05	3.00	3.12	0.058	NS
KNU100	0.87	0.87	0.89	0.022	NS
OUT005	7.49	7.38	7.46	0.102	NS
OUT029	3.25	3.34	3.27	0.056	NS
EYE075	3.25	3.26	3.47	0.081	NS
HQshin	3.20	3.31	3.29	0.051	NS
BRI056	4.48	4.46	4.71	0.100	NS
BRI057	1.88	1.95	2.01	0.059	NS
SPN081	2.12	2.14	1.94	0.100	NS
CUB045	3.35	3.50	3.57	0.069	NS
RIB041	3.27	3.28	3.38	0.064	NS
OYS036	2.81^{a}	2.69^{ab}	2.56^{b}	0.057	*
BLD096	4.35	4.37	4.36	0.056	NS
BLD084	1.27	1.24	1.17	0.048	NS
CHK068	1.09	0.98	0.99	0.033	NS
CHK074	1.93	1.98	1.88	0.029	NS
CHK078	5.37	5.12	5.25	0.116	NS
CHK081	1.41^{a}	1.47^{a}	1.21^{b}	0.044	**
CHK082	1.02	0.96	0.94	0.033	NS
FQshin	6.46^{a}	6.36^{a}	6.07^{b}	0.100	*
INT037	3.35	3.24	3.11	0.153	NS
CTR085	2.03^{a}	2.00^{a}	1.88^{b}	0.035	**

[a, b]Different superscripts indicate that means were significantly different P<0.05

Table 3 The average MSA cut distribution for the low and high line muscling steers.

MSA cut	% distribution
STA045	2.29
STP045	2.09
TDR034	0.77
TDR062	1.92
RMP131	2.58
RMP231	1.42
RMP005	1.51
RMP032	0.34
RMP087	1.29
TFL051	1.19
TFL052	2.63
TFL064	1.17
TOP001	2.12
TOP033	1.65
TOP073	6.30
KNU066	2.62
KNU098	1.03
KNU099	3.02
KNU100	0.87
OUT005	7.43
OUT029	3.30
EYE075	3.25
HQshin	3.26
BRI056	4.47
BRI057	1.92
SPN081	2.13
CUB045	3.43
RIB041	3.28
OYS036	2.75
BLD096	4.36
BLD084	1.25
CHK068	1.03
CHK074	1.96
CHK078	5.23
CHK081	1.44
CHK082	0.99
FQshin	6.41
INT037	3.29
CTR085	2.01

3.4 Recommendation

This study confirmed there was little difference in the distribution of MSA cuts from steer carcasses from the high and low muscling lines. The myostatin high muscling line showed significant differences in distribution of 9 out of 39 cuts.

It is recommended that the MSA cut distribution pattern in Table 3 which was the average of the high and low muscling lines be used to calculate the MSA Index.

A dissection guide is also contained in this report. This guide can be used if in the future it is decided to add to the data base.

4.0 Acknowledgements

Thanks to the NSW DPI team for making the boned primals from the muscling line steers available for the bone-out in particular Drs Linda Café, Malcolm Macfie and Brad Warmsley. To undertake such a detailed bone-out in 3 days requires lots of willing and capable helpers. Dr Peter McGilchrist and Miss Georgia Pugh from Murdoch University assisted with the preparations, the bone out and data handling. Thanks are due to the MSA team particularly Janine Lau, Greg Butler and Jessira Perovic for their expert assistance with weighing and cut identification. Other helpers included Xuemei Han and Glen Bullock from UNE and Haydn McKay and Elizabeth McClymount from Charles Stuart University.

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Appendix A1

The Hindquarter Spreadsheet

Carcass Number								
	Gross			Denuded		Trim	Fat	% Recovery
STR	0	*M. longissimus dorsi*	STA045	0		0	0	#DIV/0!
		M. longissimus dorsi	STP045	0				
TDR	Gross			Denuded		Trim	Fat	% Recovery
	0	*M. iliacus*	TDR034	0		0	0	#DIV/0!
		M. psoas major	TDR062	0				
RMP	Gross			Denuded		Trim	Fat	% Recovery
	0	*M. gluteus medius*	RMP131	0		0	0	#DIV/0!
		M. gluteus medius	RMP231	0				
		M. biceps femoris	RMP005	0				
		M. gluteus profundus	RMP032	0				
		M. tensor fasciae latae	RMP087	0				
TFL	Gross			Denuded		Trim	Fat	% Recovery
	0	*M. obliquus externus ab*	TFL051	0		0	0	#DIV/0!
		M. obliquus internus abd	TFL052	0				
		M. rectus abdominis	TFL064	0				
TOP	Gross			Denuded		Trim	Fat	% Recovery
	0	*M. adductor femoris*	TOP001	0		0	0	#REF!
		M. gracilis	TOP033	0				
		M. semimembranosus	TOP073	0				
KNU	Gross			Denuded		Trim	Fat	% Recovery
	0	*M. rectus femoris*	KNU066	0		0	0	#DIV/0!
		M. vastus intermedius	KNU098	0				
		M. vastus lateralis	KNU099	0				
		M. vastus medialis	KNU100	0				
OUT	Gross			Denuded		Trim	Fat	% Recovery
	0	*M. biceps femoris*	OUT005	0		0	0	#REF!
		M. gastrocnemius	OUT029	0				
		M. semitendinosus	EYE075	0				
HQshin	Gross			Denuded		Trim	Fat	% Recovery
	0	*extensor/flexor muscles*	HQshin	0		0		#DIV/0!

A2 Appendix

The Forequarter spreadsheet

Carcass Number								
	Gross			Denuded		Trim	Fat	% recovery
BRI	0	*M. pectoralis profundus*	BRI056	0		0	0	#DIV/0!
		M. pectoralis superficialis	BRI057	0				
	Gross			Denuded		Trim	Fat	% recovery
RIBSET	0	*M. spinalis dorsi*	SPN081	0		0	0	#DIV/0!
		M. longissimus dorsi	CUB045	0				
		M. latissimus dorsi	RIB041	0				
	Gross			Denuded		Trim	Fat	% recovery
BLD	0	*M. infraspinatus*	OYS036	0		0	0	#REF!
		M. triceps brachii caput lon	BLD096	0				
		M. latissimus dorsi	RIB041	0				
		M. subscapularis	BLD084	0				
	Gross			Denuded		Trim	Fat	% recovery
CHK	0	*M. rhomboideus*	CHK068	0		0	0	#DIV/0!
		M. semispinalis capitis	CHK074	0				
		M. serratus ventralis cervic	CHK078	0				
		M. spinalis dorsi	CHK081	0				
		M. splenius	CHK082	0				
	Gross			Denuded		Trim	Fat	% recovery
FQshin	0	*flexor muscles*	FQshin	0		0	0	#DIV/0!
	Gross			Denuded		Trim	Fat	% recovery
INT	0	*M. intercostales externus a*	INT037	0		0	0	#DIV/0!
	Gross			Denuded		Trim	Fat	% recovery
CTR	0	*M. supraspinatus*	CTR085	0		0	0	#DIV/0!