final report

Project code: P.PIP.5016

Prepared by: John Langbridge
Teys Australia

Date published: 10 June 2020

PUBLISHED BY
Meat and Livestock Australia Limited
Locked Bag 1961
NORTH SYDNEY NSW 2059

Validating the E+V cold carcase grading camera for Australian carcase grading

This is an MLA Donor Company funded project.

Meat & Livestock Australia acknowledges the matching funds provided by the Australian Government and contributions from the Australian Meat Processor Corporation to support the research and development detailed in this publication.

Abstract

The E+V cold carcase grading camera was calibrated against the Australian grading standards and installed into one export registered meat establishment.

The following attributes can be assessed by the E+V cold carcase camera as long as the camera is used by an accredited grader:

i. AUS-MEAT Marbling (0-5);
ii. MSA Marbling (100 – 700);
iii. Meat Colour; and
iv. Fat Colour

As a piece of technology the cameras are very reliable and produce repeatable results when the carcase are quartered correctly and the camera placed properly.

The single most important piece of work in the project was done by the ALMTech group. They developed the method through which the technology can be compared to the best human graders. As long as the cameras were no more variable that the variability that exists between the expert graders then the camera can be approved for measuring that attribute. The development of this process will pave the way for other grading technologies to be approved.

Executive summary

The project was designed to calibrate the E+V cold carcase grading camera against the Australian grading standards and to install the camera in at least one export registered meat establishment. That was achieved, although the range of attributes being measured is not the full set that meat graders measure.

The following attributes have AUS-MEAT approval to be assessed by the E+V cold carcase grading camera as long as the camera is used by an accredited grader:

(i) AUS-MEAT Marbling (0-5);
(ii) MSA Marbling (100 – 700);
(iii) Meat Colour; and
(iv) Fat Colour

As a piece of technology the cameras are very reliable and produce repeatable results.

The single most important piece of work in the project was done by the ALMTech group. They developed the method through which the technology can be compared to the best human graders. As long as the cameras were no more variable that the variability that exists between the expert graders then the camera can be approved for that attribute.

The project demonstrated that the cameras, when programmed correctly, offer no more variability between them and the expert graders as exists within the expert grader group.

For the cameras to produce those consistent and reliable results it is absolutely essential that the carcase is quartered correctly and the camera is placed correctly. The procedures that cover these need to be developed and implemented. Quartering and camera placement improve with increasing use.

Initial approval for the equipment was achieved followed by approval on site with the cameras being used under commercial conditions by trained company graders.

The camera image and grading output is available to anyone with access to a PC or smart phone. This will greatly improve the transparency of the grading process to the producer.

They are effectively the next best option if you can’t get an independent expert grader. They provide a result independent of the operator.

The development of this approval process will show the way for other grading technologies to be approved.

Table of contents

1 Background

The E+V cold carcase grading camera is currently commercially used in the USA to grade beef carcases at the quarter-site. The camera requires re-training to output AUS-MEAT and MSA grading characteristics. Completed project (P.PIP.0751: Training the E + V grading camera against Australian meat grading standards) demonstrated that the camera has high potential to meet Australian grading requirements. Initial algorithms have been developed for the E+V cold carcase grading camera from direct compassion of Teys company graders, MSA expert graders and E + V cameras assessing the same carcases for AUS-MEAT and MSA grading characteristics.

The project demonstrated that the E+V camera delivered a higher correlation with MSA expert graders for most grading traits than was achieved by Teys AUS-MEAT accredited company graders. It also demonstrated that the camera could be practically used in Australian plants, however, it also highlighted issues that this project will address.

These include: fat colour (difficulty differentiating between scores 0 and 1); fat depth (the accuracy reduces as carcases become fatter); the quality of quartering impacts on presentation of the eye-muscle surface to be assessed, and the correct and consistent placement of the camera over the eye muscle (training and Q&A procedures require development); within and between camera variation (currently low but still significant), across site variation; application in plants with a fixed grading station compared with plants without a fixed grading station; new datasets to increase the genotype and phenotype range (current results from *bos taurus* only); and independent datasets for validation of algorithms.

Initial results were achieved by expert camera operators from the US and Germany. Subsequent commercial proofing was achieved using trained company staff and company graders.

Initial approval for the equipment was achieved followed by approval on site with the cameras being used under commercial conditions by trained company graders.

2 Project objectives

The project objectives were:

1. Refine and test algorithms across a broad phenotype range of cattle at a northern (Bos Indicus) and southern plant (Bos Taurus)

2. Develop a pool of trained “quarterers” and camera users at the two sites (Camera users must be accredited graders)

3. Develop training materials and work instructions covering quartering and the correct application of the camera.

4. Develop protocols that cover when and how the camera outputs are over-written when determined they are incorrect.

5. Submit an application and gain approval for the E+V cold carcase (rib eye) grading camera from the Australian Meat Industry Language and Standards Committee covering both AUS-MEAT and MSA grading outputs.
6. Develop an interface with Graders Personal Data entry devices and the E+V cold carcase grading camera system.
7. Develop an interface to allow the pictures from the camera to be sent back to producers along with grading outcomes.
8. Develop extension material to use when sharing the camera collected MSA inputs with producers.

3 Methodology

3.1 Initial AUS-MEAT Approval criteria

There was an initial trial in 2017 (P.PIP.0751 – Training the E+V cold carcase camera) where the algorithms that would be used in the subsequent approval trails were developed. Based on the success of that AUS-MEAT were approached about how to construct a validation trial that could result in the approval of the E+V camera as an aid to conducting carcase grading under both AUS-MEAT and MSA meat quality standards

AUS-MEAT's official response is included as attachment (Section 8.1)

3.2 Trial design

There were two subsequent camera validation (approval) trials, the first from 21 May 2018 to 24 May 2018, and a follow-up trail 5 months later, from 29 to 30 October 2018.

The initial camera algorithm used, was developed from the previous project P.PIP.0751 – Training the E+V Grading Camera.

To further develop and refine the camera grading algorithm, grading data had to be collected from the same group of carcases by 2 expert MSA graders, the company grader and three cameras in the May and October trials of 2018.

During the May trials the repeatability of the cameras were also assessed by repeating the measurement a number of times on the same carcases.

The long term plan was to always have the camera operated by a grader with a current accreditation to grade under MSA standards and AUS-MEAT standards. An accredited grader would be in a better position to understand the process and the reasons for correct quartering and camera placement. They would also be in a better position to critique the ongoing quality of the camera output. They are the obvious back-up in the event of equipment failure. The approval of the camera was based around having an accredited grader available to operate it.

3.3 Data analysis

Initially the data was combined, cleaned, tabulated and analysed by independent statisticians. It was analysed by a number of different statistical tools. This became difficult as there was significant variation between the expert independent graders that made it very difficult to compare the commercial graders and the camera to.

A different method of comparing the camera output to the expert graders needed to be found.

3.4 Involvement of ALMTech group – development of a new approval criteria

The results of the two trials were shared with AUS-MEAT and the ALMTech group. Researchers funded through the ALMTech group developed a novel solution that was presented to and accepted by the Australian Livestock and Meat Industry Language and Standards Committee.

In summary the variability between a camera measurement and expert graders needs to be less than the variability between expert graders under commercial grading conditions. The proposed accuracy requirements are very conservative as they have been developed from the independent expert graders whom are currently used by industry to correlate plant graders in the commercial environment. The differences in cut surface traits provided by these two graders across a phenotypically diverse range of carcasses has been used to set the accuracy boundaries outlined below

This approved method is contained in Section 8.2.

3.5 Integration with the current carcase grading and feedback system

While E+V cold camera technology can determine some of the rib-eye measurements for a Carcase ID:

Marbling (AUS-MEAT)	Meat Colour
Marbling (MSA)	Fat Colour

and display results for each, it doesn't provide a complete solution for input of the remaining observations gathered at carcase grading:

Hump Height	Ossification	Qtr Rib
Hide Puller Damage	Fails Misc.	Grade Code
pH	Loin Temperature	User
Eye Muscle Area	Sub-cutaneous fat depth	

Without this project, the existing Personal Data Tablet (PDT) with existing inventory software would need to be used for re-keying the E+V camera results, plus entering the remaining measurements. To satisfy the requirements of AUS-MEAT for the certified grader to review and accept the E+V result before writing to the database, modifications would need to be made to the current PDT software regardless. A new single workstation screen has been designed to streamline the process to maximise efficiency (remove re-keying time and error opportunity, and make the entire entry process more efficient) and data accuracy, and satisfy regulatory requirements.

The opportunity exists to develop a new application (using commercial of the shelf information technology hardware) to integrate with the E+V camera to obtain the outputs it can determine, and present these in one screen for efficient review and entry of the remaining measurements by the grader (see Fig. 2 below), as well as generate the carcase sort label at the same workstation. This project will mitigate the risks from the E+V software (and data created) existing only on an E+V PC exposed to harsh environmental risks present on the plant floor by shifting the data onto protected servers, and allow Teys IT to support the system.

McCarthy was engaged to develop two solutions:

1) New version of the PDT chiller assessor software, which will allow some results (e.g. Loin Temperature and pH) to be collected in the chillers if required in some sites.
2) New 'touchscreen' application (per Figure 1 below), to be integrated with E+V results and enable efficient and accurate data capture for cold carcase grading, generation of carcase sorting labels and compliance with AUSMEAT user audit requirements.

3.5.1 IT Architectural Landscape

Data from the E+V cold camera PC has been replicated to the site server room (to protect it from environmental risks), and interfaced with a new central data collection solution and existing carcase grading data tables.

3.5.2 Cold carcase data collection application screen

Below is the new cold carcase data collection application screen, to show the key deliverable (new software application for cold carcase grading).

It has been integrated with the E+V cameras.

Figure 1 –Cold carcase grading screen:

Note: if the E+V camera PC station is beside the new carcase grading terminal, the image and E+V camera indicators may not be required on this screen.

3.6 Training the plant for the implementation audit

AUS-MEAT require that apart from the technology being approved, the implementation of that technology needs to be approved on a site by site basis. This is normal practice for a standards and accreditation body.

The quartering of carcases and correct camera placement are absolutely critical for the camera to deliver an accurate output.

Work instructions were developed for quartering and for camera placement. Teys Wagga Wagga staff were trained and assessed as competent in those procedures.

Amendments were made to the MSA standard operating procedure to accommodate the use of the camera.

3.7 AUS-MEAT plant implementation audit

AUS-MEAT conducted an audit of the effectiveness of the camera implementation at Wagga Wagga. That included the integration of the camera output into the carcase feedback system and well as assessing the competence of the training of the various people involved.

3.8 Final camera correlation trial

As part of the equipment approval a further correlation trial was scheduled for April 2020. This trial would again ensure that the camera remained correlated against the expert graders and hadn't "drifted" over time.

This trial has been postponed until after the movement restrictions as part of the Government response to the Covid-19 pandemic have been removed.

4 Results

4.1 Repeated camera measurements

4.1.1 Descriptive statistics

The variables were considered one at a time, beginning with AUS-MEAT Marbling (amb). For each variable, there were 2126 possible carcasses, of which camera 1 (365) measured 2020, cam2 measured 1993 and cam3 1044.

There were 1895 carcasses that were measured by all three cameras, and so comparison of the descriptive statistics was also done on the commonly measured carcasses.

Table 1 - AUS-MEAT marbling repeatability data summary

	n	nm	mean	sd	min	Q1	med	Q3	max
amb11	2020	106	1.28	0.70	0	1	1	2	5
amb12	2020	106	1.29	0.70	0	1	1	2	5
amb21	1993	133	1.27	0.71	0	1	1	2	5
amb22	1993	133	1.30	0.70	0	1	1	2	5
amb31	2044	82	1.30	0.71	0	1	1	2	5
amb32	2044	82	1.31	0.71	0	1	1	2	5
	n	nm	mean	sd	min	Q1	med	Q3	max
amb11	1895	0	1.28	0.69	0	1	1	2	5
amb12	1895	0	1.29	0.69	0	1	1	2	5
amb21	1895	0	1.28	0.71	0	1	1	2	5
amb22	1895	0	1.30	0.70	0	1	1	2	5
amb31	1895	0	1.30	0.69	0	1	1	2	5
amb32	1895	0	1.31	0.70	0	1	1	2	5

Table 2 - Meat Colour (amc) repeatability data summary

	n	nm	mean	sd	min	Q1	med	Q3	max
amc11	2020	106	3.27	1.03	0	3	3	4	7
amc12	2020	106	3.28	1.03	0	3	3	4	7
amc21	1993	133	3.48	0.99	0	3	4	4	7
amc22	1993	133	3.47	0.99	0	3	3	4	7
amc31	2044	82	3.39	1.04	0	3	3	4	7
amc32	2044	82	3.38	1.03	0	3	3	4	7
	n	nm	mean	sd	min	Q1	med	Q3	max
amc11	1895	0	3.28	1.02	0	3	3	4	7
amc12	1895	0	3.29	1.02	0	3	3	4	7
amc21	1895	0	3.47	0.98	0	3	4	4	7
amc22	1895	0	3.46	0.98	0	3	3	4	7
amc31	1895	0	3.41	1.03	0	3	3	4	7
amc32	1895	0	3.41	1.02	0	3	3	4	7

Table 3 - Fat Colour (afc) repeatability data summary

	n	nm	mean	sd	min	Q1	med	Q3	max
afc11	2020	106	0.87	1.72	0	0	0	1	7
afc12	2020	106	0.86	1.71	0	0	0	1	7
afc21	1993	133	0.88	1.71	0	0	0	1	7
afc22	1993	133	0.86	1.70	0	0	0	1	7
afc31	2044	82	0.91	1.77	0	0	0	1	7
afc32	2044	82	0.92	1.77	0	0	0	1	7
	n	nm	mean	sd	min	Q1	med	Q3	max
afc11	1895	0	0.86	1.71	0	0	0	1	7
afc12	1895	0	0.85	1.69	0	0	0	1	7
afc21	1895	0	0.84	1.68	0	0	0	1	7
afc22	1895	0	0.83	1.67	0	0	0	1	7
afc31	1895	0	0.92	1.77	0	0	0	1	7
afc32	1895	0	0.92	1.77	0	0	0	1	7

Table 4 - Sub-cutaneous - Rib Fat repeatability data summary

	n	nm	mean	sd	min	Q1	med	Q3	max
rbf11	2020	106	11.67	6.69	-2	7	11	16	38
rbf12	2020	106	11.62	6.69	-4	7	11	16	38
rbf21	1993	133	11.48	6.86	-5	6	11	16	36
rbf22	1993	133	11.71	6.93	-3	7	11	16	36
rbf31	2044	82	12.40	6.77	-2	7	12	17	44
rbf32	2044	82	12.44	6.79	-2	8	12	17	43
	n	nm	mean	sd	min	Q1	med	Q3	max
rbf11	1895	0	11.77	6.71	-2	7	11	16	38
rbf12	1895	0	11.74	6.71	-3	7	11	16	38
rbf21	1895	0	11.62	6.82	-3	6	11	16	36
rbf22	1895	0	11.86	6.90	-3	7	12	16	36
rbf31	1895	0	12.33	6.74	-2	7	12	17	44
rbf32	1895	0	12.38	6.74	-2	8	12	17	43

Table 5 - Eye Muscle Area (ema) repeatability

	n	nm	mean	sd	min	Q1	med	Q3	max
ema11	2020	106	85.88	15.43	38	75	85	96	144
ema12	2020	106	86.01	15.58	38	75	85	97	143
ema21	1993	133	86.24	15.01	41	75	86	97	135
ema22	1993	133	86.61	15.21	44	76	86	97	136
ema31	2044	82	85.07	15.35	38	74	84	95	139
ema32	2044	82	85.21	15.51	38	74	85	96	137
	n	nm	mean	sd	min	Q1	med	Q3	max
ema11	1895	0	85.55	15.29	38	75	85	96	144
ema12	1895	0	85.66	15.43	38	74	85	96	143
ema21	1895	0	86.36	14.82	41	76	86	97	135
ema22	1895	0	86.75	15.03	44	76	86	97	136
ema31	1895	0	84.51	15.07	38	74	84	95	132
ema32	1895	0	84.60	15.23	38	74	84	95	131

Table 6 - MSA Marbling repeatability

	n	nm	mean	sd	min	Q1	med	Q3	max
umb11	2020	106	404.7	92.4	193	341	384	449	917
umb12	2020	106	405.1	93.0	204	341	384	451	899
umb21	1993	133	404.8	92.9	212	340	384	450	856
umb22	1993	133	407.4	92.8	222	342	386	452	851
umb31	2044	82	410.5	93.2	193	346	390	454	907
umb32	2044	82	411.2	93.2	204	347	391	456	891
	n	nm	mean	sd	min	Q1	med	Q3	max
umb11	1895	0	405.0	91.3	193	342	384	450	888
umb12	1895	0	405.4	91.8	204	342	384	451	897
umb21	1895	0	406.1	92.7	212	342	387	450	856
umb22	1895	0	408.8	92.7	233	343	388	453	851
umb31	1895	0	409.0	91.6	193	345	389	453	886
umb32	1895	0	409.6	91.7	204	346	390	453	880

4.1.2 Correlations

The correlation within cameras is very high; the correlation between cameras tends to be also very high but not quite so high.

The pattern/model for the correlations is as follows, where R denotes the within camera correlations and r the between camera correlations, so that the correlation data should look like

	v11	v12	v21	v22	v31
v12	**R**				
v21	r	r			
v22	r	r	**R**		
v31	r	r	r	r	
v32	r	r	r	r	**R**

It is to be expected that r < R.

Estimates of R and r are given by:

$\hat{R}$ = average of the observed within camera correlations, and

$\hat{r}$ = average of the observed between camera correlations.

Table 7 - AUS-MEAT marbling repeatability correlation

	amb11	amb12	amb21	amb22	amb31		
amb12	**0.964**					**$\hat{R}$ =0.955**	
amb21	0.899	0.898				$\hat{r}$ =0.904	*0.911*
amb22	0.907	0.901	**0.941**				
amb31	0.908	0.909	0.903	0.905			
amb32	0.904	0.903	0.903	0.908	**0.961**		

Table 8 - Meat Colour repeatability correlation

	amc11	amc12	amc21	amc22	amc31		
amc12	**0.934**					**$\hat{R}$ =0.932**	
amc21	0.894	0.890				$\hat{r}$ =0.884	*0.894*
amc22	0.891	0.888	**0.930**				
amc31	0.873	0.875	0.883	0.886			
amc32	0.877	0.875	0.885	0.888	**0.933**		

Table 9 - Fat Colour repeatability correlation

	afc11	afc12	afc21	afc22	afc31		
afc12	**0.982**					**$\hat{R}$ =0.985**	
afc21	0.964	0.960				$\hat{r}$ =0.958	*0.933*
afc22	0.967	0.963	**0.986**				
afc31	0.952	0.951	0.956	0.956			
afc32	0.954	0.953	0.957	0.958	**0.987**		

Table 10 - Sub-cutaneous Rib Fat repeatability correlation

	rbf11	rbf12	rbf21	rbf22	rbf31		
rbf12	**0.984**					**$\hat{R}$ =0.988**	
rbf21	0.964	0.963				$\hat{r}$ =0.956	*0.947*
rbf22	0.962	0.962	**0.994**				
rbf31	0.947	0.949	0.959	0.958			
rbf32	0.944	0.947	0.957	0.959	**0.985**		

Table 11 - Eye Muscle Area repeatability correlation

	ema11	ema12	ema21	ema22	ema31		
ema12	**0.989**					**$\hat{R}$ =0.989**	
ema21	0.953	0.950				$\hat{r}$ =0.949	*0.939*
ema22	0.951	0.949	**0.988**				
ema31	0.945	0.941	0.952	0.954			
ema32	0.944	0.940	0.952	0.953	**0.991**		

Table 12 - MSA Marbling repeatability correlation

	umb11	umb12	umb21	umb22	umb31		
umb12	**0.995**					**$\hat{R}$ =0.986**	
umb21	0.979	0.978				$\hat{r}$ =0.979	*0.980*
umb22	0.980	0.979	**0.972**				
umb31	0.978	0.977	0.979	0.980			
umb32	0.978	0.976	0.979	0.980	**0.992**		

The correlations seem to follow the pattern; both $\hat{R}$ and $\hat{r}$ are high, indicating a high level of reliability. For the essentially continuous variables: ema, umb, rbf, the values tend to be very high. Discreteness tends to restrict the magnitude of the correlations, though it's still very high for afc, largely because most (over 70%) of the observations are in the zero category; it is a lower for amb, and lower still for amc, which has other issues.

More importantly, and more relevant is that different cameras also produce highly correlated results. This attests to the reliability as well as the repeatability of the camera measurement.

The critical issue is now: is the camera measuring the right thing? The validity needs to be determined: by comparison with the graders.

4.2 Trial data

There were two subsequent camera validation (approval) trials, the first from 21 May 2018 to 24 May 2018, and a follow-up trail 5 months later, from 29 to 30 October 2018.

To further develop and refine the camera grading algorithm grading data had to be collected from the same group of carcases by 2 expert MSA graders, the company grader and three cameras in the May and October trials of 2018.

Variables

(a three-letter abbreviation was used for all variables)

amb = AUS-MEAT marbling; values = {0,1,2,…,7}. *This indicates the total fat content of the meat.*

amc = AUS-MEAT meat colour; values = {1A,1B,1C,2,…,7}, re-coded as {0,0,1,2,…,7}. *Roughly speaking, this measures the dark-redness of the meat.*

afc = AUS-MEAT fat colour; values = {0,1,2,…,9}, though 8&9 seldom used; and not used by cameras at all. *Roughly speaking this measures the yellowness of the fat.*

rbf = subcutaneous ribfat (in mm); values = {0,1,2,3, …}.

ema = eye muscle area (in cm^2); values = {0,1,2,3, …}. The area is measured at the *M.longissimus dorsi*.

umb = MSA marbling; values = {100, 110, 120, …, 1190}. *As well as fat content, this also relates to distribution and size of the fat particles.*

Measurement labels

The notation used to distinguish the measurer is a fourth letter added to the variable name: thus amba denotes the amb measurement obtained by Expert Grader 1; amcb denotes the amc measurement obtained by Expert grader 2; afcp denotes the afc measurement obtained by the plant-grader; rbf1 denotes the rbf measurement obtained by camera 1; ema2 denotes the ema measurement obtained by camera 2; and umb3 denotes the umb measurement obtained by camera 3.

The number of lines (carcasses) with values for each variable (v=ema, amb, umb, afc, amc, rbf) and each measurer (experts a,b; plant-graders p; cameras 1,2,3) is given in the table below.

	n	nm		day1	day2	day3	day4
va	1477	2507	*37%*	451	344	326	356
vb	1477	2507	*37%*	452	344	325	356
vp	3556	428	*89%*	974	909	869	804
v1	3939	45	*99%*	1094	1085	893	867
v2	3915	69	*98%*	1101	1097	895	822
v3	3956	28	*99%*	1103	1094	894	865
	3986			1110	1099	899	878

Data adjustment

amc was converted to a numerical variable—or at least the names of its categories were changed to numbers: there were no 1A values observed; 1B → 0 and 1C → 1. This conversion is essentially a conversion to ranks. And it enables calculation of standard statistics, which would then be interpreted as rank-statistics. There is no scale defined. But nor is there for amb, afc or umb—except perhaps for some default or arbitrary scale.

The camera data for the 'continuous' variables (rbf, ema, umb) were adjusted to match the 'observable values'. Thus there were some negative rbf values that were truncated to zero, and other values were rounded to the nearest integer. Similarly ema was rounded to the nearest integer and umb rounded to the nearest multiple of 10.

Difference labels

It was relevant to compare each variable with a gold-standard. In the absence of a gold-standard, a pseudo gold-standard was used: the measurements obtained by Expert a. Accordingly difference variables with notation vxa were defined: vxa = vx – va.
Thus ambpa = ambp – amba, the difference between the measurement obtained by the plant-grader and the measurement obtained by Expert a.
Similarly amc1a = amc1 – amca, ema3a = ema3 – emaa, and so on.

Grouped variable labels

For the 'continuous' variables (i.e. the variables with too many categories: rbf, ema & umb) the data were grouped so as to better match the discrete variables in the number of groups. This was done in order to better and more fairly assess 'agreement'. These grouped variables were denoted by adding a 'g' to the variable name: thus umb → umbg; and umbgp denotes the grouped umb value for the plant-grader; and similarly, the difference variable umbgpa = umbgp – umbga. These difference variables are used to assess agreement: there is agreement between plant-grader and Expert a if umbgpa = 0.

4.2.1 May data

4.2.1.1 AUS-MEAT marbling

	amba	ambb	ambp	amb1	amb2	amb3	x	x	p	c	c	c
0	170	165	387	248	231	212	**12%**	11%	10%	6%	6%	5%
1	830	664	1924	2684	2655	2684	**56%**	45%	48%	68%	68%	68%
2	318	500	1223	831	838	880	**22%**	34%	31%	21%	21%	22%
3	133	119	360	115	128	120	**9%**	8%	9%	3%	3%	3%
4	21	22	70	52	54	52	**1%**	1%	2%	1%	1%	1%
5	5	6	13	9	9	8	**0%**	0%	0%	0%	0%	0%
6		1	4				**0%**	0%	0%	0%	0%	0%
7			2				**0%**	0%	0%	0%	0%	0%
n	1477	1477	3983	3939	3915	3956	100%	100%	100%	100%	100%	100%
nm	2507	2507	1	45	69	28						

	amba	ambb	ambp	amb1	amb2	amb3	x	x	p	c	c	c
0	158	156	218	132	132	111	**11%**	11%	15%	9%	9%	8%
1	797	634	624	904	904	916	**56%**	45%	44%	64%	64%	65%
2	305	477	380	296	285	298	**22%**	34%	27%	21%	20%	21%
3	126	116	152	50	60	58	**9%**	8%	11%	4%	4%	4%
4	21	22	33	25	26	25	**1%**	2%	2%	2%	2%	2%
5	5	6	3	5	5	4	**0%**	0%	0%	0%	0%	0%
6		1	1				**0%**	0%	0%	0%	0%	0%
7			1				**0%**	0%	0%	0%	0%	0%
	1412	1412	1412	1412	1412	1412	100%	100%	100%	100%	100%	100%

4.2.1.2 Australian meat colour

Note: The amc categories have been converted to numbers: 1B→ 0 and 1C → 1, with the other levels unchanged, i.e. 2 → 2, …, 7 → 7. But now these values are treated like numbers, for convenience. Thus whatever the underlying scale might be, it is effectively ignored. This is equivalent to treating the categories as ranks. The correlations are the same as rank correlations, and we could think of the means as average ranks, and so on. Of course, the same applies to afc and to amb, but it's more obvious in this case as some conversion to numbers needs to be made: we can't compute an average of 1C & 2. But an average of 1.7 indicates that the average is somewhere between 1C=1 and 2.

	amca	amcb	amcp	amc1	amc2	amc3		x	x	p	c	c	c
0	9	5	4	6	4		1B	**0.6%**	0.3%	0.1%	0.2%	0.1%	0.0%
1	129	46	575	130	59		1C	**8.7%**	3.1%	14.4%	3.3%	1.5%	0.0%
2	176	204	1637	688	515	443	2	**11.9%**	13.8%	41.1%	17.5%	13.2%	11.4%
3	377	480	1351	1425	1441	1259	3	**25.5%**	32.5%	33.9%	36.2%	36.8%	32.3%
4	481	451	171	1362	1469	1592	4	**32.6%**	30.5%	4.3%	34.6%	37.5%	40.9%
5	184	199	154	238	312	442	5	**12.5%**	13.5%	3.9%	6.0%	8.0%	11.3%
6	111	84	74	70	91	127	6	**7.5%**	5.7%	1.9%	1.8%	2.3%	3.3%
7	10	8	17	20	24	34	7	**0.7%**	0.5%	0.4%	0.5%	0.6%	0.9%
n	1477	1477	3983	3939	3915	3897							
nm	2507	2507	1	45	69	87							

	amca	amcb	amcp	amc1	amc2	amc3
0	7	3	1	0	0	0
1	115	42	200	41	14	0
2	163	189	497	270	201	185
3	367	460	469	465	496	435
4	458	427	83	429	461	496
5	167	182	80	123	146	174
6	105	81	50	51	58	80
7	10	8	12	13	16	22
n	1392	1392	1392	1392	1392	1392

	x	x	p	c	c	c
1B	**0.5%**	0.2%	0.1%	0.0%	0.0%	0.0%
1C	**8.3%**	3.0%	14.4%	2.9%	1.0%	0.0%
2	**11.7%**	13.6%	35.7%	19.4%	14.4%	13.3%
3	**26.4%**	33.0%	33.7%	33.4%	35.6%	31.3%
4	**32.9%**	30.7%	6.0%	30.8%	33.1%	35.6%
5	**12.0%**	13.1%	5.7%	8.8%	10.5%	12.5%
6	**7.5%**	5.8%	3.6%	3.7%	4.2%	5.7%
7	**0.7%**	0.6%	0.9%	0.9%	1.1%	1.6%

4.2.1.3 *Australian fat colour*

The category counts for each measuring 'device' based on all the data obtained are as follows.

	afca	afcb	afcp	afc1	afc2	afc3	x	x	p	c	c	c
0	576	541	1292	2875	2907	2668	39%	37%	32%	73%	74%	67%
1	263	280	1539	185	180	237	18%	19%	39%	5%	5%	6%
2	145	109	315	295	278	353	10%	7%	8%	7%	7%	9%
3	182	185	442	261	246	318	12%	13%	11%	7%	6%	8%
4	100	100	99	101	86	119	7%	7%	2%	3%	2%	3%
5	71	62	132	107	102	112	5%	4%	3%	3%	3%	3%
6	56	75	79	54	72	83	4%	5%	2%	1%	2%	2%
7	42	70	45	61	44	66	3%	5%	1%	2%	1%	2%
8	33	50	36				2%	3%	1%	0%	0%	0%
9	9	5	4				1%	0%	0%	0%	0%	0%
n	1477	1477	3983	3939	3915	3956	100%	100%	100%	100%	100%	100%
nm	2507	2507	1	45	69	28						

Using only the data based on common carcasses, which gives a fairer comparison, the category counts are given by:

	afca	afcb	afcp	afc1	afc2	afc3	x	x	p	c	c	c
0	566	529	375	861	874	793	40%	37%	27%	61%	62%	56%
1	254	271	475	62	75	76	18%	19%	34%	4%	5%	5%
2	139	103	118	138	130	137	10%	7%	8%	10%	9%	10%
3	170	175	189	157	149	185	12%	12%	13%	11%	11%	13%
4	90	93	63	65	53	70	6%	7%	4%	5%	4%	5%
5	65	58	79	59	65	69	5%	4%	6%	4%	5%	5%
6	52	69	53	27	36	40	4%	5%	4%	2%	3%	3%
7	35	62	31	43	30	42	2%	4%	2%	3%	2%	3%
8	33	47	25				2%	3%	2%	0%	0%	0%
9	8	5	4				1%	0%	0%	0%	0%	0%
n*	1412	1412	1412	1412	1412	1412	100%	100%	100%	100%	100%	100%

4.2.1.4 *Subcutaneous rib fat*

Using the grouped data, the following tally tables result:

	rbfa	rbfa	rbfp	rbf1	rbf2	rbf3						
0	257	261	131	403	405	353	17.4%	17.7%	3.7%	10.2%	10.3%	8.9%
1	292	269	842	428	407	424	19.8%	18.2%	23.7%	10.9%	10.4%	10.7%
2	264	359	775	505	516	516	17.9%	24.3%	21.8%	12.8%	13.2%	13.0%
3	311	270	749	667	669	651	21.1%	18.3%	21.1%	16.9%	17.1%	16.5%
4	180	169	451	647	620	664	12.2%	11.4%	12.7%	16.4%	15.8%	16.8%
5	99	68	355	546	529	548	6.7%	4.6%	10.0%	13.9%	13.5%	13.9%
6	48	45	169	345	358	380	3.2%	3.0%	4.8%	8.8%	9.1%	9.6%
7	16	25	42	218	207	230	1.1%	1.7%	1.2%	5.5%	5.3%	5.8%
8	10	11	42	180	204	190	0.7%	0.7%	1.2%	4.6%	5.2%	4.8%
	1477	1477	3556	3939	3915	3956						
	2507	2507	428	45	69	28						

Using the data from commonly assessed carcasses (n=1122) we obtain the following category counts.

	rbfa	rbfa	rbfp	rbf1	rbf2	rbf3							
0	88	80	67	116	99	91	*0-2*	**7.8%**	7.1%	6.0%	10.3%	8.8%	8.1%
1	192	195	261	102	97	106	*3-5*	**17.1%**	17.4%	23.3%	9.1%	8.6%	9.4%
2	229	302	247	141	165	143	*6-8*	**20.4%**	26.9%	22.0%	12.6%	14.7%	12.7%
3	285	253	230	204	203	178	*9-11*	**25.4%**	22.5%	20.5%	18.2%	18.1%	15.9%
4	165	155	130	170	163	198	*12-14*	**14.7%**	13.8%	11.6%	15.2%	14.5%	17.6%
5	96	63	113	158	160	151	*15-17*	**8.6%**	5.6%	10.1%	14.1%	14.3%	13.5%
6	42	41	41	102	99	116	*18-20*	**3.7%**	3.7%	3.7%	9.1%	8.8%	10.3%
7	15	23	14	62	69	69	*21-23*	**1.3%**	2.0%	1.2%	5.5%	6.1%	6.1%
8	10	10	19	67	67	70	*24+*	**0.9%**	0.9%	1.7%	6.0%	6.0%	6.2%
	1122	1122	1122	1122	1122	1122							

4.2.1.5 Eye muscle area

Using the grouped data, we construct a tally table:

	emag a	emag b	emag p	emag 1	emag 2	emag 3	x	x	p	c	c	c
1	6	14	2	10	8	7	**0%**	1%	0%	0%	0%	0%
2	75	75	33	85	83	89	**5%**	5%	1%	2%	2%	2%
3	148	154	181	352	305	358	**10%**	10%	5%	9%	8%	9%
4	301	333	757	722	640	665	**20%**	23%	21%	18%	16%	17%
5	358	346	1119	1088	976	1040	**24%**	23%	31%	28%	25%	26%
6	332	298	961	883	1007	944	**22%**	20%	27%	22%	26%	24%
7	174	164	374	549	575	539	**12%**	11%	11%	14%	15%	14%
8	64	71	116	182	239	232	**4%**	5%	3%	5%	6%	6%
9	19	22	13	68	82	82	**1%**	1%	0%	2%	2%	2%
n	1477	1477	3556	3939	3915	3956	**100%**	100%	100%	100%	100%	100%
nm	2507	2507	428	45	69	28						

Using the data based on commonly assessed carcasses (n=1122) we obtain the following category counts.

	emag a	emag b	emag p	emag 1	emag 2	emag 3	x	x	p	c	c	c
1	1	6	0	1	0	1	**0%**	1%	0%	0%	0%	0%
2	17	16	11	15	9	13	**2%**	1%	1%	1%	1%	1%
3	47	55	60	58	59	63	**4%**	5%	5%	5%	5%	6%
4	182	211	252	201	168	190	**16%**	19%	22%	18%	15%	17%
5	313	308	353	322	323	325	**28%**	27%	31%	29%	29%	29%
6	312	280	276	262	287	260	**28%**	25%	25%	23%	26%	23%
7	170	157	121	175	172	161	**15%**	14%	11%	16%	15%	14%
8	62	69	44	66	78	74	**6%**	6%	4%	6%	7%	7%
9	18	20	5	22	26	35	**2%**	2%	0%	2%	2%	3%
n	1122	1122	1122	1122	1122	1122						

4.2.1.6 MSA marbling

	umbga	umbgb	umbgp	umbg1	umbg2	umbg3	x	x	p	c	c	c
1	27	30	58	1			**1.8%**	2.0%	1.6%	0.0%	0.0%	0.0%
2	50	58	99	20	18	15	**3.4%**	3.9%	2.8%	0.5%	0.5%	0.4%
3	116	98	67	229	214	200	**7.9%**	6.6%	1.9%	5.8%	5.5%	5.1%
4	453	404	1062	859	830	801	**30.7%**	27.4%	29.9%	21.8%	21.2%	20.2%
5	359	270	677	1174	1147	1198	**24.3%**	18.3%	19.0%	29.8%	29.3%	30.3%
6	207	301	673	661	688	690	**14.0%**	20.4%	18.9%	16.8%	17.6%	17.4%
7	102	179	496	417	433	434	**6.9%**	12.1%	13.9%	10.6%	11.1%	11.0%
8	88	84	198	267	244	272	**6.0%**	5.7%	5.6%	6.8%	6.2%	6.9%
9	49	26	141	147	162	170	**3.3%**	1.8%	4.0%	3.7%	4.1%	4.3%
10	26	27	85	164	179	176	**1.8%**	1.8%	2.4%	4.2%	4.6%	4.4%
	1477	1477	3556	3939	3915	3956						

Using the data based on commonly assessed carcasses (n=1122) we obtain the following

	umbga	umbgb	umbgp	umbg1	umbg2	umbg3	x	x	p	c	c	c
1	5	6	27	0			**0.4%**	0.5%	2.4%	0.0%	0.0%	0.0%
2	19	14	43	5	7	7	**1.7%**	1.2%	3.8%	0.4%	0.6%	0.6%
3	62	46	19	72	70	72	**5.5%**	4.1%	1.7%	6.4%	6.2%	6.4%
4	335	297	301	234	224	212	**29.9%**	26.5%	26.8%	20.9%	20.0%	18.9%
5	295	202	209	320	314	307	**26.3%**	18.0%	18.6%	28.5%	28.0%	27.4%
6	176	272	189	159	179	187	**15.7%**	24.2%	16.8%	14.2%	16.0%	16.7%
7	90	158	164	117	111	113	**8.0%**	14.1%	14.6%	10.4%	9.9%	10.1%
8	75	77	70	93	86	87	**6.7%**	6.9%	6.2%	8.3%	7.7%	7.8%
9	43	25	66	63	59	65	**3.8%**	2.2%	5.9%	5.6%	5.3%	5.8%
10	22	25	34	59	72	72	**2.0%**	2.2%	3.0%	5.3%	6.4%	6.4%
	1122	1122	1122	1122	1122	1122						

4.3 October data

4.3.1.1 AUS-MEAT marbling

amb	amba	ambb	ambp	amb1	amb2	x	x	p	c	c
0	8	27	36	24	30	**2%**	6%	8%	5%	6%
1	304	262	272	325	322	**66%**	56%	59%	70%	69%
2	109	138	109	74	75	**23%**	30%	23%	16%	16%
3	29	26	30	23	18	**6%**	6%	6%	5%	4%
4	6	3	8	10	11	**1%**	1%	2%	2%	2%
5	4	3	4	8	8	**1%**	1%	1%	2%	2%
6	4	3	5			**1%**	1%	1%	0%	0%
7		1				**0%**	0%	0%	0%	0%
8		1				**0%**	0%	0%	0%	0%
9						**0%**	0%	0%	0%	0%
all	464	464	464	464	464	**100%**	100%	100%	100%	100%

4.3.1.2 Australian meat colour

Note: The amc categories have been converted to numbers: 1B→ 0 and 1C → 1, with the other levels unchanged, i.e. 2 → 2, …, 7 → 7. But now these values are treated like numbers, for convenience.

Thus whatever the underlying scale might be, it is effectively ignored. This is equivalent to treating the categories as ranks. The correlations are the same as rank correlations, and we could think of the means as average ranks, and so on. Of course, the same applies to afc and to amb, but it's more obvious in this case as some conversion to numbers needs to be made: we can't compute an average of 1C & 2. But an average of 1.7 indicates that the average is somewhere between 1C=1 and 2.

	amca	amcb	amcp	amc1	amc2		x	x	p	c	c
0	1	0	1	0	0	1B	**0.2%**	0.0%	0.2%	0.0%	0.0%
1	23	6	49	10	2	1C	**5.0%**	1.3%	10.6%	2.2%	0.4%
2	65	45	200	79	54	2	**14.0%**	9.7%	43.1%	17.0%	11.6%
3	158	168	176	181	172	3	**34.1%**	36.2%	37.9%	39.0%	37.1%
4	168	204	13	169	199	4	**36.2%**	44.0%	**2.8%**	36.4%	42.9%
5	31	32	18	19	30	5	**6.7%**	6.9%	3.9%	4.1%	6.5%
6	18	9	7	6	5	6	**3.9%**	1.9%	1.5%	1.3%	1.1%
7	0	0	0	0	2	7	**0.0%**	0.0%	0.0%	0.0%	0.4%
	464	464	464	464	464						

4.3.1.3 Australian fat colour

	afca	afcb	afcp	afc1	afc2	x	x	p	c	c
0	176	176	132	183	171	38%	38%	28%	39%	37%
1	198	200	247	191	198	43%	43%	53%	41%	43%
2	21	18	22	24	29	5%	4%	5%	5%	6%
3	18	14	22	10	7	4%	3%	5%	2%	2%
4	26	14	10	19	24	6%	3%	2%	4%	5%
5	11	19	21	23	18	2%	4%	5%	5%	4%
6	10	17	4	8	15	2%	4%	1%	2%	3%
7	2	5	5	6	2	0%	1%	1%	1%	0%
8	2	1	1	0	0	0%	0%	0%	0%	0%
n	464	464	464	464	464					

4.3.1.4 Subcutaneous rib fat

		rbfga	rbfgb	rbfgp	rbfg1	rbfg2	x	x	p	c	c
1	0-2	14	15	12	26	20	3.4%	3.6%	2.9%	6.3%	4.8%
2	3-5	77	90	151	73	70	18.6%	21.7%	36.4%	17.6%	16.9%
3	6-8	149	153	114	135	143	35.9%	36.9%	27.5%	32.5%	34.5%
4	9-11	109	80	76	96	95	26.3%	19.3%	18.3%	23.1%	22.9%
5	12-14	29	48	35	43	53	7.0%	11.6%	8.4%	10.4%	12.8%
6	15-17	23	15	13	26	26	5.5%	3.6%	3.1%	6.3%	6.3%
7	18-20	9	8	11	13	7	2.2%	1.9%	2.7%	3.1%	1.7%
8	21-23	2	5	2	2	1	0.5%	1.2%	0.5%	0.5%	0.2%
9	24+	3	1	1	1	0	0.7%	0.2%	0.2%	0.2%	0.0%
n		415	415	415	415	415					

4.3.1.5 Eye muscle area

		emaga	emagb	emagp	emag1	emag2	x	x	p	c	c
1	(0,49)	0	3	0	0	1	0%	1%	0%	0%	0%
2	(50,59)	7	10	3	6	6	2%	3%	1%	2%	2%
3	(60,69)	13	12	16	18	21	4%	4%	5%	5%	6%
4	(70,79)	63	81	100	107	105	19%	24%	30%	32%	31%
5	(80,89)	118	106	123	109	115	35%	32%	37%	33%	34%
6	(90,99)	100	85	72	72	67	30%	25%	21%	21%	20%
7	(100,109)	28	28	19	21	18	8%	8%	6%	6%	5%
8	(110,119)	4	9	2	1	1	1%	3%	1%	0%	0%
9	(120,–)	2	1	0	1	1	1%	0%	0%	0%	0%
		335	335	335	335	335	100%	100%	100%	100%	100%

4.3.1.6 MSA marbling

Using the grouped data based on the commonly assessed carcasses (n=415), we construct a tally table:

	umbga	umbgb	umbgp	umbg1	umbg2	x	x	p	c	c
(0,195)	0	0	8	0	0	**0.0%**	0.0%	1.9%	0.0%	0.0%
(195,245)	0	2	16	0	0	**0.0%**	0.5%	3.9%	0.0%	0.0%
(245,295)	8	24	5	22	26	**1.9%**	5.8%	1.2%	5.3%	6.3%
(295,345)	172	131	161	117	123	**41.4%**	31.6%	38.8%	28.2%	29.6%
(345,395)	114	118	92	128	116	**27.5%**	28.4%	22.2%	30.8%	28.0%
(395,445)	71	87	45	57	61	**17.1%**	21.0%	10.8%	13.7%	14.7%
(445,495)	20	29	53	24	28	**4.8%**	7.0%	12.8%	5.8%	6.7%
(495,545)	15	13	14	28	23	**3.6%**	3.1%	3.4%	6.7%	5.5%
(545,595)	7	6	12	13	15	**1.7%**	1.4%	2.9%	3.1%	3.6%
(595,--)	8	5	9	26	23	**1.9%**	1.2%	2.2%	6.3%	5.5%
	415	415	415	415	415					

4.4 Plant audit results

The facility passed the AUS-MEAT desk audit conducted on the 16th of January 2020 and the site audit conducted on the 29th of January 2020.

All outstanding issues were closed out by the 14th of February 2020.

5 Discussion

5.1 Comparison with Accreditation Standards

5.1.1 Accreditation standards for cameras assessing MSA and AUS-MEAT loin eye traits, based on expert grader commercial performance

AUS-MEAT and MSA chiller assessment traits	Recommended accuracy standards for cut surface cameras
MSA marbling	≥49% within 50 MSA marble score points from the expert graders <30% within 51 to 100 MSA marble score points from the expert graders <18% within 101 to 200 MSA marble points from the expert graders <3% more than 200 MSA marble points from the expert graders
AUS-MEAT marbling (0 to 6)	≥65% with the same AUS-MEAT marble score as the expert graders Up to 32% ± 1 score AUS-MEAT marble scores different to the expert graders <3% ± 2 or more AUS-MEAT marble scores different to the expert graders
High AUS-MEAT marbling (0 to 9+)	≥47% with the same AUS-MEAT marble score as the expert graders Up to 44% ± 1 score AUS-MEAT marble scores different to the expert graders <8% ± 2 or more AUS-MEAT marble scores different to the expert graders
AUS-MEAT Meat Colour	≥63% with the same AUS-MEAT Meat Colour score as the expert graders Up to 34% ± 1 score AUS-MEAT Meat Colour score different to the expert graders <3% ± 2 or more AUS-MEAT Meat Colour scores different to the expert graders
Eye muscle area (cm^2)	74% within ± 4 cm^2 of the expert grader 21% within ± 4.1 to 8 cm^2 of the expert grader 4% within ± 8.1 to 12 cm^2 of the expert grader 1% allowed to be more than ± 12 cm^2 of the expert grader
AUS-MEAT Fat colour	≥55% with the same AUS-MEAT Fat Colour score as the expert graders Up to 40% ± 1 score AUS-MEAT Fat Colour score different to the expert graders <5% ± 2 or more AUS-MEAT Fat Colour scores different to the expert graders
Sub cutaneous rib fat (≤5 mm)	>84% with ≤ 1mm difference to the expert grader <13% with ≤ 2mm difference to the expert grader <2% with ≤ 3mm difference to the expert grader <1% with > 3mm difference to the expert grader
Sub cutaneous rib fat (>5 mm but ≤10 mm)	>60% with ≤ 1mm difference to the expert grader <21% with ≤ 2mm difference to the expert grader <11% with ≤ 3mm difference to the expert grader <8% with > 3mm difference to the expert grader
Sub cutaneous rib fat (>10 mm)	>49% with ≤ 1mm difference to the expert grader <21% with ≤ 2mm difference to the expert grader <16% with ≤ 3mm difference to the expert grader <14% with > 3mm difference to the expert grader

5.1.2 May trial data cleaned

To “clean” the data, only the data where there is data from the two expert graders and the difference between the two is within acceptable limits as per the ALMTech proposal, and where there are 3 cameras results has been left in for the analysis. Where required by the ALMTech proposal the average or median is used as appropriate.

Table 13 - AUS-MEAT Marbling comparison with expert graders (May)

	0	1185	
	1	252	
	>=2	4	
	Sum	1441	
65%	0	82.2%	Complies
32%	1	17.5%	Complies
3%	>=2	0.3%	Complies

Table 14 - MSA Marbling comparison with expert graders (May)

	<=50	1184	
	51 to 100	215	
	101 to 200	46	
	>200	0	
	Sum	1445	
49%	<=50	81.9%	Complies
30%	51 to 100	14.9%	Complies
18%	101 to 200	3.2%	Complies
3%	>200	0.0%	Complies

Table 15 - Meat Colour comparison with expert graders (May)

	0	951	
	1	468	
	>=2	24	
	Sum	1443	
63%	0	65.9%	Complies
34%	1	32.4%	Complies
3%	>=2	1.7%	Complies

Table 16 - Fat Colour comparison with expert graders (May)

0	1071
1	334
>=2	40
Sum	1445

55%	0	74.1%	Complies
40%	1	23.1%	Complies
5%	>=2	2.8%	Complies

Table 17 - Eye Muscle Area comparison with expert graders (May)

<=4 cm^2	797
4.1 to 8cm^2	428
8.1 to 12cm^2	142
>12cm^2	64
Sum	1431

74%	<=4 cm^2	55.7%	Does not comply
21%	4.1 to 8cm^2	29.9%	Does not comply
4%	8.1 to 12cm^2	9.9%	Does not comply
1%	>12cm^2	4.5%	Does not comply

Table 18 - Sub-Cutaneous Rib Fat comparison with expert graders (May)

0	621
1	328
2	193
>=3	304
Sum	1446

84%	0	42.9%	Does not comply
13%	1	22.7%	Does not comply
2%	2	13.3%	Does not comply
1%	>=3	21.0%	Does not comply

5.1.3 October trial data cleaned

To "clean" the data, only the data where there is data from the two expert graders and the difference between the two is within acceptable limits as per the ALMTech proposal, and where there are 2 cameras results has been left in for the analysis. Where required by the ALMTech proposal the average or median is used as appropriate.

Table 19 - AUS-MEAT Marbling comparison with expert graders (Oct)

0	415
1	46
>=2	0
Sum	461

65%	0	90.0%	Complies
32%	1	10.0%	Complies
3%	>=2	0.0%	Complies

Table 20 - MSA Marbling comparison with expert graders (Oct)

<=50	409
51 to 100	46
101 to 200	8
>200	0
Sum	463

49%	<=50	88.3%	Complies
30%	51 to 100	9.9%	Complies
18%	101 to 200	1.7%	Complies
3%	>200	0.0%	Complies

Table 21 - Meat Colour comparison with expert graders (Oct)

0	299
1	142
>=2	10
Sum	451

63%	0	66.3%	Complies
34%	1	31.5%	Complies
3%	>=2	2.2%	Complies

Table 22 - Fat Colour comparison with expert graders (Oct)

0	353
1	94
>=2	0
Sum	447

55%	0	79.0%	Complies
40%	1	21.0%	Complies
5%	>=2	0.0%	Complies

Table 23 - Eye Muscle Area comparison with expert graders (Oct)

<=4 cm^2	195
4.1 to 8cm^2	116
8.1 to 12cm^2	57
>12cm^2	12
Sum	380

74%	<=4 cm^2	51.3%	Does not comply
21%	4.1 to 8cm^2	30.5%	Does not comply
4%	8.1 to 12cm^2	15.0%	Does not comply
1%	>12cm^2	3.2%	Does not comply

Table 24 - Sub-Cutaneous Rib Fat comparison with expert graders (Oct)

0	172
1	103
2	68
>=3	76
Sum	419

84%	0	41.1%	Does not comply
13%	1	24.6%	Does not comply
2%	2	16.2%	Does not comply
1%	>=3	18.1%	Does not comply

5.2 Camera approval

The Australian Meat Industry Language and Standards Committee granted the equipment provisional approval on the 19th of November 2019. A copy can be found in Section 8.3.

The approval is limited to:

(i) AUS-MEAT Marbling (0-5);
(ii) MSA Marbling (100 – 700);
(iii) Meat Colour; and
(iv) Fat Colour

5.3 Failure to get the eye muscle area attribute approved

The variability between the expert graders was much less than the variability between the expert grader and the camera. The technology developer is unsure why this is the case. The camera currently uses an algorithm to make the eye muscle area prediction. It is not a measurement.

Further work will be done with this attribute with the intention of it eventually being added to the camera approval.

5.4 Failure to get the sub-cutaneous Rib Fat measurement attribute approved

The camera was unable to differentiate between the subcutaneous rib fat depth and the total rib fat depth. It could not identify the seam between those two layers of fat. Human graders were much more capable of finding the seam and then making the correct measurement. The camera appeared to do a much better job of measuring the total Rib Fat.

5.5 QA system amendment/implementation training

The various quality system documents related to Quartering, and carcase grading were amended to reflect the correct use of the camera. That included the addition of the process of over-writing a camera result if the camera operator (accredited grader) believed that the camera had graded an attribute(s) incorrectly, and keeping records and analysis of the number and frequency of over-writing.

Persons quartering were retrained to ensure that the quartered carcases were presented correctly for camera assessment. Camera users (accredited graders) were trained and the competency assessed for placement of the camera.

5.6 Plant approval

The plant was audited on the 29th of January 2020 and final site approval to use the camera as granted on the 14th of February 2020.

6 Conclusions/recommendations

The project was designed to calibrate the camera against the Australian grading standards and the install the camera in at least one export registered meat establishment. That was achieved although the range of attributes being measured is not the full set that AUS-MEAT accredited meat graders measure.

The following attributes can be assessed by the E+V cold carcase camera as long as the camera is used by an accredited grader:

(i) AUS-MEAT Marbling (0-5);
(ii) MSA Marbling (100 – 700);
(iii) Meat Colour; and
(iv) Fat Colour

We will continue to work with E+V to resolve the eye muscle area measurement.

7 Key messages

7.1 Camera – repeatability and reliability

As a piece of technology the cameras are very reliable and produce repeatable results.

7.2 Measurement of variability (the standard)

The single most important piece of work in the project was done by the ALMTech group. They developed the method through which the technology can be compared to the best human graders. As long as the cameras were no more variable that the variability that exists between the expert graders then the camera can be approved for that attribute.

7.3 Comparison to the expert graders

The project demonstrated that the cameras, when programmed correctly, offer no more variability between them and the expert graders as exists within the expert grader group.

7.4 Correct quartering and camera placement

For the cameras to produce consistent and reliable results it is absolutely essential that the carcase is quartered correctly and the camera is placed correctly. Quartering and camera placement improve with increasing use.

7.5 Transparent and independent

The camera image and grading output is available to anyone with access to a PC or smart phone. This will greatly improve the transparency of the grading process to the producer.

They are effectively the next best option if you can't get an independent expert grader. They provide a result independent of the operator.

7.6 Pathway for other grading technology/aids

The development of this approval process will open the way for other grading technologies to be approved.

8 Appendix

8.1 AUS-MEAT Requirements for Approving Equipment

AUS-MEAT

AUS-MEAT Requirements for Approving Equipment

Guidance for Conducting Trial

PURPOSE

To ensure that all equipment and systems submitted to AUS-MEAT for approval are tested and proven to fulfill their stated purpose in an efficient and effective manner adhering to the respective standard.

Main Judgment Criteria: Accuracy, repeatability and reliability to be determined within each piece of equipment and between pieces of equipment (three pieces of equipment required).

GENERAL

An AUS-MEAT equipment approval is normally sought by and awarded to the manufacturer of, or distribution agent for the nominated equipment. AUS-MEAT approval is normally for a specific brand, model and process application. Approval by AUS-MEAT is determined by the Australian Meat Industry Standards and Language Committee (AMISLC).

It is the responsibility of the submitting company to arrange and design the trial with the necessary input from the trial conductors and justify an appropriate validation protocol for approval by AUS-MEAT. This may include acquiring the necessary scientific, industrial and statistical evidence to justify the validity of any proposed trial design for the equipment or system. The concern of AUS-MEAT in this process is to ensure no possible risk to the integrity of the relevant AUS-MEAT standards.

Submitted equipment must have successfully completed the manufacturers own final inspection and test procedure for version of equipment submitted for approval.

- Step 1: Contact AUS-MEAT with introduction of the equipment and what part of industry standard approval is sort so some guidance can be provided.
- Step 2: Submitting company when ready is to arrange the trial.
- Step 3: Notify AUS-MEAT of where and when the trial is to take place. (Note: AUS-MEAT may need to attend the trial).
- Step 4: Provide AUS-MEAT with a documented trial process.
- Step 5: Submitting company to formally apply for approval for the equipment or process. (Note: fee involved and may include expenses incurred from the trial).
- Step 6: Submitting company to provide AUS-MEAT with the final report of the trial.
- Step 7: AUS-MEAT to present final report and relevant papers for the AMILSC on behalf of the submitting company.
- Step 8: When approval is granted a letter of approval is provided to the submitting company and details of the equipment is added to the *National Accreditation Standard*.

Submitting Company: Company which has applied to AUS-MEAT for a trial to be conducted.
Trial Conductors: Recognised organisation that conducts the trial as an independent body.

AUS-MEAT Requirements for Approving Equipment

The submitting company are to

- (i) Notify AUS-MEAT of their purposed equipment to be trialed and for what part of the industry standard they are assessing.
- (ii) Supply AUS-MEAT with the make, model and software version of equipment
- (iii) Contact the organisation identified to conduct the trial and arrange with them the specifics of the trial which should fulfill the trial requirements and this is at their cost.
- (iv) Supply equipment for trial (three pieces of equipment or unless approved by AUS-MEAT for less than three (3) pieces of equipment).
- (v) Provide Samples where applicable for the trial. These samples should cover the current range of criteria within the industry markets.
- (vi) Describe how the samples will be identified and integrity of the samples remain throughout the trial. The condition in which the samples are to prepare and stored.
- (vii) Documented work instruction for the equipment trialed.
- (viii) Accept input from the trial conductors.
- (ix) Provide AUS-MEAT with a copy of the proposed trial design
- (x) Provide AUS-MEAT with the final report.
- (xi) Provide AUS-MEAT with a formal application for the equipment to be approved.

Trial Conductors are to:

- (i) Provide the documented objectives for the trial that validates the instruments against the proven method for accuracy.
- (ii) Provide documented procedure of the trial which includes responsibilities, data security, control of procedure to the submitting company so as to be included in the Trial Design and the Final Report.
- (iii) Provide declaration of independence (from the submitting company).
- (iv) Conduct the trial as per documented procedure.
- (v) Have an overseer to ensure the trial is conducted as per procedure, and be available for advice if there is any technical problems.
- (vi) Permit AUS-MEAT to observe the trial process.
- (vii) Ensure security of the data collected during the trial.
- (viii) Provide the final results and raw data of the trial to AUS-MEAT.
- (ix) Where applicable the statistical analysis of the trial results.

The Trial Design to include:

- (i) Date and time of the trial
- (ii) Objective of the trial
- (iii) Documented procedure to be followed during the trial.
- (iv) Provide a detailed trial plan which is designed proves that the equipment is:
  - Accurate
  - Is Accurate & Repeatable across multiple units
  - Is Accurate & Repeatable for multiple measurements of the same tested product
  - Is Accurate & Repeatable after any calibration process.
- (v) Persons responsibilities within the trial.
- (vi) Make, model and software version of equipment use within the trial.
- (vii) Data to be collected during the trial and commitment to providing the statistical analysis of the results.
- (viii) How security is achieved of the data collected during the trial and analysis of that data.
- (ix) Reporting commitment.

AUS-MEAT Requirements for Approving Equipment

(x) Declaration of independence from the Trial conductors from the submitting company.

The Final Report to include:

(i) Date and time of the trial
(ii) Objective of the trial
(iii) Confirmation the trial procedure was followed during the trial any deviations noted.
(iv) Responsible persons and their responsibilities within the trial.
(v) Make, model and software version of equipment use within the trial.
(vi) Data collected during the trial and the statistical analysis of the results.
(vii) General functionality of the equipment.
(viii) Summary and overview of the process.

GENERAL

AUS-MEAT or the Australian Meat Industry Language and Standards Committee, may also ask for information regarding other practical matters such as hygiene, ergonomics, training, servicing etc.
AUS-MEAT require further in formation in regards the equipment from the Submitting company or the Trial conductors.
Provide any overseas approvals for the equipment pertaining to the AUS-MEAT language approval being sort.

COSTS
A fee of $500.00 plus GST applies for submitting the paper to the AMILSC for their disposition of the equipment.

Expenses incurred in AUS-MEAT representative in attending the trial which will be charged at half day or full day increments. Any travel related costs will be charged at cost.

KEY CONTACT

Tony Webb
AUS-MEAT Limited
E: Tony.webb@ausmeat.com.au
M: 0421032696

8.2 Accreditation standards for cut surface camera grading technologies in Australian beef carcasses

A document produced on behalf of the Industry Calibration Working Group (ICWG) in collaboration with the Advanced Livestock Measurement Technologies (ALMTech) Project team.

Introduction

The ALMTech Project has been investigating a number of cut surface grading cameras over the past two years. There has been significant investment by the Australian beef industry and technology companies in the development and validation of these cameras.

To further progress the production and delivery of commercial solutions for the Australian beef industry, accreditation standards suitable for cut surface camera grading technologies must be defined to reflect the commercial accuracy of 'expert' graders.

Establishing clear accuracy boundaries for grading cameras will be critical for continued investment by companies into objective carcass technologies in Australia. This document proposes industry standards for the accuracy and repeatability/precision requirements for camera technologies for AUS-MEAT accreditation.

Why current standards are not suitable for grading technologies

The On-site Correlation and Practice system (OsCap) is the current method used by AUS-MEAT and MSA graders to achieve and maintain on-going accreditation status. This software-based method of objectively calibrating graders provides a series of loin eye images which tests for AUSMEAT's Chiller Assessment Language and MSA Grading attributes. Graders are required to pass an OsCap assessment on a run of 20 images every 8 weeks to maintain their accreditation as an assessor (grader).

However, the OsCap system cannot be used by grading technologies to achieve and maintain ongoing accreditation status. Nor can the accreditation standards set by OsCap be used for accreditation of cut surface grading technologies. Reasons for this include:

- *Cameras are unable to utilise OsCap images for their calibration. Camera's cannot "log-on" to test themselves as human graders do, as light reflecting from the surface of a computer screen, or even a 2D photo differs from that reflected from the cut surface of the loin.*
- *The OsCap calibration of human graders occurs in front of a computer screen in an office – a comfortable environment that is likely to enhance their performance in predicting OsCap. By contrast, cameras are trained and validated against graders that are operating under commercial grading conditions. This is likely to add to the variation in grader scores that the cameras are trying to predict. Indeed when comparing expert graders our MSA marbling data has demonstrated that under abattoir/commercial conditions their grading scores often differ by more than 100 points, hence do not meet the OsCap accreditation standards.*

- *OsCap images are selected from a large pool of images that remain constant, which is an advantage of this system when correlating graders across Australia. By contrast the variation in grader assessment of loin eye traits in an abattoir creates a “moving target” for those technologies attempting to predict them.*

For these reasons the OsCap accuracy requirements cannot be transferred to the assessment of a camera technologies ability to predict expert graders in an abattoir/commercial environment. Therefore, to facilitate accreditation of cut surface grading technologies, a different approach for accreditation standards is needed and is outlined in this document.

An alternative approach to the present OSCAP correlation standard is to state that **the variability between a camera measurement and expert graders needs to be less than the variability between expert graders** under commercial grading conditions. This approach would set the minimum accuracies required for devices to obtain industry approval. Importantly, the proposed accuracy requirements below are very conservative as they have been developed from the independent expert graders whom are currently used by industry to correlate plant graders in the commercial environment. The differences in cut surface traits provided by these two graders across a phenotypically diverse range of carcasses has been used to set the accuracy boundaries outlined below.

Therefore, the ALMTech ICWG propose that these boundaries are used as minimum accuracy requirements for a device to be accredited by AUS-MEAT/industry.

Experiments demonstrating current commercial accuracy of expert graders

Two major experiments were conducted at two processing plants (plant A and plant B).

At plant A for experiment A, grading data was collected at six time points over a 48-hour period on 116 F1 Wagyu carcasses with MSA marble scores between 330 and 1190.

- Carcasses were graded by two independent expert MSA graders for MSA marbling, AUS-MEAT marbling and meat colour at 5 time points –12h (grade 1), 18h (grade 2), 24h (grade 3), 36h (grade 4), 48h (grade 5) and 60h (grade 6) hours post slaughter
- EMA and subcutaneous rib fat were also measured at grade 5
- Fat colour was not assessed due to all carcasses being grain fed and a lack of variation in this trait

At Plant B for experiment B, grading data was collected at 1 time point (18 to 24 hrs post mortem) on 1478 carcasses. This experiment was conducted over 2 different weeks, but each carcass was graded independently by the same two expert MSA graders.

- Carcasses were graded for all cut surface traits - MSA marbling, AUS-MEAT marbling, EMA, rib fat depth, meat colour, fat colour and subcutaneous fat depth
- Carcasses were chosen to give a wide range in all traits listed above
- The range in marbling was limited to the range of carcasses available at plant B, with values ranging from 120 up to 600.

Table 1 outlines the differences between expert graders. These are represented as the frequency of observations within the correlation categories presently set by OsCap. More detailed representation of the raw data from these experiments is shown in the Appendix.

Recommended accreditation standards

- MSA marbling - the recommended accuracy standards (Table 1) are based on the accuracy of the expert graders during experiment A. The carcasses represented at experiment A cover most of the range of MSA marble scores, hence these values are recommended as the accreditation standard since industry needs cameras to be more accurate than expert graders over the total range of MSA marble scores.
- AUS-MEAT marbling - the recommended accuracy standards (Table 1) are based on the average accuracy of the expert graders for the experiments A and B. The average of carcasses represented at Plant A and B are heavily weighted towards AUS-MEAT marbling scores 0 to 6.
- High AUS-MEAT marbling - the recommended accuracy standards (Table 1) are based on the average accuracy of the expert graders from experiment A. The average of carcasses represented at Plant A range from AUS-MEAT marbling scores 2 to 9+.
- AUS-MEAT Meat Colour - the recommended accuracy standards (Table 1) are based on the average accuracy of the expert grader performance for experiments A and B. Meat Colour ranged from 1B to 7 across both experiments.
- Eye muscle area and Fat Colour - the recommended accuracy standards (Table 1) are based on the average accuracy of the expert graders for experiment B. The EMA of carcasses represented during experiment B ranged from 40 to 140 cm^2, while fat colour ranged from AUS-MEAT 0 to 9.
- Subcutaneous fat depth - the recommended accuracy standards (Table 1) are based on the average accuracy of the expert graders for experiment B. The rib fat depth of carcasses represented at Plant B ranged from 0 to 28mm.

Table 1: Recommended accreditation standards for cameras assessing MSA and AUS-MEAT loin eye traits, based on expert grader commercial performance

AUS-MEAT and MSA chiller assessment traits	Recommended accuracy standards for cut surface cameras
MSA marbling	≥49% within 50 MSA marble score points from the expert graders <30% within 51 to 100 MSA marble score points from the expert graders <18% within 101 to 200 MSA marble points from the expert graders <3% more than 200 MSA marble points from the expert graders
AUS-MEAT marbling (0 to 6)	≥65% with the same AUS-MEAT marble score as the expert graders Up to 32% ± 1 score AUS-MEAT marble scores different to the expert graders <3% ± 2 or more AUS-MEAT marble scores different to the expert graders
High AUS-MEAT marbling (0 to 9+)	≥47% with the same AUS-MEAT marble score as the expert graders Up to 44% ± 1 score AUS-MEAT marble scores different to the expert graders <8% ± 2 or more AUS-MEAT marble scores different to the expert graders
AUS-MEAT Meat Colour	≥63% with the same AUS-MEAT Meat Colour score as the expert graders Up to 34% ± 1 score AUS-MEAT Meat Colour score different to the expert graders <3% ± 2 or more AUS-MEAT Meat Colour scores different to the expert graders
Eye muscle area (cm^2)	74% within ± 4 cm^2 of the expert grader 21% within ± 4.1 to 8 cm^2 of the expert grader 4% within ± 8.1 to 12 cm^2 of the expert grader 1% allowed to be more than ± 12 cm^2 of the expert grader
AUS-MEAT Fat colour	≥55% with the same AUS-MEAT Fat Colour score as the expert graders Up to 40% ± 1 score AUS-MEAT Fat Colour score different to the expert graders <5% ± 2 or more AUS-MEAT Fat Colour scores different to the expert graders
Sub cutaneous rib fat (≤5 mm)	>84% with ≤ 1mm difference to the expert grader <13% with ≤ 2mm difference to the expert grader <2% with ≤ 3mm difference to the expert grader <1% with > 3mm difference to the expert grader
Sub cutaneous rib fat (>5 mm but ≤10 mm)	>60% with ≤ 1mm difference to the expert grader <21% with ≤ 2mm difference to the expert grader <11% with ≤ 3mm difference to the expert grader <8% with > 3mm difference to the expert grader
Sub cutaneous rib fat (>10 mm)	>49% with ≤ 1mm difference to the expert grader <21% with ≤ 2mm difference to the expert grader <16% with ≤ 3mm difference to the expert grader <14% with > 3mm difference to the expert grader

Recommendations for within camera repeatability/precision

Presently, there are no AUS-MEAT guidelines describing the required repeatability and precision for measurements made with cut surface camera technologies. It is also very difficult to get multiple expert grader scores on the same carcass within a timeframe that assures the traits do not change. This is due to the commercial necessities of processing plants to bone carcasses.

It is recommended that the repeatability and precision found between expert graders (Table 1) is used as the minimum requirements for within and between cut surface camera measurement repeatability and precision for AUS-MEAT accreditation.

Recommended guidelines for accreditation experiments

- At least three graders with a minimum of 2 Australian expert graders (identified by MSA) to independently grade each carcass for all cut surface traits.
- The “score” for each trait for each carcass is the average score of all three graders, unless one graders score is deemed an outlier and thus removed from the data set for that trait.
- At least 3 of the same cut surface camera technology will be used to grade each carcass (3 cameras tested at once) to enable the assessment of between camera variability.
- Each camera must take 3 ‘images’ of the same carcass (ensuring the camera is removed from the surface and repositioned for each image) to enable the assessment of within camera variability.
- At least 200 carcasses per day must be graded by each grader and by each cut surface camera technology over a minimum 3 day period
- Ensure that the carcasses used for accreditation meet the minimum image requirements and do not need overrides. In this case avoid carcasses with slumped fat, saggy loins, rough quartering cuts, and whizzer knifed fat at the quartering site.
- Ensure a broad phenotypic range in each trait that is being tested for approval, and that carcases are adequately represented across this range.
- Equipment manufacturers/suppliers can nominate the carcass traits for accreditation, and request accreditation for only a limited range of marbling relevant to specific beef classes (ie domestic grass-fed).
- Ideally intramuscular fat (IMF) % samples should be collected from each carcass after grading according to the protocol outlined in the ALMTech traits manual. These should be sampled as follows.
    - 15mm thick steak removed from the striploin or cube roll, all external fat and seam fat removed. Freeze dried, ground and analysed by the ICWG approved method (lab-based NIR trained on Soxhlet) at an approved laboratory to determine IMF content.
    - In the future when IMF is accepted as the “gold standard” for marbling determination, then IMF sample collection would be mandatory and the accuracy standards would be adjusted accordingly.
- Accuracy and repeatability are reported for each trait that is to be approved.
- The trial and analysis should be conducted by a scientific or standards body that is independent from the commercial company seeking accreditation. The data from the grader and cut surface technology will be collected for later analysis by an independent entity.

Other factors that need to be determined for cut surface camera technologies – commercial operation needs

- Clearly defined internal/daily calibration system, including frequency of calibration and what should be reported.
- No maximum number of overrides imposed on a device for each trait – but a requirement to report the % of over-rides for each trait each day.
- For each trait industry needs to outline the acceptable % of over-rides, % for concern, and % which will need an investigation. This would allow identification of clear errors by the camera, and/or processing errors which cause overrides e.g. poor quartering, water discolouration from spray chilling. This will create a feedback loop optimising carcass presentation for cameras.
- Percentage of eye muscle required for MC, EMA, MB, MSA MB assessment or the ability to override and adjust area of EMA used to determine these traits
- Accreditation for one or more cut surface traits (maximum of all 6 traits) during each accreditation experiment

Appendix

The figures below show the number and distribution of the data for each trait in experiments A and B outlined above.

MSA Marbling

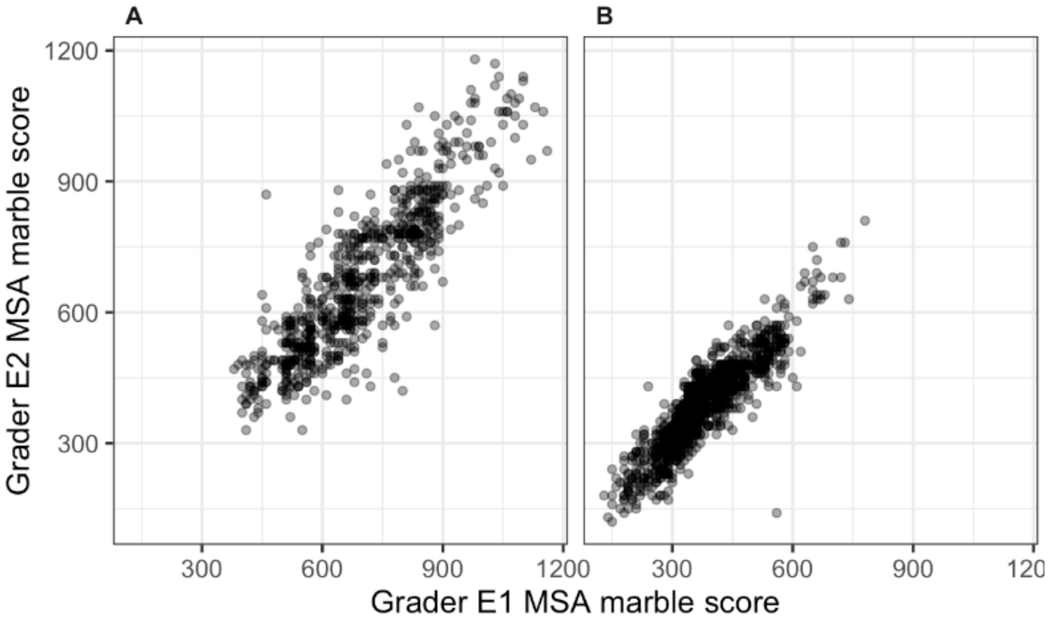

Figure 1: The distribution of MSA marble scores from expert grader 1 (E1) and expert grader 2 (E2) during experiments A and B measured at the same grading time point

AUS-MEAT Marbling

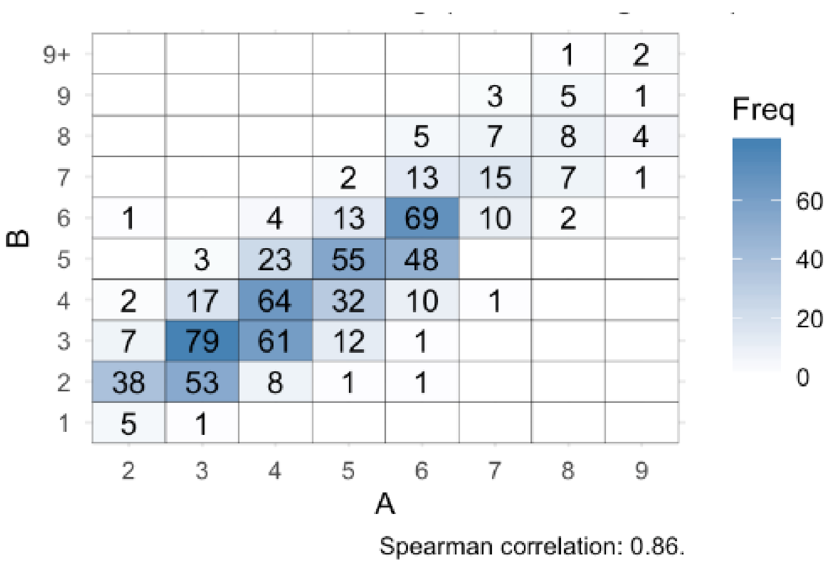

Figure 2: The distribution of AUS-MEAT marble scores from expert grader 1 and expert grader 2 during experiment A measured at the 6 grading time points.

AUS-MEAT Meat Colour

Figure 3: The distribution of AUS-MEAT Meat Colour scores from expert grader 1 (A) and expert grader 2 (B) during experiment B measured at the same grading time point

Eye Muscle Area

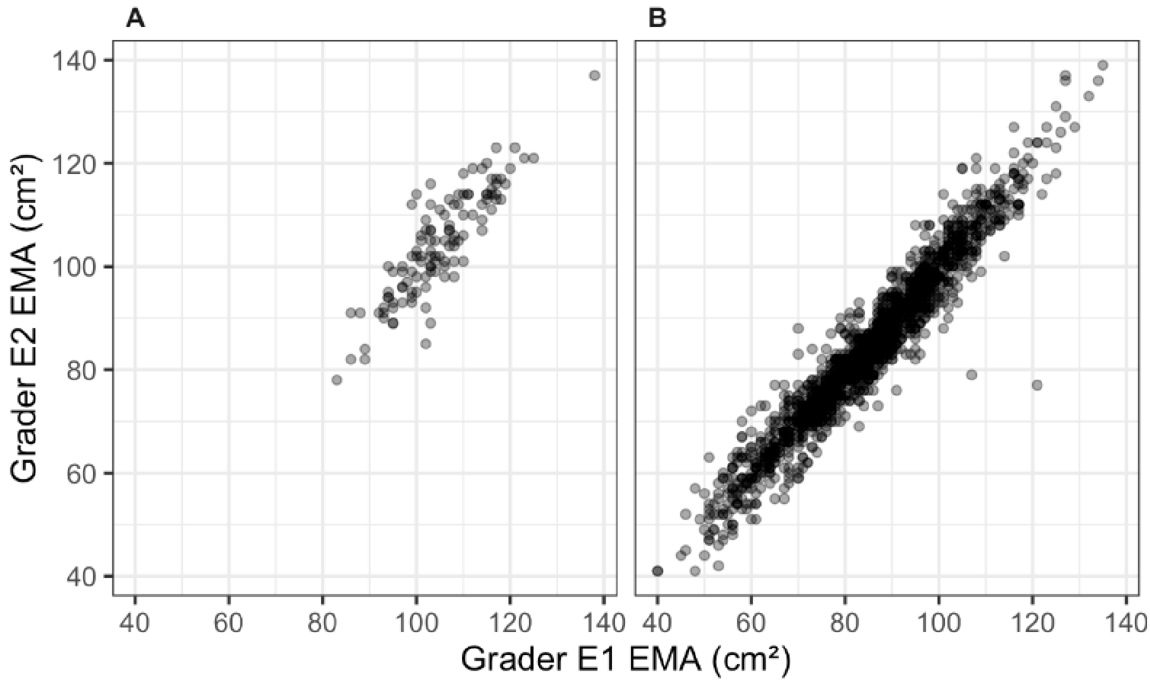

Figure 4: The distribution of eye muscle areas from expert grader 1 (E1) and expert grader 2 (E2) during experiments A and B measured at the same grading time point.

AUS-MEAT Fat Colour

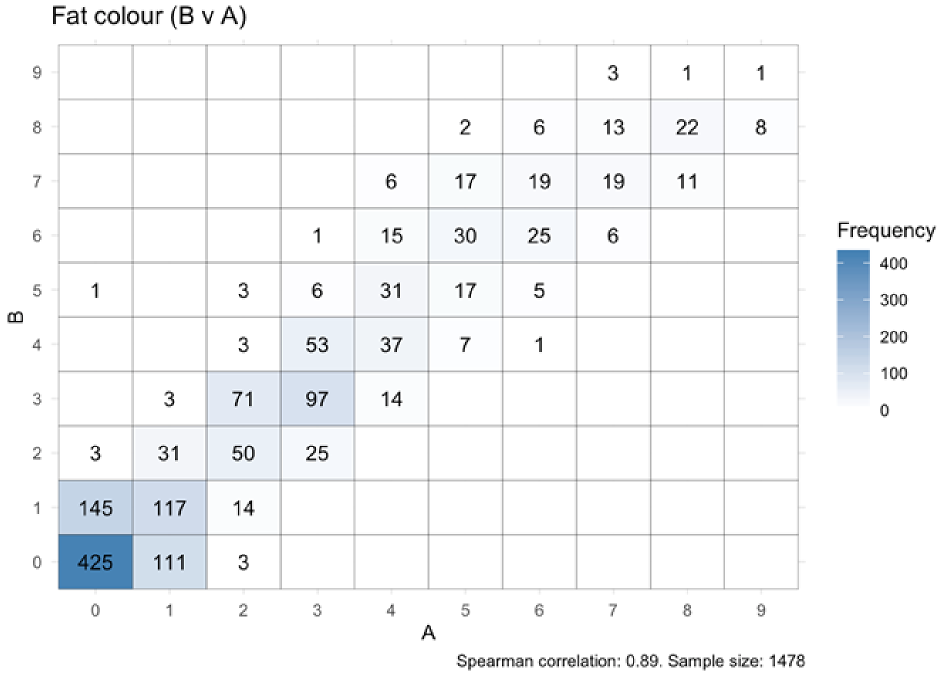

Figure 5: The distribution of AUS-MEAT Fat Colour scores from expert grader 1 (A) and expert grader 2 (B) during experiment B measured at the same grading time point

Subcutaneous rib fat

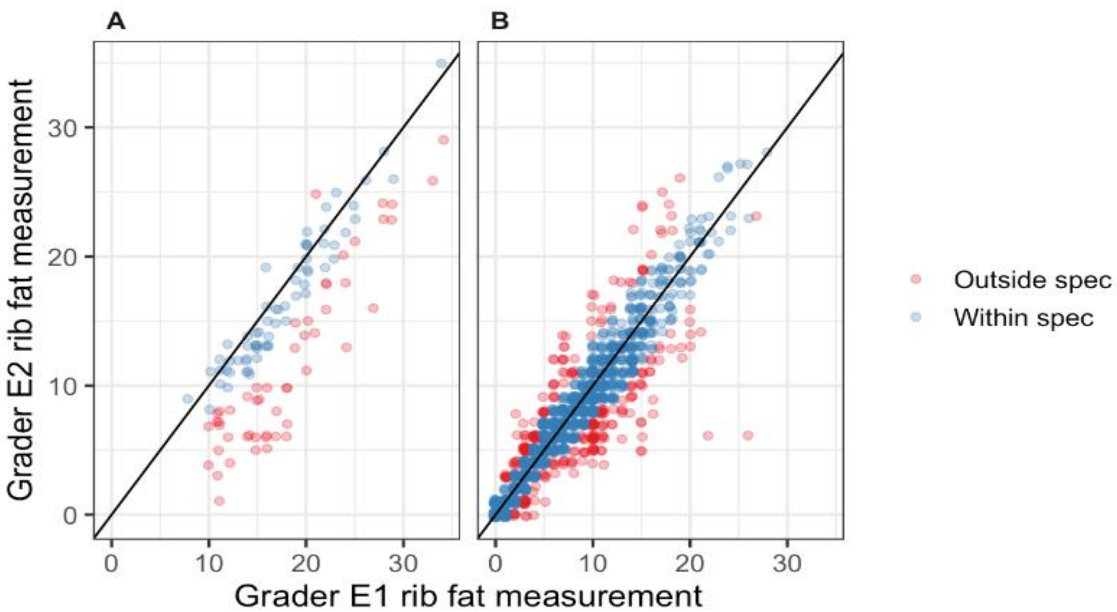

Figure 6: The distribution of subcutaneous rib fat depth measurements from expert grader 1 (E1) and expert grader 2 (E2) during experiments A and B measured at the same grading time point. In this case data for experiment A shows considerable error, likely influenced by cold-trimming of carcases.

8.3 Camera approval

AUS-MEAT AUS-QUAL

19 November 2019

Horst Eger
Managing Director
E+V Technology GmbH& Co.KG
Am Heidering 14
16515 Oranienburg
GERMANY

By Email:

Dear Mr Eger,

Re: APPLICATION FOR APPROVAL OF E+V COLD CARCASS BEEF GRADING CAMERA VBG2000

I refer to previous communications regarding the application from **E+V Technology GmbH& Co.KG** (supplier) for AUS-MEAT Limited (AUS-MEAT) to consider the above equipment with respect to its suitability for measuring specific AUS-MEAT and Meat Standards Australia (MSA) Chiller Assessment attributes in accordance with the requirements of the *Australian Meat Industry Classification System* (AUS-MEAT Language).

The Australian Meat Industry Language and Standards Committee (AMILSC), as the entity responsible for the approval of equipment used to measure these attributes, has met to consider the suitability of the **E+V Cold Carcass Beef Grading Camera VBG2000** (equipment) against the *AUS-MEAT Requirements for Approving Equipment* guidelines.

The Committee has granted **CONDITIONAL APPROVAL** for the equipment as an aid for evaluating the following chiller assessment attributes:

(i) AUSMEAT Marbling (0-5);
(ii) MSA Marbling (100-700);
(iii) Meat Colour; and
(iv) Fat Colour.

The ***Conditions of Approval*** for use of the equipment in AUS-MEAT Accredited Establishments are as follows

1. A further validation trial on the approved attributes is to be conducted within six (6) months of the date of this notice; the results of which will be presented to AMILSC for review.
2. Equipment to be to be used for the full ribbing method between the 12th/13th Rib site only.
3. Any communication regarding the status of approval by the supplier must be stated in full as 'Conditional Approval".
4. The approval status applies to the equipment hardware **VBG2000** and software **Version** 2.2.1.0.
5. AUS-MEAT is notified of (and approves) the modification of any hardware and software changes.

AUSMEAT@AUSMEAT.COM.AU T| 1800 621 903 | PO BOX 3403 TINGALPA DC QLD 4173
AUSQUAL@AUSQUAL.COM.AU T| 1800 630 890 ABN| 44 082 528 881

6. The supplier is required to ensure that the equipment is updated to changes to industry standards (AUS-MEAT Language) as amended from time to time.
7. Approval of equipment will be rescinded where the equipment hardware or software no longer meets industry standards (AUS-MEAT Language).
8. Any promotional material which refers to AUS-MEAT or this notice of Conditional Approval for the equipment must be presented to AUS-MEAT by the supplier for approval prior to release.
9. That upon request, the supplier must provide or facilitate AUS-MEAT with access to a current version of the equipment.
10. Each AUS-MEAT Accredited Establishment seeking to use the equipment must first apply to AUS-MEAT for site specific approval prior to commencement of commercial use.

Yours Sincerely

Allan Bloxsom
Chairman
AUS-MEAT Limited.

CC Mr John Langbridge, Teys Australia

Page 2 of 2

8.4 Site Approval

14 February 2020

Ray McFadden
QA Manager
Teys Australia Southern Pty Ltd Wagga Wagga
1 Dampier Street, Wagga Wagga
NSW 2650 Australia

By Email:

Dear Ray,

Re: APPROVAL FOR USE - E+V Cold Carcass Beef Grading Camera VBG2000

I refer to previous communication of 3 December 2019 regarding the Australian Meat Industry Language and Standards Committee's (AMILSC's) granting of conditional approval to E+V Technology for the use of the *E+V Cold Carcass Beef Grading Camera VBG2000* (equipment); and the associated conditions for the use of this equipment in AUS-MEAT Accredited Establishments.

The scope of approval is as an aid for evaluating the following chiller assessment attributes: as defined in the *Australian Meat Industry Classification System* (AUS-MEAT Language):

(i) AUS-MEAT Marbling (0-5);
(ii) MSA Marbling (100-700);
(iii) Meat Colour; and
(iv) Fat Colour.

As you are aware, AUS-MEAT has conducted a formal review (including desktop and site audit) to assess the suitability of the installation at *Teys Australia Southern Pty Ltd (Wagga Wagga);* including the installation, operational use and the effectiveness of Establishment's Quality Management System (QMS) against the established facility conditions of approval criteria.

AUS-MEAT has granted **APPROVAL** for the use of the equipment at *Teys Australia Southern Pty Ltd Wagga Wagga* subject to the following conditions:

1. The ongoing capability of the equipment to correctly determine the approved chiller assessment attributes.
2. Details outlining the use, control and management of the approved equipment at the establishment is maintained within the establishment's QMS.
3. All individual approved equipment units at the establishment are maintained to the approved hardware (VBG2000) and software (Version 2.2.1.0) version.
4. AUS-MEAT is notified of (and approves) the modification of any hardware and software changes.
5. Ongoing approval for the use of the equipment will be rescinded where the equipment hardware or software no longer meets industry standards.

AUSMEAT@AUSMEAT.COM.AU T| 1800 621 903 | PO BOX 3403 TINGALPA DC QLD 4173
AUSQUAL@AUSQUAL.COM.AU T| 1800 630 890 ABN| 44 082 528 881

6. Any promotional material which refers to AUS-MEAT or this notice of Approval for the use of the equipment must be presented to AUS-MEAT by the facility for approval prior to release.
7. That upon request, the establishment must provide or facilitate AUS-MEAT with access to a current version of the equipment.
8. Individual equipment installations and accuracy of assessment will be subject to ongoing audits by AUS-MEAT. The cost of any such audit will be in accordance with standard AUS-MEAT fee rates.
9. AUS-MEAT may withdraw or suspend approval of the approved equipment at the establishment where the conditions of approval for use are not met.
10. Conditions of ongoing approval of the establishment for the use of the equipment are subject to change by AUS-MEAT at the discretion of the AMILSC.

The above conditions of approval for the use of the equipment are to be read in conjunction with the Standards for AUS-MEAT Chiller Assessment as defined within the AUS-MEAT National Accreditation Standards.

Yours sincerely

Kurt Steele
Program Manager / Auditor
AUS-MEAT Limited.