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Quantifying the impact of Modified Atmospheric Packaging (MAP) and alternative packaging solutions on eating quality.

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Abstract

This project was initiated to build on results from an earlier study (P.PIP.0488) that reported a serious and significant detrimental eating quality effect on retail steak packed for 9 days in 80:20 high Oxygen MAP. The current study investigated MAP, VSP and possible alternative gas mixes in Trigas and 80:20 Nitrogen with visual and sensory consumer evaluation at 1, 3, 5, 7 and 9 days in the retail pack. Both high oxygen and Trigas MAP had significantly lower eating quality from day 1 and throughout the display period. The 80:20 Nitrogen packs had an unsatisfactory visual rating however performed well and similar to VSP in sensory appraisal as cooked steak. Results of the study informed the MSA Pathways committee decision to impose an 8 point Meat Quality (MQ4) score penalty on any MSA product packed in high oxygen MAP.

Executive summary

This study provides vital yet somewhat confronting knowledge for the beef industry. It substantiates reported results from the prior packaging study conducted under P.PIP.0488 which documented a highly significant decline in eating quality resulting from retail packaging in 80:20 high oxygen modified atmosphere (MAP), a predominant packaging system utilised by major retailers in Australia, relative to overwrap (OWP) and vacuum skin pack (VSP) alternatives.

Legitimate industry concerns were raised in relation to the prior study in that it utilised only northern grass fed bullocks, was primarily designed to test colour and consumer based visual pack appeal and included a large proportion of raw material with pH above the MSA upper threshold of 5.70. The concerns from industry were that 1) younger southern cattle were more typical of supply chains, 2) that grain fed cattle were not included, 3) that the raw product was not all MSA compliant and 4) that consumer sensory evaluation of cooked steak was only conducted after 9 days in retail packs.

To address these concerns the current study was designed to evaluate product both visually and by consumer sensory taste tests at 1, 3, 5, 7 and 9 days after retail packing. All product was drawn from 54 MSA compliant cattle sourced equally from grain and grass fed young southern Australian British breed cattle. The collected product was further balanced across three Meat Quality (MQ4) based eating quality bands within grass and grain fed categories.

As the previous study had found no difference in packaging effect across 3 cuts (tenderloin, striploin and rump) after 5, 12 or 40 days ageing as vacuum packed primals prior to retail packing the current study only utilised the *M.Longissimus thoracis and lumborum* muscle (cube roll and striploin) with retail packing after 16 days of storage as vacuum packed primals. The OWP treatment was not used in the new study with MAP and VSP providing linked comparison to the original research. Two additional packaging treatments utilising alternative gas mixtures were included however. These were a TRIGAS (TRI) treatment with 40% Oxygen, 30% Nitrogen and 30% Carbon Dioxide and a high Nitrogen (NIT) treatment with 80% Nitrogen and 20% Carbon Dioxide gas mix. Both the additional treatments had been advocated by parties in Europe and could potentially provide a low cost transition from conventional high oxygen MAP as no change was required in packaging machinery.

By utilising the cube roll and striploin, 10 test samples were prepared from each carcase enabling strong within animal linkage across the 4 packaging treatments and ageing time in retail packaging. In all 540 packs, (135 per packaging treatment, 108 per ageing treatment, 27 per treatment x aged combination were prepared for retail display and sensory testing as cooked steak samples. Extensive design and accompanying control records and protocols were developed to enable the design to be delivered within a commercial value adding facility.

All product was firstly fabricated from vacuum packed primals to 25mm slices, utilising a cutting jig with slices, then allocated to the alternative packaging system in accordance with the specified muscle position. Each pack was identified by a unique laminated 4 digit alphanumeric code, with a coloured dot on the pack side signifying ageing group. Each open pack was evaluated for colour then

transferred to one of four commercial packaging lines, one allocated to each treatment, for retail packing. After packing, all packs were transferred to Charles Sturt University (CSU).

A commercial open fronted retail display cabinet, a make and model used in major supermarkets, was installed in the residential dining and kitchen facility at CSU and used to display the steak product each display day. On each display day the 108 steak packs, allocated to the ageing period (Days 1, 3, 5, 7 or 9) were placed in pre-allocated positions together with a constant reference group of 36 packs of the 9 day treatment. Only the 108 packs aged for 9 days were viewed on the final day.

The display position of every pack was controlled utilising an 8 x 8 Latin square design to ensure that each set of 8 trays, one of each packaging treatment within each of 4 grass and 4 grain fed samples, was presented according to the Latin square rows. The sets of 8 were dispersed across the well and 3 shelves and balanced for shelf position (left, right, front and rear) to balance potential cabinet position effects.

The same consumer meat colour (CMC) evaluation system was utilised as in the prior experiment. This required each pack to be scored by 10 consumers by marking a 100 mm line scale anchored by “extremely appealing” and “extremely unappealing” together with marking one of 3 boxes related to purchasing intent (would definitely buy, definitely buy if discounted or definitely not buy). Consumers were asked to evaluate three nominated sets of 8 packs. This utilised 356 consumers across the trial who recorded a total of 8,544 pack observations.

The CMC judgements, and the calculated discrimination into purchase categories was consistent with the prior study and indicated a high level of consensus.

As expected the high oxygen MAP and TRI treatments obtained the highest visual ratings being most differentiated at day 1 and declining somewhat over the 9 days of display. As in the earlier study the VSP scores were lower however were constant across the display period and rated as acceptable. The NIT product was severely downgraded with a very dark grey to brown appearance at day 1 which improved somewhat as display days increased.

After viewing, the packs allocated to that viewing day were removed from the cabinet, scored for colour immediately on opening and after a 20 minute bloom time, were fabricated into MSA consumer grill samples (each comprising 5 small steaks), utilising MSA protocols. Following fabrication they were vacuum packed and frozen, maintaining their individual ID. After completion of the 9 days of visual appraisal, the frozen samples were allocated to picks (36 test samples allocated to a group of 60 consumers) with each pick including both grass and grain fed product from all packaging types and across ageing periods.

Consumer sensory evaluation was conducted in the greater Melbourne region in accordance with MSA protocols with 10 consumers evaluating each sample. Each consumer was served 7 samples, 6 test samples following a first mid quality “link”. The 5 steaks within each sample were cooked in 5 different “rounds” to avoid possible serving order effects. The samples were arranged into 6 products ranging from expected lowest to highest eating quality and their presentational order governed by a 6 x 6 Latin square design to ensure each was served an equal number of times before and after each other product and equally in each cooking order.

Consumer scoring, as dictated by the protocol, utilised four 100 mm line scales for tenderness, juiciness, flavour and overall liking together with a choice of 4 categories being unsatisfactory, good everyday, better than everyday or premium quality. The 4 line scale scores were combined as tender * 0.3 + juicy * 0.1 + flavour * 0.3 + overall * 0.3 to create a MQ4 score which was used as the primary rating of each sample.

The sensory results were clear and statistically highly significant. As with the earlier study, sensory scores were much higher for the VSP packaging relative to MAP and within the confidence interval of the first study, although slightly lower numerically. In contrast to the visual ratings, the NIT treatment was similar to VSP with high sensory ratings. The TRI packaging produced results very similar, however trending slightly above the MAP treatment. The effect of ageing was not significant with the sensory relationships evident from day 1 post packing. A trend approaching significance for further MQ4 score reduction with ageing was evident for the MAP and TRI treatments.

On the basis of results from both studies the MSA Pathways Committee recommended that all high oxygen packed product, including MAP and TRI, be discounted by 8 MQ4 points. This recommendation was accepted by the MSA Beef Taskforce and implemented commercially.

The study offers critical guidance to the Australian Meat Industry and further emphasises the impact of MSA grading outcomes reflecting a direct consumer satisfaction measure. As a result of the project, industry has been alerted to the impact of retail packaging systems on consumer satisfaction with this impact made visible through substantiated MQ4 deductions.

While there is no MSA requirement to utilise any packaging system there is now a clear consequence of utilising MAP, as with HGP treatments and other production factors. This raises challenges due to the widespread adoption of MAP in large retail chains due to the associated visual retail appeal. The inclusion of TRI and NIT in this study evaluated two possible alternatives, both of which were unsuccessful. The NIT treatment however did fully overcome the detrimental eating quality impact but failed visually. Subsequent discussion has raised a possibility that more severe scavenging during pack evacuation may alleviate the discolouration through further reduced residual oxygen. It is recommended that this be evaluated as a transition to NIT packing would be highly effective and low cost given that only a change in gas mix would be required to implement.

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1 Background

This project was originated to expand on previous work reported in P.PIP.0488 (Polkinghorne et al. 2017; Polkinghorne et al. 2018) and to resolve a number of questions raised in relation to the findings. As the earlier project reported a significant eating quality reduction with high oxygen MAP packaging and recommended imposition of a 12 MQ4 point MSA reduction for 80:20 MAP product there was considerable industry interest and reaction. Adoption of the recommendation was claimed to have potential severe commercial ramifications and further work to substantiate the findings and expand on the scope was requested.

The earlier project investigated interactions between AUS-MEAT meat colour scores (AMC) taken from the loin quartering site during MSA grading and immediately after boning. AMC was recorded on the tenderloin, striploin and rump from both carcase sides, subsequently after placement in retail packing following 5, 12 or 42 days in vacuum packaging and finally after 9 days of subsequent retail display following each ageing period. Instrumental colour and pH readings were also taken at each step with trial carcases selected from a matrix of over and under 5.70 pH at grading for AMC 3 to 5 and below 5.70 for AMC 1C, and 2. Forty eight carcases from northern Australian grass fed bullocks with a dentition range of 0 to 6 teeth, were utilised in the P.PIP.0488 project.

The P.PIP.0488 project retail packed steak portions of every cut in overwrap (OWP), 80:20 high oxygen (MAP) and vacuum skin pack (VSP). The retail packs were subsequently viewed in a commercial upright chilled retail cabinet, as used in the major supermarket chains, and scored for colour appeal and willingness to purchase over a 9 day period by untrained consumers with 10 viewings for each pack on each viewing day.

At the completion of viewing the packs were fabricated into MSA sensory samples 9 days post retail packing and frozen prior to sensory testing. The sensory results indicated that the 12 MQ4 point MAP reduction was consistent across the three muscles and also across each of the primal ageing periods.

While this defined the MAP effect at 9 days of retail display the rate of this developing was not studied and raised the question of whether it increased over time and, if so, at what rate and whether in a linear or other pattern.

There was an additional knowledge gap regarding the impact of alternative MAP gas mixtures and their potential to reduce the eating quality impact. Researchers from the Danish Meat Research Institute (DMRI) had reported that a 40:30:30 “Trigas” mix could be satisfactorily used based on trained panel observation (Tørngren, M., 2003). An AMPC funded study with DMRI had also investigated Trigas using exported Australian product. Unfortunately it had not been possible to incorporate MSA consumer testing in this study which was evaluated by a trained panel (Tørngren and Darré, 2016). The MSA Pathways Committee concluded that Trigas should be compared with 80:20 however raised concerns as to whether 30% oxygen at packing was sufficient to maintain retail appearance given the very low (3%) residual oxygen reported by (DMRI) and other reviews suggesting that a minimum of 55% is needed for stable retail colour.

A further reservation with the original study related to the source cattle which were all grass fed central Queensland bullocks, some to 6 teeth with almost half having a loin pH over 5.70 at grading. Various industry groups queried whether the study findings would be applicable to MSA eligible (pH less than 5.71) carcases from typical southern grass and grain fed carcases.

These were legitimate concerns requiring resolution through further work.

2 Project objectives

The initial contract objectives were listed as below:

1. To quantify the progressive visual and sensory differences between 80:20 MAP and Trigas packaging after 1, 3, 5, 7 and 9 days of retail display.
2. To quantify visual and sensory progression in VSP retail packs at 9, 16, 23 and 30 days of retail display.
3. To evaluate differences in current VSP and a new board format in visual display and sensory outcomes.
4. To compare visual display and sensory outcome of VSP retail packs packed directly into retail VSP at boning versus preparation from vacuum packed primal after 5 days ageing.
5. To report microbiological and flavour volatile outcomes across the packaging and ageing treatments.
6. To provide a reliable knowledge base for industry use in assessing and managing retail packaging systems within alternate supply chains.
7. Delivery of practical guidelines and reliable data for industry use as a base to select and manage alternative retail packaging systems.

After further development of the trial design objectives 2 and 3 were modified to apply identical ageing and associated retail viewing and sensory treatments to the VSP and MAP samples. The board format was also replaced by a further 80:20 Nitogen:Oxygen MAP alternative believed to offer a potential solution to the high oxygen problem identified in the earlier study.

3 Methodology

3.1 Trial design and cut allocation

The trial design was developed to address concerns from the prior project, P.PIP.0488, discussed above. In particular the following factors were elected for testing:

1. Product sourcing from younger southern produced cattle typical of supermarket supply chains.
2. Inclusion of grain fed carcases.

3. All source carcases to be successfully MSA graded with none outside pH, rib fat or meat colour ranges.
4. Control VSP samples to be directly compared to 80% oxygen:20% carbon dioxide high oxygen MAP.
5. Product to be visually rated in a retail display cabinet 1, 3, 5, 7 and 9 days post retail packing.
6. Product to be consumer sensory tested after 1, 3, 5, 7 and 9 days of retail display.

It was agreed that OWP packing did not need to be re-tested due to the previous equivalence of VSP and OWP but prospective alternative gas mixtures advocated by European researchers, including the Danish Meat Research Institute (DMRI), could be tested in conjunction to provide benchmarks. Consequently two further MAP gas mixes were adopted:

7. TriGas a 40% Nitrogen:30% oxygen:30% carbon dioxide mix reported in research literature by DMRI (TRI).
8. An 80% Nitrogen:20% carbon dioxide high nitrogen mix (NIT) reported from trade sources in Europe.

Cut collection for this project was conducted simultaneously with two other projects, P.PIP.0550 and L.EQT.1814, each of which required collection of multiple cuts sourced from a wide quality range. To minimise plant disruption a single large collection was planned to obtain all cuts to be utilised in the three R&D projects, with data from each to be interlinked and consequently more valuable. Consequently the trial design encompassed all required cuts with their subsequent allocation to the component projects.

The combined projects required collection of ribs, briskets, striploins, cube rolls, eye rounds and knuckles from an extreme range of grass and grain fed carcases. The briskets, ribs, eye rounds and knuckles plus the lower quality striploins and cube rolls were also programmed to provide direct USA and Australian consumer linkage across a wide variety of cooking and value adding treatments.

The current packaging project was planned to utilise only striploin and cube roll, to be managed as a single *M.longissimus dorsi* (LD) muscle due to the previous P.PIP.0408 study finding no packaging effect differences between striploin, tenderloin and rump. The LD also suited the experimental requirements in that up to 10 samples could be prepared from a carcase providing within animal comparison of treatments. Carcase side and position within the LD were required to be rotated to balance and allow statistical adjustment for side and position.

A cattle quality range restricted to MSA grading of 3* and above was also designated with a structured grain and grass fed mix further balanced on the basis of MSA predicted MQ4 score bands to reflect three MSA based quality levels. This structure was designed to statistically assess any inter-relationship with either initial raw material MQ4 or feed type.

As many of the background R&D questions from the 3 projects related to interactions between different muscles sourced from carcases of different inherent initial quality a structured extreme range for collection was planned as shown in Table 1.

Table 1. Cattle collection by quality category.

Projected Carcase Quality	FEED	No. Head		
Premium MSA Quality	Grain	9	Striploins and Cube Rolls utilised in packaging project	
	Grass	9		
High MSA Quality	Grain	9		
	Grass	9		
Base 3* MSA Quality	Grain	9		
	Grass	9		
Ungrade MSA Quality	Grain	9		
	Grass	9		
Manufacturing non MSA Quality	Grass	18		
	Total	**90**	Packaging	**54**

To maximise the possible treatments within animal and quality range, cuts from both sides were collected across all 90 bodies. While the design envisaged collecting all product from a single southern Australian plant, the lower two categories, ungraded grass fed and manufacturing, were not found within the initial kill despite grading and selection from over 500 head. Arrangements were made to complete the product collection at a Northern plant 10 days later.

Striploins and cube rolls designated for the packaging project were drawn from the 9 grass and 9 grain fed carcases in the top three quality categories, a total of 54 head. All these were obtained at the southern plant. A summary of principal carcase traits utilised within MSA prediction modelling is shown in Table 2.

Table 2: Mean carcase traits, variance and range for the 54 carcases utilised in the packaging study

Carcass Traits	Mean	Standard Deviation	Range
Hot Carcass weight (kg)	371	61.1	262 – 526
Hump height (mm)	77	12.4	50 – 105
Marbling score	425	156.3	210 – 880
Ossification score	176	22.7	110 – 230
Rib fat (mm)	9	3.9	3 – 22
P8 (mm)	16	6.4	May-30
Meat colour score	2.2	1.1	0-4
Ultimate pH	5.52	0.08	5.39-5.67
Loin temperature (oC)	4.8	0.932	3.0 - 6.1

Table 3 lists the primal cuts collected from both sides of each carcase and the subsidiary muscles available for study. While only striploins and cube rolls were utilised in this packaging study, results can be linked within animal to other cuts which were utilised for different research projects. The spinalis muscle from the 108 (54 x 2 per body) cube rolls used in the packaging study were sensory tested in conjunction with the LD samples as a further direct linkage.

This stage of the project involved the selection of both grass and grain fed carcases after MSA grading, with collection of multiple cuts during boning. A critical success factor was outstanding plant cooperation and detailed communication prior to the collection date to determine working procedures that could achieve the design requirements within commercial operations.

Table 3. Cuts collected from all carcase sides

Primal	HAM no.	MSA Code	Muscle
Short ribs	1691	INT037	M.intercostales externus and internus
		RIB041	M.latissimus dorsi
		RIB078	M.serratus ventralis thoracis
		BRI056	M.pectoralis profundus
NEB	2340	BRI056	M.pectoralis profundus
PEB	2330	BRI057	M.pectoralis superficialis
Cuberoll	2243	CUB045	M.longissimus dorsi et thoracis
Striploin	2142	STR045	M.longissimus dorsi et lumorum
Eye Round	2040	EYE075	M.semitendinosus
Knuckle	2070	KNU066	M.rectus femoris
		KNU098	M.vastus intermedius 2069
		KNU099	M. vastus lateralis 2068
		KNU100	M.vastus medialis

3.1.1 Collection of Primals – Southern Australia 21st to 23rd October 2017

A summary of the plant operations from kill to cut collection is as follows:

1. The cooperating plant adjusted the kill on Friday October 20th to enable a wide supply of cattle quality to meet the design specifications. Analysis of the previous two weeks kill indicated that more very high quality, non-HGP grain fed might be required together with manufacturing grade cattle. Both were actively sourced prior to the kill run. The full requirement from each grade of cattle was sourced, except for 18 head of manufacturing grade cattle and 9 head of grass fed 'MSA ungraded' cattle requiring a subsequent collection of 27 head which was done at a northern plant on October 31st 2017. A Friday kill was agreed together with weekend overtime labour for carcase grading and marshalling to provide sufficient time for assessment and selection without delaying boning operations.

2. To enable full MSA grade data collection from non MSA eligible cattle, ossification was measured on the slaughter floor for all cattle in the kill. MSA eligible bodies were recorded through the terminal as normal however, non-MSA bodies were manually recorded on the morning of Saturday the 21st.

   On Saturday October 21st over 500 carcases anticipated to meet the numbers and range required were graded by company graders between 4am and 8am and transferred to rails in the boning room marshalling area. Carcase numbers, required by grade quality and feed type, were as shown previously in Table 1. In essence there were 10 subsets of 9 carcases with two manufacturing cow and 8 others representing grain and grass fed within the four higher quality categories.

3. The grading data was extracted from the plant system and further compiled by research personnel to enable assignment of carcases to the specified quality bands which differed from the standard plant MSA Plant Boning Run (PBR) specifications. Carcases were then selected to fit the design numbers per category and lists printed to target final carcase selection and MSA assessment by Janine Lau, the senior MSA research grader.

4. Research personnel worked through the marshalled carcases using the list to select the required number in each category. Slapsheets were applied post grading to prevent drying of the eye muscle. A DNA sample was taken from all project carcases.

5. Nix colour measures and HunterLAB measurements were recorded on all selected carcases.

6. After selection, a large pre-prepared and numbered coloured tag was pinned with a 150mm stainless steel skewer to the cube roll on each carcase side to clearly identify those required for cut collection. Early on the morning of Sunday October 22nd plant personnel re-circulated the 500 bodies and railed off the 63 selected for the research programs into three runs: MSA Grainfed, MSA Grassfed and Non MSA Grassfed using the cube roll tag to identify required bodies and a printed list to assign to the boning runs.

7. Additional tagging was then completed with 7 additional labels applied to each side: PE Brisket, NE Brisket, Chuck Rib, Short Rib, Cube Roll, Striploin, Eye Round and Knuckle. The eye round and knuckle tickets were pinned into the Topside face for transfer in the boning room after the loin/butt saw. The NE brisket, PE Brisket and striploin tickets were pinned in the relevant muscle at designated muscle positions to suit cutting lines. The chuck and short rib tickets were applied during boning on Monday October 23rd after removal of the 6 rib section early in the boning process. Both labels were pinned on a single pin to the bone-in 6 rib section immediately after they were removed from the carcase, with ID confirmed by reference to the carcase CUD number on the cube roll ticket. The short ribs and chuck ribs were left as a single piece to reduce complexity, with both tickets placed in the bag for subsequent allocation during sample fabrication.

8. The tickets were in 5 colours with colour designating their destination and refrigeration regime. The coding was:

   PINK – Freeze and ship to TTU

   YELLOW – Freeze and hold in Australia

   GREEN – Maintain chilled and hold for retail packaging

   BLUE – Maintain chilled and ship to TTU

   RED – Maintain chilled and hold in Australia

Different cuts within each side had different coloured tickets other than the striploins and cube rolls designated for the packaging project as shown in Figure 1.

Label Colours
Freeze TTU
Freeze Aust
Chilled TAFS
Chilled TTU
Chilled Aust

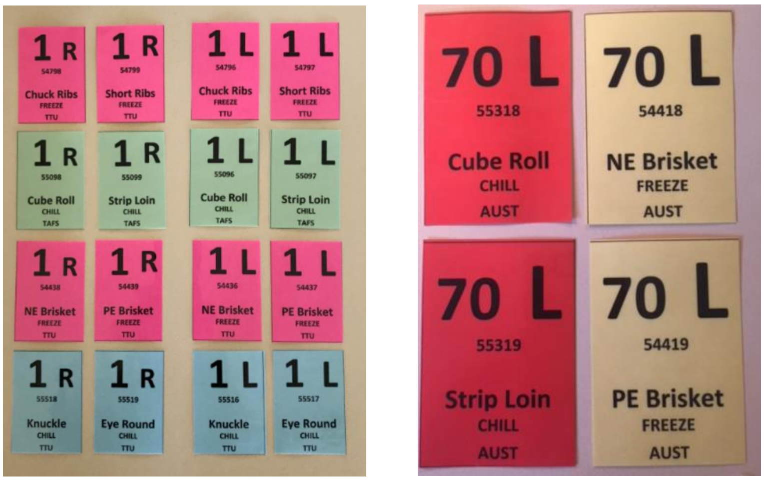

Figure 1. Example of tickets for right and left sides

9. Objective measurements were taken on Sunday 22nd October as follows: Aaron Van Den Heuvel, Xuemei Han and Katie Austin (UNE) took images with an Meat Imaging Japan (MIJ) camera and a Frontmatic hyperspectral camera. Nick van den Berg and Jordon Kitschke took measurements using an experimental Meat Eating Qualtiy (MEQ) Probe device. The MIJ and frontmatic cameras imaged the cut grading surface only. The MEQ probe probed the loin, eye round and knuckle cuts.

10. Due to the boning room layout and complexity of the collection 42 people were required to assist with cut collection on Monday October 23rd. The plant provided 12 experienced staff with the balance from MLA (3), TTU (2), UNE (5), CSU (14) and PPL (6). A safety and hygiene practices briefing was conducted for non-plant personnel. A detailed task list was produced in conjunction with boning room management to define where each person was to be located and their specific task.

11. Actual boning room activity commenced at 6:00 am with the research collection to begin at 7:30. This provided time for all research team members to be shown their allocated position and to observe the routine in that area. Each was instructed on the particular research project duties at that position (applying rib tags, checking tag and pin security at key line transition points, observing transfer of tags and pins during boning and slicing, removing pins and placing labels in the vacuum bags with matching cuts, confirming all cuts in a carton have common coloured tags etc). This occurred prior to 7:30 when the research collection commenced. It was completed within an hour.

12. Staff positioned at each cut bagging station retrieved the metal skewers and placed the laminated tags on the cut within the bag. The skewers were counted after the collection to ensure none remained on plant.

3.1.2 Product codes and transport

Trial specific product codes were assigned by the plant including designation and refrigeration statements in addition to cut description. This controlled carton sorting and subsequent load out to TTU, other Australian sites and for the cuts retained for the packaging study. As it was likely that there would be partial cartons it was important to ensure in advance that the system would allow these to be packed off.

After collection was completed, piece and carton counts were confirmed together with weights. A critical check was that all cuts in any carton had the same label colour and that the piece counts were correct.

All the packaging project cuts were confirmed and moved to chilled on plant storage for ageing prior to retail fabrication.

3.2 Retail Packaging Experimental Design

The experimental design required the 4 packaging formats to be directly compared across balanced muscle positions. This balance was important due to previous MSA research, which established positional differences along the LD muscle with eating quality reducing from the anterior cube roll portion to the posterior section of the striploin. Due to carcase ribbing at the 10/11 rib the length of the cube roll (CUB045) and striploin (STR045) was similar and 3 positions, anterior (A), centre (C) and posterior (P) were designated within each.

This provided for up to 6 LD derived samples to be prepared from each carcase side, a total of 12 per body. In practice the extreme posterior of the LD is often flat and not ideal for steak preparation. To reduce positional variation this “P” position was allocated to Link (non-core test samples served first in the consumer testing) leaving 5 positions (CUB045 A, C, P and STR A and C) per side available for the packaging treatments.

A single centre position was nominated for the spinalis (CUB081) muscle which was removed and sensory tested in conjunction with the LD portions. The packaging comparisons were only made within the LD, the CUB081 being prepared and packed under standard MSA grill protocols and included in sensory evaluation to provide a high end quality anchor.

In addition, 5 ageing variations of 1, 3, 5, 7 and 9 days in the retail pack were required within each of the packaging treatments. With the addition of 16 days primal ageing in vacuum this resulted in total sample ageing of 17, 19, 21, 23 and 25 days and a total of 20 treatment variations (4 packaging treatments by 5 ageing periods). By utilising 5 positions within each side, ageing the five pack ageing periods of 1, 3, 5, 7 and 9 days were applied to all sides and enable 5 of the possible 10 ageing comparisons within each carcase.

To reduce position by ageing interactions it was elected to pair ageing treatments within packaging type across the two carcase sides so that, the left and right side CUB045 A positions for Body 1 were both MAP packed with the left aged 19 days and the right 17 (example as shown in Table 4). This arrangement enabled one ageing comparison within each packaging type (8 samples) to be compared in every carcase plus an additional pair from one packaging treatment and two link samples from the STR045 P positions to utilise the 12 available LD positions within each carcase.

Table 4 represents a portion of the Cut Up Developer (CUD) file, produced by MSA software, which was utilised in trial design. It can be seen that the CUB081 samples were designated as GRL, the standard MSA format, and the STR045 P positions all allocated to "LNK". The paired packaging treatment by ageing blocks were rotated along the designated 5 LD positions as illustrated by the 2 (of 9) bodies displayed in 3 (of 6) quality categories.

Table 4. Allocation of packaging and ageing treatments by muscle position.

Group	Body	Cut	Tment	Daged	Pos	Side	Group	Body	Cut	Tment	Daged	Pos	Side	Group	Body	Cut	Tment	Daged	Pos	Side
504.1	8	CUB081	GRL	17	C	L	504.3	26	CUB081	GRL	17	C	L	504.5	44	CUB081	GRL	17	C	L
504.1	8	CUB081	GRL	17	C	R	504.3	26	CUB081	GRL	17	C	R	504.5	44	CUB081	GRL	17	C	R
504.1	9	CUB081	GRL	17	C	L	504.3	27	CUB081	GRL	17	C	L	504.5	45	CUB081	GRL	17	C	L
504.1	9	CUB081	GRL	17	C	R	504.3	27	CUB081	GRL	17	C	R	504.5	45	CUB081	GRL	17	C	R
504.1	1	CUB045	MAP	19	A	L	504.3	19	CUB045	TRI	17	A	L	504.5	37	CUB045	VSP	25	A	L
504.1	1	CUB045	VSP	21	C	L	504.3	19	CUB045	NIT	21	C	L	504.5	37	CUB045	NIT	19	C	L
504.1	1	CUB045	TRI	17	P	L	504.3	19	CUB045	VSP	25	P	L	504.5	37	CUB045	MAP	21	P	L
504.1	1	CUB045	MAP	17	A	R	504.3	19	CUB045	TRI	23	A	R	504.5	37	CUB045	VSP	21	A	R
504.1	1	CUB045	VSP	23	C	R	504.3	19	CUB045	NIT	17	C	R	504.5	37	CUB045	NIT	17	C	R
504.1	1	CUB045	TRI	25	P	R	504.3	19	CUB045	VSP	19	P	R	504.5	37	CUB045	MAP	23	P	R
504.1	2	CUB045	VSP	21	A	L	504.3	20	CUB045	MAP	19	A	L	504.5	38	CUB045	TRI	17	A	L
504.1	2	CUB045	VSP	25	C	L	504.3	20	CUB045	MAP	21	C	L	504.5	38	CUB045	NIT	21	C	L
504.1	2	CUB045	MAP	23	P	L	504.3	20	CUB045	TRI	17	P	L	504.5	38	CUB045	VSP	25	P	L
504.1	2	CUB045	VSP	17	A	R	504.3	20	CUB045	MAP	17	A	R	504.5	38	CUB045	TRI	23	A	R
504.1	2	CUB045	VSP	19	C	R	504.3	20	CUB045	MAP	23	C	R	504.5	38	CUB045	NIT	17	C	R
504.1	1	STR045	VSP	23	A	L	504.3	19	STR045	NIT	23	A	L	504.5	37	STR045	NIT	17	A	L
504.1	1	STR045	NIT	25	C	L	504.3	19	STR045	MAP	19	C	L	504.5	37	STR045	TRI	23	C	L
504.1	1	STR045	LNK	17	P	L	504.3	19	STR045	LNK	17	P	L	504.5	37	STR045	LNK	17	P	L
504.1	1	STR045	VSP	19	A	R	504.3	19	STR045	NIT	25	A	R	504.5	37	STR045	NIT	25	A	R
504.1	1	STR045	NIT	21	C	R	504.3	19	STR045	MAP	21	C	R	504.5	37	STR045	TRI	19	C	R
504.1	1	STR045	LNK	17	P	R	504.3	19	STR045	LNK	17	P	R	504.5	37	STR045	LNK	17	P	R
504.1	2	STR045	TRI	19	A	L	504.3	20	STR045	VSP	23	A	L	504.5	38	STR045	MAP	23	A	L
504.1	2	STR045	NIT	17	C	L	504.3	20	STR045	NIT	25	C	L	504.5	38	STR045	MAP	19	C	L
504.1	2	STR045	LNK	17	P	L	504.3	20	STR045	LNK	17	P	L	504.5	38	STR045	LNK	17	P	L
504.1	2	STR045	TRI	21	A	R	504.3	20	STR045	VSP	19	A	R	504.5	38	STR045	MAP	25	A	R
504.1	2	STR045	NIT	23	C	R	504.3	20	STR045	NIT	21	C	R	504.5	38	STR045	MAP	21	C	R
504.1	2	STR045	LNK	17	P	R	504.3	20	STR045	LNK	17	P	R	504.5	38	STR045	LNK	17	P	R

The format of 2 ageing comparisons from each of the 4 pack types per body was firstly assigned across a 5 body layout, as displayed in Table 5. As shown in Table 5, this resulted in a fully balanced muscle position x packaging type by side allocation with a further unallocated pair available.

Table 5. Rotation of ageing by treatment pairs across carcases

		AGEING		
Body	POS	L	R	PACK
1	CA	3	1	MAP
	CC	5	7	
	CP	1	9	TRI
	SA	7	3	VSP
	SC	9	5	NIT
	SP	LINK	LINK	
2	CA	5	1	VSP
	CC	9	3	
	CP	7	9	MAP
	SA	3	5	TRI
	SC	1	7	NIT
	SP	LINK	LINK	
Days aged counts				
	1	2	2	
	3	2	2	
	5	2	2	
	7	2	2	
	9	2	2	

		AGEING		
Body	POS	L	R	PACK
3	CA	5	7	TRI
	CC	1	9	VSP
	CP	7	3	NIT
	SA	9	5	MAP
	SC	3	1	
	SP	LINK	LINK	
4	CA	9	3	MAP
	CC	7	9	TRI
	CP	3	5	NIT
	SA	1	7	VSP
	SC	5	1	
	SP	LINK	LINK	
Days aged counts				
	1	2	2	
	3	2	2	
	5	2	2	
	7	2	2	
	9	2	2	

		AGEING		
Body	POS	L	R	PACK
5	CA	1	9	NIT
	CC	7	3	MAP
	CP	9	5	
	SA	3	1	TRI
	SC	5	7	VSP
	SP	LINK	LINK	
6	CA	7	9	NIT
	CC	3	5	VSP
	CP	1	7	
	SA	5	1	MAP
	SC	9	3	TRI
	SP	LINK	LINK	
Days aged counts				
	1	2	2	
	3	2	2	
	5	2	2	
	7	2	2	
	9	2	2	

		AGEING		
Body	POS	L	R	PACK
7	CA	7	3	
	CC	9	5	TRI
	CP	3	1	VSP
	SA	5	7	NIT
	SC	1	9	MAP
	SP	LINK	LINK	
8	CA	3	5	
	CC	1	7	MAP
	CP	5	1	TRI
	SA	9	3	NIT
	SC	7	9	VSP
	SP	LINK	LINK	
Days aged counts				
	1	2	2	
	3	2	2	
	5	2	2	
	7	2	2	
	9	2	2	

		AGEING		
Body	POS	L	R	PACK
9	CA	9	5	VSP
	CC	3	1	NIT
	CP	5	7	MAP
	SA	1	9	
	SC	7	3	TRI
	SP	LINK	LINK	
10	CA	1	7	TRI
	CC	5	1	NIT
	CP	9	3	VSP
	SA	7	9	
	SC	3	5	MAP
	SP	LINK	LINK	
Days aged counts				
	1	2	2	
	3	2	2	
	5	2	2	
	7	2	2	
	9	2	2	

The unallocated positions in Table 5, represented in Table 4 by dark red cell borders, were then filled by rotating the packaging treatments with ageing pairs as against the empty cells in Table 5. This resulted in each ageing comparison being represented once across each pair of bodies as read vertically. When repeated on a second body, the lower half of table 5, each packaging treatment was repeated twice and each ageing comparison (1:3, 1:5, 1:7, 1:9, 2:3, 2:5, 2:7, 2:9, 3:5, 3:7, 3:9, 5:7, 5:9, 7:9) included once in each position as read to the right.

When extended this produced 540 retail tray samples (10 samples x 54 bodies of 3 quality categories) subdivided into 108 trays for each days ageing, 27 per packaging treatment.

This design was consequently implemented utilising the MSA CUD software and supplementary processes.

3.2.1 Fabrication and Retail Packing – 5th November 2017

Fabrication of the vacuum packed striploins and cube rolls was conducted on Sunday November 5th, 2017 in a commercial large scale retail fabrication facility that produced retail product in VSP and MAP formats for major supermarket groups. The cuts had been aged 16 days in vacuum packaging at this point.

The facility operates on a two shift-6 day per week production schedule and was made available on a Sunday to enable the research activity to be conducted without disrupting normal operations or compromising research requirements. The plant also provided staff to assist in processing the cuts and operating the packaging equipment in addition to supplying packaging consumables including gas mixes.

The outstanding cooperation and valuable technical input from the plant management and staff is acknowledged and greatly appreciated.

The process adopted was as follows:

1. Each primal was removed from vacuum packaging at a common processing room entry point and placed on a plastic tray together with the cut identification label put in the bag during cut collection at boning.

2. A pH reading was recorded for each cut with the measurement taken at the quartering point end to align with the grading site and provide an ultimate pH for comparison.

3. The tray was passed to one of several preparation stations manned by company butchers who were instructed in MSA preparation protocols. Each striploin was denuded removing all fat and silverskin and reduced to the LD muscle by removing the multifidi and portion of rump from the posterior end.

4. The cube roll was denuded and the spinalis muscle removed after which further connective tissue and surface fat were trimmed to leave the LD and Spinalis (*M.spinalis doris*) as separated and denuded muscles.

5. The denuded muscles and associated identification labels were retained on individual trays, as shown in Fig 2. They were then transferred to another butcher who cut 25mm slices across the grain from head to tail, following MSA protocols utilising a cutting jig to control thickness. The slices were placed back on the tray maintaining order to control position allocation for packaging.

Figure 2: Denuded LD from cube roll with associated ID

6. Packaging was controlled in a designated packaging preparation area. A second set of plastic serving trays was used to prepare the retail pack trays for the 4 packaging types (MAP, TRI, NIT and VSP) for each primal with the matching sample ID labels and packing instructions.

7. A control file derived from MSA CUD software specified a position within each muscle for the 4 packaging types. The design also rotated the packaging types through cut positions to ensure balance, as discussed previously. Packaging trays used were standard retail 170 x 220mm pre-formed clear plastic (MAP) trays with soaker pad for the MAP, TRI and NIT and 190 x 230mm clear VSP trays which were formed within the packaging equipment.

8. Pre-prepared laminated labels for each primal number and the associated unique 4 digit alphanumeric codes (the EQSRef) were placed in envelopes and held in primal number order in ring binders together with printed extracts from the CUD CutUp file for each primal which designated the treatment and cut position allocation for each EQSRef. Laminated A4 colour-

coded packing indicators displaying MAP, TRI, NIT and VSP were also prepared as shown in Fig 3.

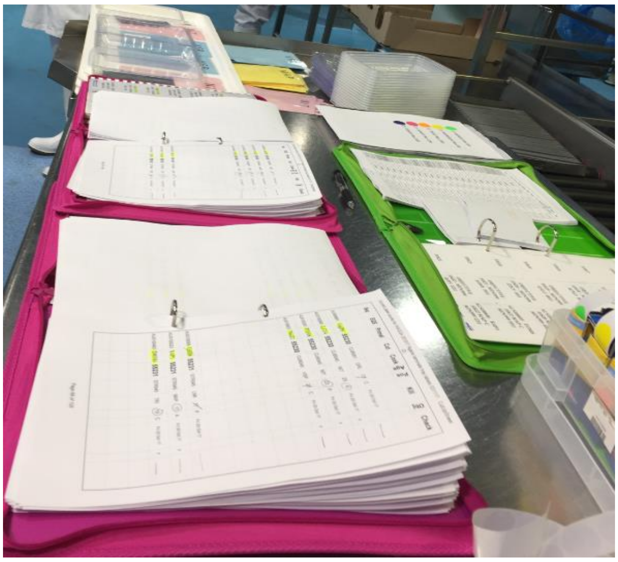

Figure 3: Pre-packed envelopes with laminated labels as per CUD

9. As a tray with the sliced primal was moved to the packaging area the Primal number was located, the duplicate primal label transferred from the envelope to a new plastic tray and the treatment for each cut position referenced from the CutUp extract. The A4 laminated pack type designators were then placed in the allocated position order on the plastic tray and the appropriate empty packaging trays placed over them with soaker pads (temporary blank trays were used to hold the VSP allocated slices prior to their transfer to the packaging machine).

10. The laminated EQSRef ID labels were then taken from the envelope labelled with corresponding primal number and placed in the allocated empty retail trays, this again being referenced from the CutUp extract. A coloured dot to indicate the correct ageing period prior to visual and sensory testing (1,3,5,7, or 9 days) was placed on the side of the retail tray. An additional laminated label was placed on a VSP base for Links or CUB081 and a sticky label for micro applied to sample tubes.

11. The packaging tray was then transferred to the cutting station and aligned with the sliced primal and the ID cross-checked. Five slices from the primal were then placed in the retail trays with the slice order aligned with the tray positions to maintain the allocated cut position. The slices were placed to achieve a typical retail pack appearance and the laminated EQSRef label placed in a designated corner of the pack as shown in Fig 4. The LINK product and spinalis (CUB081) were packed on VSP and sent directly to the VSP packing line for packing.

Figure 4: Placement into retail packs showing 4 treatment types

12. The tray with the filled retail packs was then transferred to a colour recording station and all samples bloomed for 20 minutes. A MSA independent grader was utilised to view each retail tray and assign an AUS-MEAT meat colour score. Recordings for each tray were also made with HunterLab and NIX instruments as shown in Fig 5.

Figure 5: Recording colour, HunterLab and NIX readings

13. Immediately following the colour analysis, HunterLab and NIX readings the trays were taken to the relevant retail packing line where they were processed according to standard practice. A dedicated Multivac™ line was utilised for each packaging treatment with gas analysis taken at hourly intervals.

Packaging material specifications may be seen in Appendix 10.1

14. The coloured dot on the side of the retail packing trays denoted the ageing period allowing collating at the end of the packing line. MAP, NIT, TRI and VSP packs were mixed in each of the 5 ageing groups. Packed samples were then transferred to chilled storage in their ageing groups of 1, 3, 5, 7 and 9 days at which time they were transferred in refrigerated transport to the retail viewing cabinet at Charles Sturt University.

3.3 Retail cabinet display at Charles Sturt University (CSU)

A commercial chilled retail display cabinet was utilised at Charles Sturt University for evaluation. The cabinet utilised a three deck display and well and was of a type widely used by Australian retailers. The number of packs able to be displayed was constrained by the shelf dimensions with 144 packs the maximum. As there were a total of 540 packs, 108 per display day allocation, it was not possible to have all packs on display at all times. To enable a consistent full cabinet for evaluation the design shown in Table 6 was adopted.

This dictated that the 108 packs designated for a particular day were interspersed with a constant 36, 9 per packaging type, from the 9 day samples. On day 9 only 108, the entire 9 day cohort were displayed.

Table 6: Number of steak packs displayed by treatment and days post retail packing

	DAYS IN RETAIL PACKAGING					
TREATMENT	**1**	**3**	**5**	**7**	**9**	**Total**
MAP-1	27					**27**
MAP-3		27				**27**
MAP-5			27			**27**
MAP-7				27		**27**
MAP-9	9	9	9	9	27	**27***
TRI-1	27					**27**
TRI-3		27				**27**
TRI-5			27			**27**
TRI-7				27		**27**
TRI-9	9	9	9	9	27	**27***
NIT-1	27					**27**
NIT-3		27				**27**
NIT-5			27			**27**
NIT-7				27		**27**
NIT-9	9	9	9	9	27	**27***
VSP-1	27					**27**
VSP-3		27				**27**
VSP-5			27			**27**
VSP-7				27		**27**
VSP-9	9	9	9	9	27	**27***
TOTAL	**144**	**144**	**144**	**144**	**108**	**540***
Consumers	90	90	90	90	68	**428**

* Adjusted to actual total packs

To balance out potential case position and adjacent packaging type effects each packaging treatment was allocated within an 8 x 8 Latin square design with two of each packaging type, one grass fed and one grain fed, within each “set” of 8 and the relative order of each type rotated according to rows within the Latin square. The three quality levels of product within grass and grain were also evenly distributed across the Latin Square rows and order. A final “set” of 4 packs, one per treatment, was created to allocate all samples and enable a full cabinet display on days 1 to 7. The Latin square rows or “sets” were further rotated within shelf (Top to well) and shelf position (front, back, right and left and centre for the well only).

An example of a “set”, representing one of 8 Latin Square rows used to determine pack order on the cabinet shelf is displayed in Table 7.

Table 7: Example of allocation pack quality, display order and cabinet position for an example set

GROUP	CUD No	BODY No	Primal	EQS	Set No	Order	Cab Pos	Description	Cut	Cook	Age
Premium GRAIN	9	824	55128	P1N6	18	1	3D	BLUE. THIRD shelf. FRONT row. RIGHT side.	CUB045	VSP	25
Classic GRAIN	19	559	55171	R9Q9	18	2	3D	BLUE. THIRD shelf. FRONT row. RIGHT side.	STR045	NIT	25
Premium grass	18	149	55167	A5X0	18	3	3D	BLUE. THIRD shelf. FRONT row. RIGHT side.	STR045	VSP	25
Premium GRAIN	9	824	55131	R9F6	18	4	3D	BLUE. THIRD shelf. FRONT row. RIGHT side.	STR045	TRI	25
Classic grass	30	208	55214	R3Z0	18	5	3D	BLUE. THIRD shelf. FRONT row. RIGHT side.	CUB045	MAP	25
Classic GRAIN	19	559	55168	F8P8	18	6	3D	BLUE. THIRD shelf. FRONT row. RIGHT side.	CUB045	VSP	25
Premium grass	18	149	55164	W2J9	18	7	3D	BLUE. THIRD shelf. FRONT row. RIGHT side.	CUB045	VSP	25
Classic grass	30	208	55212	R6Z2	18	8	3D	BLUE. THIRD shelf. FRONT row. RIGHT side.	CUB045	MAP	25

The GROUP indicates the product eating quality category and whether from grass or grain fed carcases linked to a CUD design number, plant body number and Primal ID from which the sample was fabricated. The source cut, cooking method and days aged from slaughter (with the first 16 days as a vacuum packed primal) to the date of display are shown to the right. The unique pack ID for each pack is the EQSRef with the order of display and cabinet position 3D assigning the 8 packs to the front of the third cabinet shelf, right hand side in the designated 1 to 8 order (See figure 6 for shelf designation coding).

The description “BLUE, THIRD shelf, FRONT row, RIGHT side” and the EQSRef was reproduced utilising an R software routine on the 10 related consumer scoring forms to guide the consumers to the 8 trays for assessment with “BLUE” indicating a blue label attached to the starting shelf position (See cabinet in Fig 7).

The 36 packs allocated to display across the entire period were maintained in a fixed cabinet position as a reference point across each display period. All packs not on display were held in a CSU chiller at approximately 3˚C.

Individual case layouts were produced for each viewing day (1, 3, 5, 7 and 9 days from packing) with the 108 of the applicable day packs and 33% (36 packs) of the 9 day treatment displayed for consumer evaluation. A typical cabinet plan allocating each EQSRef to a specific position within its’ set and shelf position is shown in Fig 6 with the constant 9 day samples shaded blue.

CABINET LAYOUT FOR CSU COLOUR TRIAL - DAY 1 - MONDAY Nov 6th, 2017

	TOP SHELF																
	F9D9	M4T2	F1H4	Z8K9	W6X0	H9K2	M6V9	Y7S3	L4Q8	W8A8	Y5B2	C8V2	Y6W1	Y0R9	N0J3	X6V0	
1A	Set 10	Set 10	Set 10	Set 10	Set 10	Set 10	Set 10	Set 10	Set 3	Set 3	Set 3	Set 3	Set 3	Set 3	Set 3	Set 3	1C
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	
	S0F8	S2A1	N5Z8	Q3S8	N0D7	C4A3	S6G0	Z5H9	M8Q8	Z1U2	X3B3	S3T2	F9Y7	E6D1	Z6K4	N7B4	
1B	Set 15	Set 15	Set 15	Set 15	Set 15	Set 15	Set 15	Set 15	Set 8	Set 8	Set 8	Set 8	Set 8	Set 8	Set 8	Set 8	1D
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	
	WHITE with BLUE dots								GREEN								
	SECOND SHELF																
	F5D2	W4T2	P1S7	G9L2	R7D5	B6K6	J0X5	S9A8	N7J8	Z3Z3	F4Z6	P2X8	D1V8	W5B7	M3F6	P8B3	
2A	Set 1	Set 1	Set 1	Set 1	Set 1	Set 1	Set 1	Set 1	Set 17	Set 17	Set 17	Set 17	Set 17	Set 17	Set 17	Set 17	2C
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	
	L0T0	D1F5	Q0F3	R4F1	F3E6	S9J1	H9D3	Z3Z6	D1S1	Q9N1	N3J5	V5N2	T2P1	E0R5	T3V0	G5V6	
2B	Set 6	Set 6	Set 6	Set 6	Set 6	Set 6	Set 6	Set 6	Set 12	Set 12	Set 12	Set 12	Set 12	Set 12	Set 12	Set 12	2D
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	
	RED								WHITE								
	THIRD SHELF																
	A5A2	C9W6	M2P3	A5T2	Y5V1	M6M7	L1C6	D2G3	E1T6	J2P2	U5P6	S9G6	T9G9	Y2A7	U3D1	Q0Q7	
3A	Set 14	Set 14	Set 14	Set 14	Set 14	Set 14	Set 14	Set 14	Set 9	Set 9	Set 9	Set 9	Set 9	Set 9	Set 9	Set 9	3C
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	
	M7M6	J0R5	M9S6	D0F0	T9R7	R5E5	V1B0	C5G0	P1N6	R9Q9	A5X0	R9F6	R3Z0	F8P8	W2J9	R6Z2	
3B	Set 7	Set 7	Set 7	Set 7	Set 7	Set 7	Set 7	Set 7	Set 18	Set 18	Set 18	Set 18	Set 18	Set 18	Set 18	Set 18	3D
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	
	GREEN with ORANGE dots								BLUE								
	BOTTOM SHELF																
	V6C2	P0T6	F9N8	R5G7	F9J9	Y0B0	S6Y4	L8W3	E6P0	C9B3	R9D2	Q8N7	C7K9	K5Y7	D0D5	R9T5	
4A	Set 11	11	11	11	11	11	11	11	Set 4	Set 4	Set 4	Set 4	Set 4	Set 4	Set 4	Set 4	4D
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	
	V3F5	D6S7	E7Y8	L5T4	L2C3	E8P6	E0B6	R1R9	A0G3	F4U5	P2M7	Y6D1	V7Y7	C8S9	U3Q8	W6S2	
4B	Set 16	Set 16	Set 16	Set 16	Set 16	Set 16	Set 16	Set 16	Set 13	Set 13	Set 13	Set 13	Set 13	Set 13	Set 13	Set 13	4E
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	
	W9R4	M7U1	U9T2	R7X5	Q4H9	X2U9	Z6D3	D0U4	W1F7	T2D5	R7A0	G6Q6	S7A2	Y4P1	U0D4	F7C1	
4C	Set 2	Set 2	Set 2	Set 2	Set 2	Set 2	Set 2	Set 2	Set 5	Set 5	Set 5	Set 5	Set 5	Set 5	Set 5	Set 5	4F
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	
	YELLOW								WHITE with PINK dots								

MINCE CABINET

	TOP SHELF					
	V0E0	E5U2	S4J2	V3H1	G4M0	
1A	Set 20	Set 20	Set 20	Set 20	Set 19	5E
	1	2	3	4	1	
	A9A7	U0R8	C4E1	N8F1	T0J8	
1B	Set 22	Set 22	Set 22	Set 22	Set 19	5E
	1	2	3	4	2	
	RED				WHITE Label	
	SECOND SHELF					
	K4P3	X2A3	R4B0	N2J8	G4M7	
2A	Set 22	Set 22	Set 22	Set 22	Set 19	5E
	5	6	7	8	3	
	W2T3	K1G0	P7J8	Z7A2	P7S6	
2B	Set 23	Set 23	Set 23	Set 23	Set 19	5E
	1	2	3	4	4	
	BLUE				WHITE Label	
	THIRD SHELF					
	V0R4	R9F7	D3M8	Q9H9	D9R6	
3A	Set 21	Set 21	Set 21	Set 21	Set 19	5E
	1	2	3	4	5	
	W2V3	S3Y0	D9W4	T1U9	V0C4	
3B	Set 23	Set 23	Set 23	Set 23	Set 19	5E
	5	6	7	8	6	
	GREEN				WHITE Label	
	BOTTOM SHELF					
	K5W2	K3E9	T1L1	M7G3		
4A	Set 20	Set 20	Set 20	Set 20		5E
	5	6	7	8		
	R2P9	Z2C9	N8U9	N7P8	B4V4	
4B	Set 21	Set 21	Set 21	Set 21	Set 19	5E
	5	6	7	8	7	
	X0J4	J0E4	A6A9	L8H8	J5H0	
4C	24	24	24	24	Set 19	5E
	1	2	3	4	8	
	YELLOW				WHITE Label	

Figure 6: Cabinet Plan for Day 1 retail viewing display

After viewing, the 108 packs for that day were removed for colour measurement and converting to consumer sensory samples then frozen with the 9 day packs remaining in the cabinet.

Each consumer visually evaluated 3 sets of 8 packs. Ten consumers evaluated each pack utilising the same scoring system as used in the original packaging study. The cabinet and associated layout is shown in Fig7.

Figure 7: Retail display cabinet. Note mix of packaging treatments and coloured locator flags

3.4 Consumer assessment of visual pack appeal

In accordance with the experimental design each pack was viewed for visual assessment by 10 consumers with each consumer required to assess 24 packs being 3 sets of 8 from the 144 steak packs on display. This required up to 81 consumers to view the cabinet for each viewing day/ageing cycle, a total of 356 for the entire experiment resulting in 8,544 pack observations.

Consumer recruitment was conducted by Charles Sturt University primarily via fundraising with community groups supported by the individual panellists. Where no affiliation was noted a movie pass was offered to the individual. Viewing times were scheduled across the day in 15 minute blocks between 8am and 8pm.

On arrival each consumer was briefed in regard to the scoring procedure and given a clipboard with one sheet of demographic questions as shown in the appendix followed by 2 pages, each relating to an assigned set of 8 retail packs identified by EQSRef number and display order within the relevant set of 8. Each set was preceded by an instruction defining the cabinet position such as "Blue Label, top shelf, back row" to assist in accurate location of the first sample.

The demographic and visual CMC scoring sheet is presented in Appendix 10.2.

Each sample was scored via a 100mm line scale anchored by the words extremely unappealing and extremely appealing. For each sample the consumer was also asked to choose one of three category boxes described as definitely would buy, definitely would buy if discounted and definitely would not buy. An example scoring sheet is shown in the appendix. The sample order on each sheet reflected the pack order in the case from left to right with the EQSRef pre-printed in the ID box.

The consumer was accompanied to the cabinet and assisted in locating the first starting position to ensure the instruction was understood. Figure 7 displays the cabinet and typical layout.

All consumer scores were measured twice and the data entered independently by two separate teams at different locations. Any result where the two scores differed by more than 2 (mm) was resolved by re-checking the original sheet. A zero tolerance was applied to the 3 category boxes.

The consumer response files combined with source files detailing linkage of the EQSRefs to the packaging system, source muscle and carcase including MSA grading data and to the days aged in vacuum packaging prior to retail packing were forwarded to Dr Ray Watson and Dr Garth Tarr accompanied by an analysis brief. All original questionnaires were filed and retained for reference.

On completion of each viewing session (days 1,3,5,7 and 9) CSU processed all samples for the final colour measurement and fabrication to MSA sensory samples.

3.5 Preparation of MSA consumer samples and data recording post retail display.

On the completion of viewing for each ageing group, CSU and MSA research staff removed the sample trays from the display cabinet and transferred to an adjacent work area where they were progressively opened and allowed to bloom for a minimum of 20 minutes. At this point a colour assessment using AUS-MEAT meat colour chips was completed by the same MSA grader who assessed colour at cut up. A HunterLab reading was also recorded for each tray.

The retail display samples were then fabricated into MSA grill sensory steaks following MSA protocol (Watson et al., 2008). In brief this required fabrication of 5 steaks 25mm thick and approximately 50 x 38mm or equivalent area with each wrapped in freezer wrap prior to vacuum packing as a set of 5 and freezing down on the day of removal from the retail display cabinet. Each set of consumer sensory steaks were identified by attaching an Avery label incorporating the EQSRef (produced from the source CUD file) to the vacuum bag during transfer from the retail tray and fabrication. This label replaced the laminated EQSRef label placed in each retail pack on November 5th in preparation for retail observation.

3.6 MSA consumer testing

MSA sensory testing by untrained consumers was conducted on all 540 retail pack grill samples to evaluate differences between the 4 packaging treatments and 5 ageing periods which were rotated and balanced across ten *M.longissimus dorsi* (cube roll and striploin) positions. The product was tested within 19 groups of 60 Melbourne consumers (each group of 60 comprising a pick) with linkage to other trials through some picks having product from two or more experiments included. All consumer testing was conducted in the greater Melbourne area by Tastepoint Pty Ltd.

3.6.1 Pick design

The individual "picks" each allocated 42 samples across 60 consumers, tested in three groups of 20 per session. All consumers received a "link" sample as the first of 7 samples with this product sourced from the collected striploins posterior position and predicted to be of mid range eating quality. The allocation of samples followed MSA protocols (Watson *et al.*, 2008b) which in brief allocate six test samples, each from a separate product, according to a 6x6 Latin square that ensures each product is served an equal number of times in each serving order and equally before and after the other 5 products to balance potential halo or serving order effects. The samples were allocated to product groupings by packaging treatment and ageing days to ensure each consumer received a wide quality range. Many picks utilised the *M.spinalis dorsi* removed from the trial cube rolls as a high end anchor with further linkage to other MSA data through inclusion of selected product from other projects in further picks.

3.6.2 Consumer recruitment

Consumer recruitment for sensory testing of cooked product was managed by Tastepoint who utilised community groups for recruitment with the community organisation/group paid for participation rather than individual consumers.

Consumers were screened and selected on the following criteria:

- Aged between 18 and 70
- Regular consumers of red meat, at least once per fortnight
- Prefer beef cooked to medium doneness

3.6.3 Cooking, serving and data protocols

MSA grill cooking and serving protocols were utilised for all sensory testing as described by Watson *et.al*, 2008a. In brief a 3 phase Silex (STronic 165) double sided grill was utilised with all cooking procedures regulated by count up timers. A first round of scrap meat was cooked to stabilise plate temperature recovery with the link and six sample rounds following at designated intervals. The round sheets were aligned beside the grill and steaks transferred onto the grill and after cooking to a cutting board for serving in a strict 3-4-3 left to right, top to bottom sequence to ensure ID was maintained.

10 steaks, approximately 50mm x 38mm by 25mm thick were cooked within each of the seven rounds, rested for 2 minutes after removal from the grill then halved with each served to 2 consumers. The ID on the consumer plates was further checked against the empty round sheet codes during cutting and serving. Allocation of steaks to rounds and to consumer ID was controlled by software in accordance with the design criteria described previously.

After an initial briefing each consumer completed a number of demographic questions followed by an individual scoring sheet for each of the 7 samples. Each sample was identified only by the 4 digit alphanumeric EQSref code and related Q code. The sample score sheets included four 100mm line scales for each of tenderness, juiciness, flavour and overall liking followed by four category boxes labelled as unsatisfactory, good everyday quality, better than everyday quality and premium quality.

The tenderness scale was anchored with the words not tender and very tender, the juiciness scale with not juicy and very juicy and the flavour and overall liking scales with dislike extremely and like extremely. Consumers were instructed to make a vertical line across each scale at a point that reflected their judgement for each sample. They were also asked to mark one of the four category boxes.

The consumer demographic and sample scoring sheets are shown in Appendix 10.3 and 10.4.

Following serving and evaluation of the 7 samples each consumer was asked to mark a further line scale graduated in $10 increments from $0 to $80/kg representing the $/kg value they ascribed to each of the category boxes.

Each sheet was checked after completion by serving staff and scanned twice by the contractor with software that displayed the sheet and scores on screen while highlighting any score differences between scans. The mm to the consumer mark from the left end of the linescale was recorded as a score between 0 and 100. Each sheet required manual acceptance before writing to a sensory data file. The completed file for each pick (420 rows of data) was then emailed to the research manager who utilised further software to calculate both 10 consumer averages for each line scale and category score and a clipped score that removed the two highest and two lowest scores and averaged the remaining central six.

In addition a raw and clipped MQ4 score was calculated by multiplying the tenderness, flavour and overall scores by 0.3 and the juiciness scores by 0.1 before summing the results. The output was visually checked and raw product means calculated prior to uploading the sensory summary for each sample (a single row with the 10 consumer averages and clipped scores) to the AUSBlue database where the sensory data was matched to the record of animal, carcase, grading, ageing and packaging detail.

Examples of the demographic, scoring sample and WTP (willingness to pay) sheets are presented in Appendices.

The collated AUSBlue data was forwarded to Dr Garth Tarr, Dr Ray Watson and Professor John Thompson for independent analysis.

4 Statistical Analysis

Independent statistical analysis was conducted by Dr Ray Watson, Dr Garth Tarr and Professor John Thompson and presented to the MSA Pathways Committee for review.

Dr Tarr utilised the R statistical package (R Core Team, 2019) for primary analysis including linear mixed models using the lme4 package (Bates et al., 2015) and posthoc analysis using the emmeans package (Lenth, 2019). The ggplot2 package was used to generate all visualisations (Wickham, 2016). Days in retail packaging were tested as both a categorical and continuous variable.

Professor Thompson conducted analysis using a mixed model (SAS, 2002) which examined the effect of position within the *m. longissimus* muscle, treatment and days in the retail pack before samples were taken out of the packs frozen for subsequent sensory analysis. There were a total of 54 carcases used in this experiment. A random term for carcass number was included in the analysis. The random term accounts for animal specific variation embedded in the experimental design. First order interactions between position within muscle, treatment and days in the retail pack were tested. These were all found to be non significant (P>0.05) and were not included in the final models.

The interaction between treatment and time in the retail pack was not significant (P>0.05) indicating that the difference between retail pack treatments did not alter when held in the retail packs for 1, 3, 5,7 and 9 days before subsequently processing for sensory evaluation. Any effect on eating quality was immediate (i.e. present at day 1) for all packaging methods.

5 Results

The results for each aspect of the project were definitive in regard to both visual and sensory evaluation when cooked. The primary comparison of MAP and VSP also aligned with the prior P.PIP.0488 outcomes with close to identical boundaries for consumer colour score thresholds. Differences between 80:20 high oxygen MAP and VSP were marginally lower than in the earlier study but did not differ statistically. The negative MAP deduction was statistically significant from day 1 after retail packing with a trend to increase over time to day 9 due to deterioration in MAP and TRI scores. The previous study only evaluated sensory at 9 days.

5.1 Visual appraisal of packaging in retail display case

The consumer meat colour (CMC) score statistic developed and utilised in P.PIP.0488 was again used to record consumer ratings of visual appeal and to define cut-off points that effectively assigned retail packaged product to “would definitely buy”, “would definitely buy if discounted” or “would definitely not buy” categories. There were clear and significant differences between the packaging treatments as displayed in Figure 8.

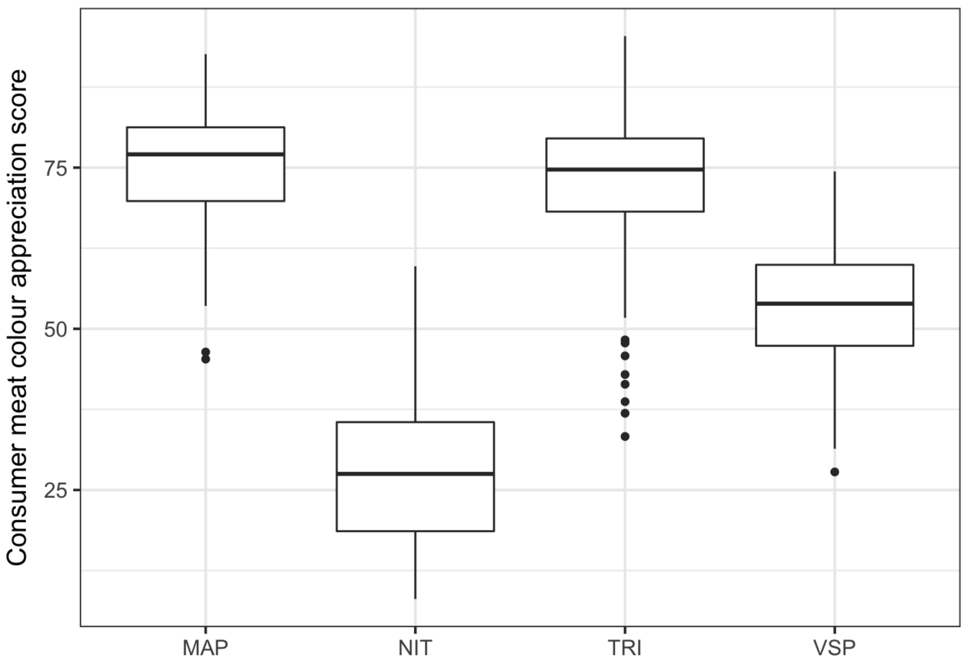

Figure 8: Distribution of Consumer Meat Colour (CMC) score by packaging type

Clearly both the MAP and TRI packaging with 80% and 30% oxygen respectively provided a superior CMC value whereas NIT packaging was scored substantially lower and VSP intermediate. Results of a linear mixed model by REML of CMC related to pack and days in pack produced contrast values displayed in Table 7.

Table 7: Contrast estimates and standard error for CMC and Packaging Types

Contrast	Est CMC	se
NIT -TRI	-43.75	1.9
NIT - VSP	-25.7	1.19
MAP - TRI	2.78	1.18
TRI - VSP	18.05	1.19
MAP - VSP	20.83	1.19
MAP - NIT	46.53	1.19

When examined at a more detailed cut and position level as demonstrated by Fig 9 it is clear that the packaging effects are relatively uniform across cuts and position within cut. Analysis indicated significance (P<0.001) for packaging type and the interaction of packaging type and days in pack.

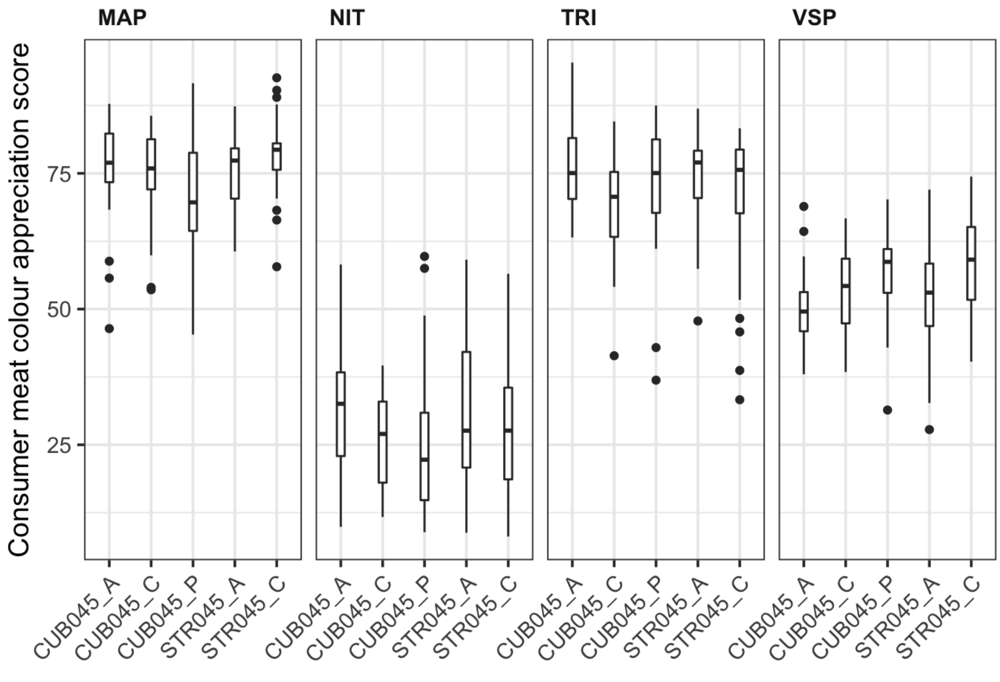

Figure 10: Distribution of CMC scores by cut position within packaging type

These contrasts are also reflected in the allocation to purchase intent categories displayed in the violin plots in Fig 8. They were remarkably consistent and very close to the previous project CMC cut-offs. A linear discriminate analysis produced classification cut-offs of 58.4 and 33.9 with a corresponding overall in-sample prediction accuracy of 81.2% whereas a classification and discriminate regression tree approach yielded cut-off values of 60.5 and 30.5 with accuracy of 82.2%.

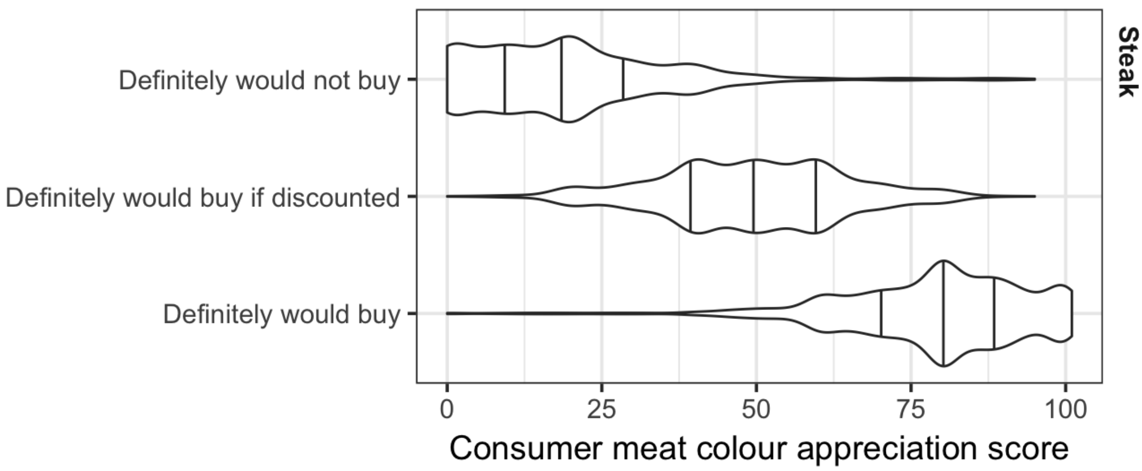

Figure 11: Distribution of consumer meat colour (CMC) scores for retail packs of steak by purchase intent. The three vertical lines in each violin plot indicate the first quartile, median and third quartile respectively.

The relationship between CMC and AUS-MEAT meat colour measured during MSA grading was less than convincing as depicted in Fig 12 and in more detail in Fig 13 where, while the clear CMC differences are evident across each of the packaging types and retail viewing dates there is little relationship or trend in regard to the AUS-MEAT meat colour scores. This aligns with the previous study and remains a concern given the extensive Industry use of the AUS-MEAT scores in purchase criteria.

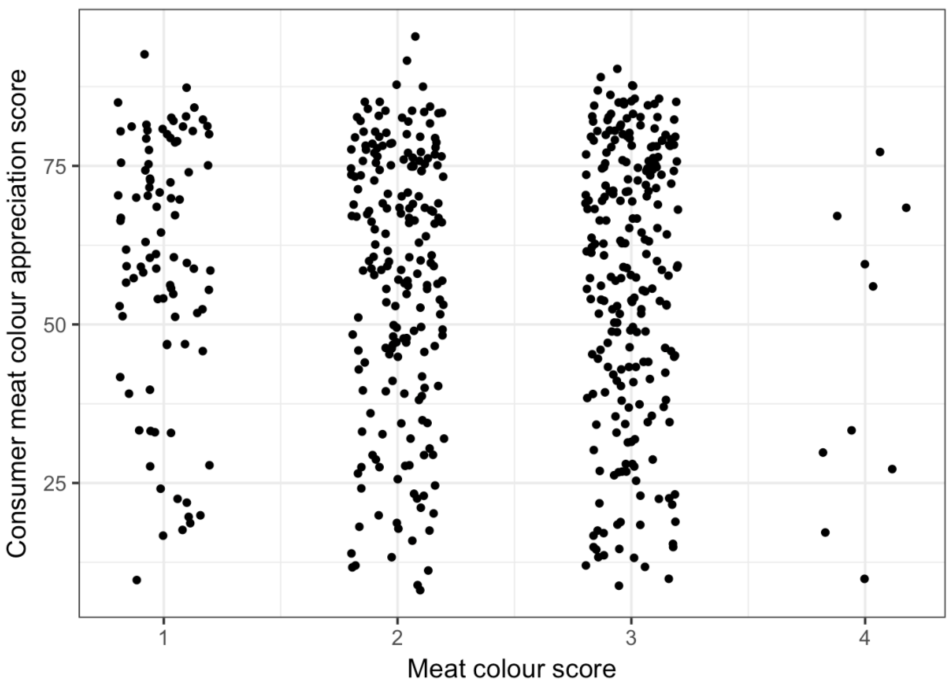

Figure 12: Relationship of CMC score to AUS-MEAT Meat Colour score at grading

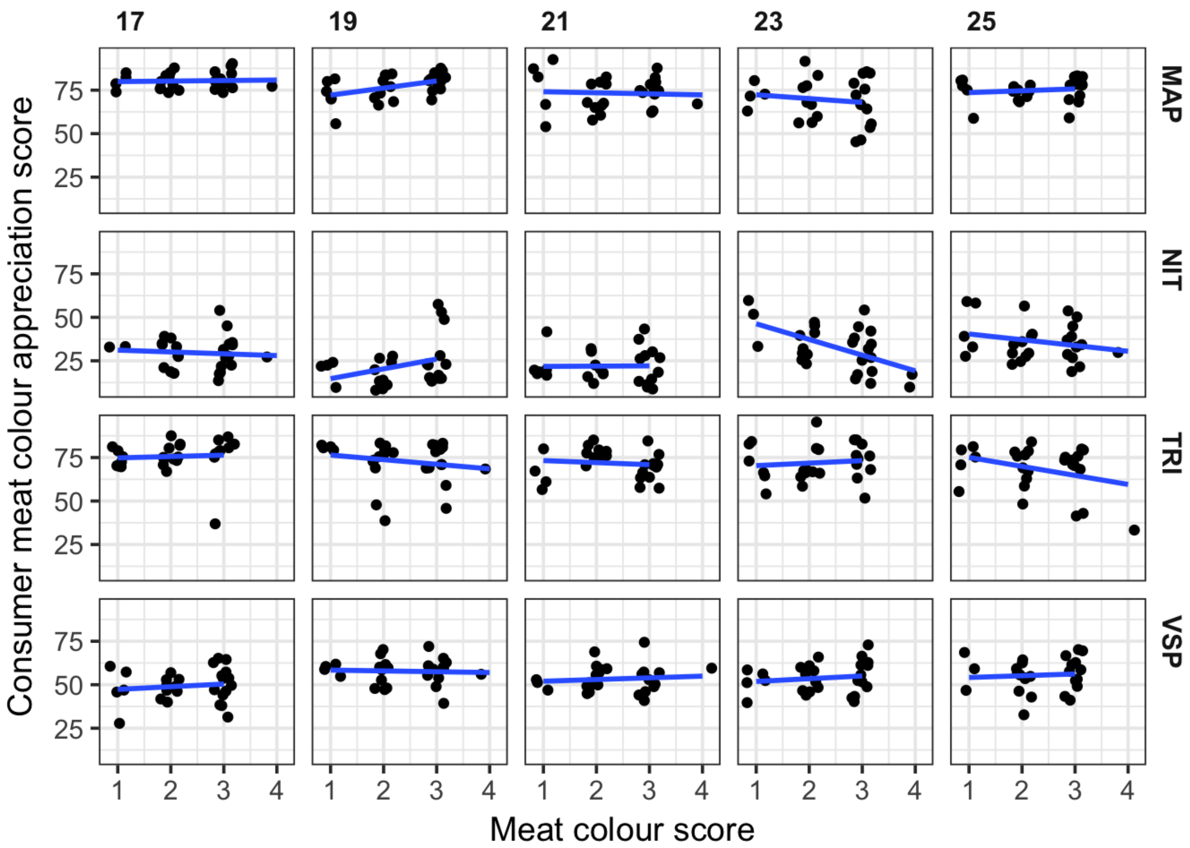

Figure 13: Relationship of CMC to AUS-MEAT Meat Colour at grading by packaging type and display date

5.2 Sensory appraisal of cooked steaks with alternative retail packaging and display period treatments

The distribution of eating quality MQ4 values by packaging type over the display period are illustrated in Figure 14. In contrast to the CMC visual appeal scores the MAP and TRI treatments are significantly (P<0.001) lower than the NIT and VSP. Relative to VSP the MAP treatment predicted MQ4 mean is -6.32, TRI -4.04 and NIT -0.98. The detrimental MAP effect was reduced relative to the prior P.PIP 0488 2015 trial but approached a similar negative position by day 9 with the results for both experiments within the confidence interval.

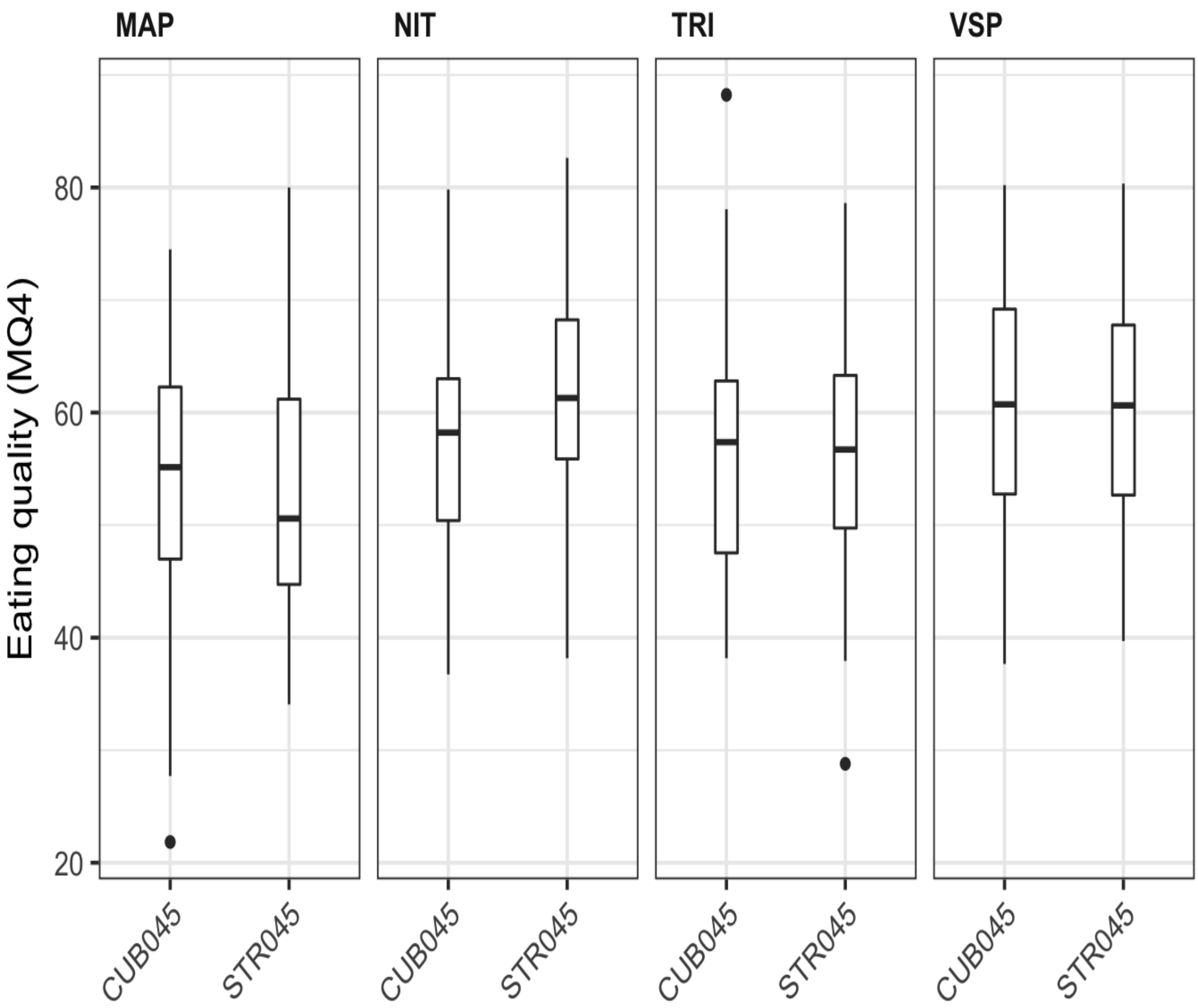

Figure 14: Distribution of MQ4 score by cut within packaging type

When analysed using a linear model and treating days in retail pack as a categorical value days in pack failed to reach significance (P<0.05) across all packaging types. The predicted mean values for each packaging type at the 5 retail pack display periods are shown in Table 8 and graphically in Fig 15. There are different trends, although not reaching statistical significance. The MAP and TRI-GAS declined with increased days of display with the difference between them reducing with time, the NIT increased and the VSP effectively remained stable, a pattern not dissimilar to the meat colour acceptance observations.

Table 8: Adjusted mean MQ4 values for packaging type and display period

PACKAGING	DISPLAY PERIOD (DAYS)				
	1	3	5	7	9
VSP	60.9	60.6	60.2	59.8	59.5
NIT	57.8	58.5	59.1	59.8	60.5
TRI-GAS	58.2	57.1	56.1	55.1	54.1
MAP	55.1	54.5	53.8	53.2	52.6

While slightly reduced the TRI-GAS treatment paralleled the MAP effect in magnitude and pattern over time. The NIT treatment appears to trend upward over time with the VSP trending slightly lower.

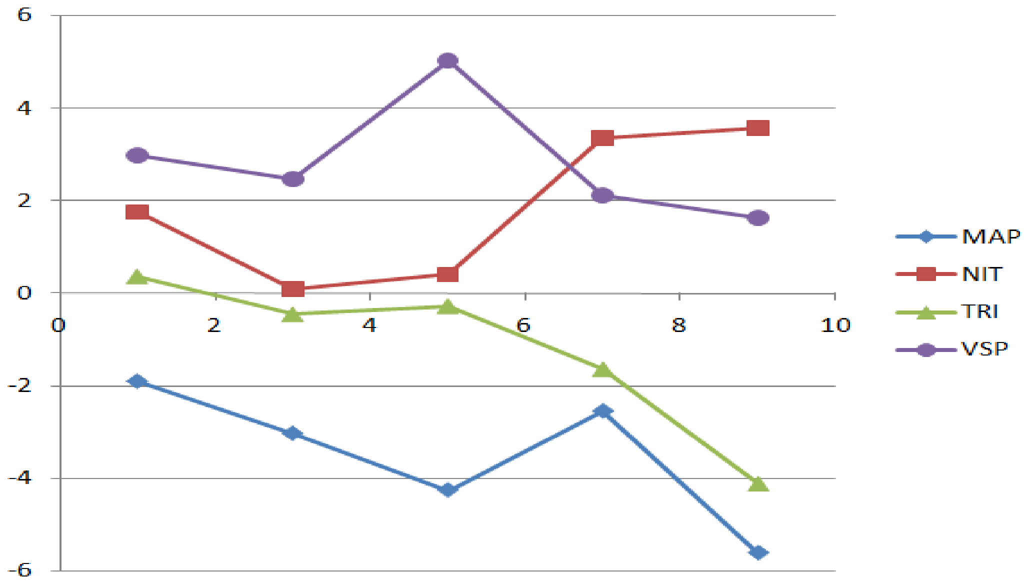

Figure 15: Adjusted MQ4 differences between packaging types across a 9 day period

A mixed model analysis produced a similar outcome albeit with some smoothing of the adjusted values across the time frame after removing the cut x days aged interaction as illustrated by Figure 16, a pattern mirrored at an individual cut x packaging type level as shown in Fig 17.

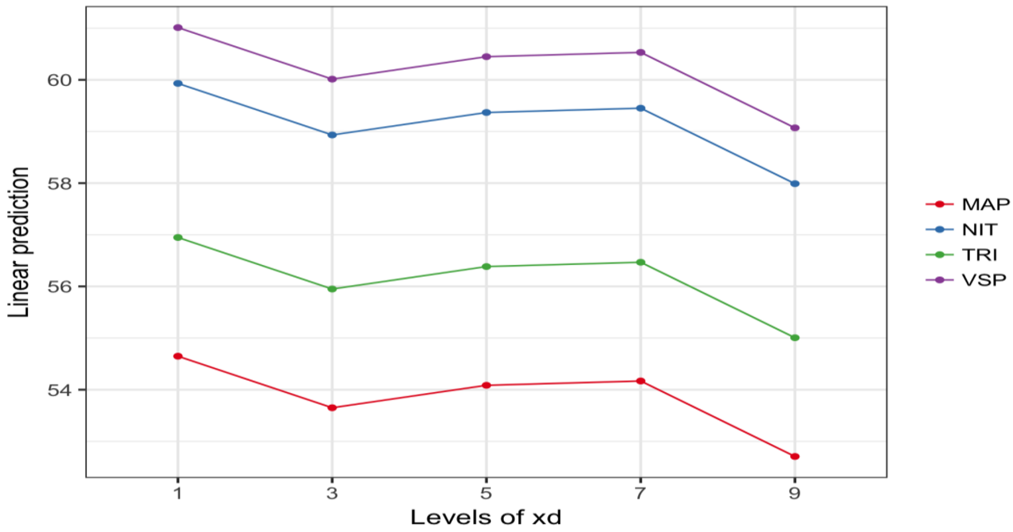

Figure 17: Mixed model MQ4 values by packaging type across 1, 3, 5, 7 and 9 day display periods (xd).

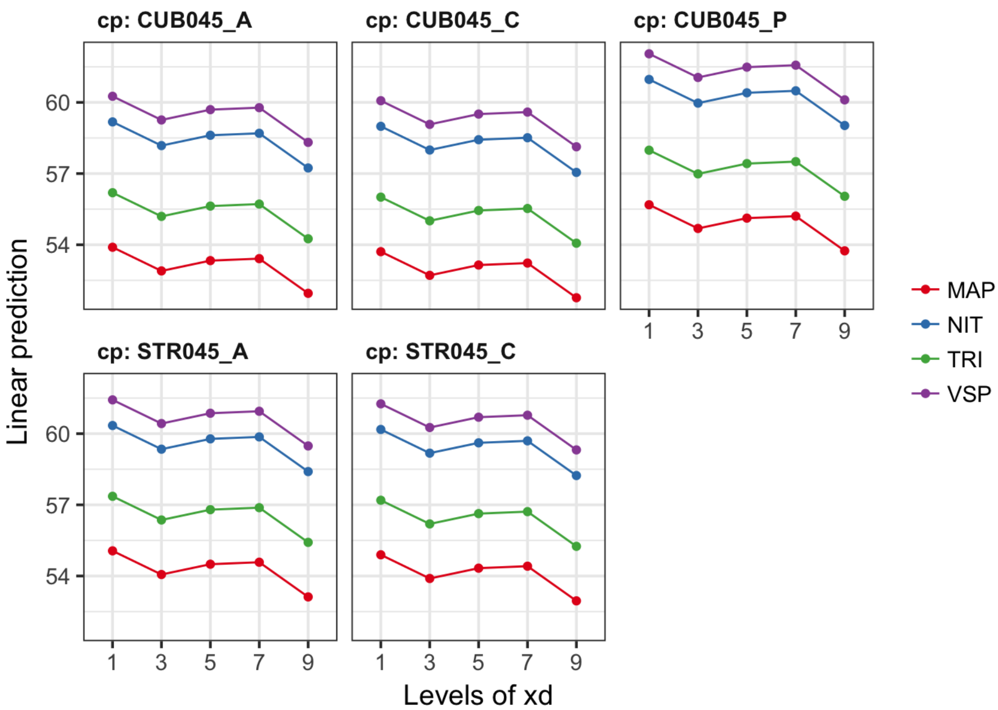

Figure 18: Mixed model MQ4 values by packaging type & muscle position and days in pack (XD). The lines are parallel because there were no significant interactions between muscle position and days in pack.

The days in pack across all treatments approached significance (P<0.05540) when days in pack were treated as a continuous variable.

Despite differences in cattle type, dentition and pH, primal ageing, muscles tested and days of display the packaging effects were statistically similar for both this and the previous study reported in P.PIP.0488 with overlapping confidence intervals. The final MSA Pathways recommendation of an 8 MQ4 point deduction reflects these findings.

Further analysis was conducted to investigate possible animal effect interactions including HGP and marbling. The tested product was obtained from 54 British breed steer carcases which differed significantly in eating quality (P<0.001). The carcases comprised 20/34 from No HGP/HGP implanted cattle. Previous work suggested that retail packs using high O2 MAP resulted in tougher meat. The literature suggested that this toughening may have been caused by a number of different mechanisms including deactivation of the calpain/calpastatin enzymes and crosslinking of myosin heavy chain proteins through disulfide bonding. (Geesink et al 2015). The recent paper by Polkinghorne et al (2018) discounted the deactivation of the calpain/calpstatin system as a contributing factor to the high O2 MAP effect as the effect was similar in muscles that aged at different rates (ie tenderloin, rump and striploin) and were aged in the bag for different times (5, 12 or 40 days before being placed in retail packs).

Including HGP and the interaction between HGP and treatment in the mixed model effectively provided a further test whether the high O2 MAP effect interacted with HGP effects. As expected the HGP effect was significant (ie HGP treated carcases were tougher, P<0.05), but there was no interaction between the treatment x HGP interaction. This further supports the results of Polkinghorne et al (2018) that higher calpastatin in the HGP treated carcases did not interact with the magnitude of the high O2 MAP effect.

The fourfold range in marbling scores in the 54 carcases provided an opportunity to test if marbling interacted with packaging treatments. As expected whilst marbling had a large effect on sensory scores the interaction between marbling score and treatment was not significant (P>0.05).

6 Discussion

These results provide valuable albeit challenging insights for industry. High oxygen MAP has been the predominant retail packaging type adopted by major retailers for many years supplanting the traditional overwrap packaging prepared in store and enabling central packaging models to be employed. In recent years VSP has become more evident but still substantially less common than MAP. In part this has been influenced by a belief that the darker visual colour of non-oxygenated beef would reduce consumer attractiveness and sales. To an extent this perception may have reduced in recent years due to a number of premium brands being VSP packed. In the previous trial there were indications that while consumers rated the colour of VSP lower than MAP they had some understanding that it may have an equal or better sensory outcome at equivalent scores as indicated by lower CMC thresholds between the higher categories.

The existing situation consequently creates a position where superior consumer visual appeal equates to decreased consumer sensory satisfaction. Both studies have confirmed a lower visual rating for VSP relative to MAP but also that the difference is perhaps not as extreme as some predictions. A transition to improved consumer satisfaction through changing to VSP however raises further challenges due to the cost of replacing or modifying existing machinery and adapting store systems. An upside could be the additional shelf life of VSP reducing distribution costs and time pressures from central packaging facilities.

It would be convenient if a solution could be found to avoid the decrease in eating quality while utilising the same packaging equipment. Two potential options in TRI and NIT treatments were evaluated in the study without success. The NIT treatment however did resolve the eating quality problem leaving a visual appearance issue. It has been suggested that residual oxygen levels are critical to avoid colour problems with the suggestion that more aggressive pack evacuation could resolve the issue. It is recommended that this be investigated further. A further alternative requiring more change to store systems and distribution would be adoption of a mother bag system to transfer centrally packed OWP trays with oxygen permeable film restoring colour when removed from the mother bag environment.

7 Conclusions/recommendations

It is concluded that high oxygen packaging at either 80% (MAP) or a reduced 30% (TRI) oxygen content have significant detrimental effects on eating quality. These effects were not evident in either NIT or VSP packaging which maintained eating quality across a 9 day retail display period.

It is also reported that consumer assessment of meat colour appeal and related purchase intent is extremely consistent being noted across two studies for steak retail packaging. While the MAP and TRI treatments were superior to VSP this difference was moderate and tended to decrease over the display period. The NIT treatment colour however was unacceptable to consumers.

Further work is recommended to investigate possible approaches to countering the unattractive colour generated by the NIT treatment. One possibility is more aggressive evacuation during packaging to reduce residual oxygen. Success in this aspect would provide an attractive low cost commercial alternative utilising existing MAP equipment with a change of gas mix.

8 Key messages

High oxygen MAP retail packaging decreases eating quality. This effect is evident within 24 hours of packing and persists or increases over a 9 day retail display period.

Consumers are highly consistent in their visual scoring of retail pack appearance. This consistency translates to purchase attitudes.

While VSP packaging has a lesser visual attractiveness relative to MAP and TRI this effect is moderate with VSP also recording strong purchase intent.

NIT high nitrogen packaging has an unacceptable visual appearance but does not reduce sensory ratings of cooked product.

9 Acknowlegements

The support of MLA staff, in particular Jessira Perovic and Janine Lau who provided grading data, colour scoring and daily supervision of the retail display and subsequent sensory sample fabrication is gratefully acknowledged as is the funding support of MLA.

Students of CSU were also deeply involved in all trial aspects from product collection to retail and sensory sample preparation and their willing and cheerful assistance is much appreciated. The commitment of CSU to permanently install a retail display cabinet and provide facilities for product storage and sample preparation is also acknowledged.

Further the outstanding collaborative assistance of Teys Australia and Teys Australia Food Service personnel at Wagga is acknowledged as is their PIP funding of the initial research study. No aspect of the research could have been achieved without their outstanding cooperation.

Tastepoint Pty Ltd are thanked for their expert management of sensory product testing.

Judy Philpott and Clare Mathieson (Polkinghornes) are thanked for their valuable contribution and assistance throughout the field work and in report production.

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Watson R, Gee A, Polkinghorne R and Porter M. (2008b). Consumer assessment of eating quality - development of protocols for Meat Standards Australia testing. Australian Journal of Experimental Agriculture, 48, 1360–1367.

11 Appendix

11.1 Retail packing material specifications

Sealed Air
Food Care

Cryovac® TOD1401CSC P 170X223 X60 N75LD - 100799751

Product Information Sheet

Major Attribute	
Material	Polypropylene (PP)
Color	Clear
Code	PAB01

Attribute	UOM	Target	Tolerance
Weight	g	23.500	22.325 to 24.675

Approval for Food Grade

The raw materials used in the manufacture of all products comply with the following relevant food contact regulations:

- US FDA CFR21 Regulation for food contact
- AS2070 Plastics Materials for Food Contact Use

Storage Conditions

Dry goods storage area. Do not store in temperature above 35 deg C. Pallets are not to be double stacked or any items places on top of pallet.

Environmental Impact

Polypropylene (PP), Recycling code "5"

Sealed Air Food Care Australia

In VIC:	In NSW:	In QLD	In WA	In SA:
1126 Sydney Rd,	29 Chifley Street	Unit 3, 5 Hentry St	41 Baile Rd	15 Greenfields Dr
Fawkner, VIC, 3060	Smithfield, NSW, 2164	Loganholme, QLD, 4129	Canning Vale, WA, 6155	Greenfields, SA, 5107
ph: (03) 9358 2244	ph: (02) 9725 5933	ph: (07) 3451 1400	ph: (08) 9455 9999	ph: (08) 8283 2300

Sealed Air
Food Care

Cryovac® LID1050

High Abuse, Anti-Fog Barrier Shrink Film

Product Information Sheet

Attribute	UOM	Nominal Value	ASTM Reference
Gauge	µm	25	
Yield	m^2/kg	42	
Sealing Guide:			
Seal Temp	°C	145	
Seal Time	sec	1	
Sealant Direction	-	Wound in	
Roll length	m	1600	
Core Diameter	mm	76	
Oxygen Transmission	cc/m2/day at 23∘C, 0%RH	32	ASTM D3985

Product Regulatory Compliance

Complies with EU and FDA regulations for all foods types at room temperature and below.

Recycle Profile

Conforms to classification code 7 – 'other'

Limitations of Use

Suitable for chilled or frozen applications. Not suitable for pasteurization. Suitable for microwaving up to 100°C for 3 minutes with a vent hole.

Sealed Air Food Care Australia
In VIC:
1126 Sydney Rd,
Fawkner, VIC, 3060
ph: (03) 9358 2244

In NSW:
29 Chifley Street
Smithfield, NSW, 2164
ph: (02)

In QLD
Unit 3, 5 Hentry St
Loganholme, QLD, 4129
ph: (07)

In WA
41 Baile Rd
Canning Vale, WA, 6155
ph: (08)

In SA:
15 Greenfields Dr
Greenfields, SA, 5107
ph: (08)

Sealed Air
Food Care

Cryovac® TOK2520CSC P 232x297x60 N6Y7D - 100779287

Product Information Sheet

Major Attribute

Material	Polypropylene (PP)
Color	Clear
Code	PAB01

Attribute	UOM	Target	Tolerance
Weight	g	44.290	42.076 to 46.505

Approval for Food Grade

The raw materials used in the manufacture of all products comply with the following relevant food contact regulations:

- US FDA CFR21 Regulation for food contact
- AS2070 Plastics Materials for Food Contact Use

Storage Conditions

Dry goods storage area. Do not store in temperature above 35 deg C. Pallets are not to be double stacked or any items placed on top of pallet.

Environmental Impact

Polypropylene (PP), Recycling code "5"

Sealed Air Food Care Australia

In VIC:
1126 Sydney Rd,
Fawkner, VIC, 3060
ph: (03) 9358 2344

In NSW:
29 Chifley Street
Smithfield, NSW, 2164
ph: (02) 9725 5933

In QLD
Unit 3, 5 Henry St
Loganholme, QLD, 4129
ph: (07) 3451 1400

In WA
41 Baile Rd
Canning Vale, WA, 6155
ph: (08) 9455 9999

In SA:
15 Greenfields Dr
Greenfields, SA, 5107
ph: (08) 8283 2800

11.2 Consumer visual appraisal - demographics input

I.D.				

Thank you for your participation today.

Consent for Meat Colour Trial

- There will be no personal monetary gain from this trial however if I am representing an organisation / club / group they will be financially remunerated for my participation.
- My responses in this trial indicate my opinion of meat colour.
- All information collected in this survey is strictly confidential and I will retain anonymity.
- I understand the above and that completing this questionnaire implies my agreement to participate.

Name of organisation/club/charity I am representing today

____

I am not representing an organisation, charity or club ☐ *(please tick if applicable)*

Date: | D | D | M | M | Y | Y |

1. Gender: *(Use **X** in one box only)*

Male ☐ Female ☐

2. Age Group: *(Use **X** in one box only)*

18-19 ☐ 20-25 ☐ 26-30 ☐ 31-39 ☐ 40-60 ☐ 61-70 ☐

3. From where do you usually purchase your beef? *(Use **X** in all applicable)*

Butcher ☐ Supermarket ☐ Farmers Market ☐ I do not do the beef purchasing ☐

- EACH person will be given a DIFFERENT SET OF SAMPLES to view so please do not compare with other people near you.
- The only correct answer is **your opinion** of meat colour.
- Please score the samples **only** on how appealing **you** think the samples are in **colour**.

  Do not score the samples for your perception of eating quality or for how you think they would cook, taste or eat.
- The friendly staff will explain how to score the samples and assist you if you have any questions.

11.3 Consumer visual appraisal- CMC scoring sheet

Consumer No. ______

Please go to the XXXXxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx and rank the 8 meat trays to the right on how appealing the MEAT COLOUR of each sample is to you.

Please match each ID to the meat tray, place a mark on the scale and then tick one of the boxes to the right.

ID		Please tick
☐	Extremely Unappealing ——————— Extremely Appealing	☐ Definitely would buy ☐ Definitely would buy if discounted ☐ Definitely would not buy
☐	Extremely Unappealing ——————— Extremely Appealing	☐ Definitely would buy ☐ Definitely would buy if discounted ☐ Definitely would not buy
☐	Extremely Unappealing ——————— Extremely Appealing	☐ Definitely would buy ☐ Definitely would buy if discounted ☐ Definitely would not buy
☐	Extremely Unappealing ——————— Extremely Appealing	☐ Definitely would buy ☐ Definitely would buy if discounted ☐ Definitely would not buy
☐	Extremely Unappealing ——————— Extremely Appealing	☐ Definitely would buy ☐ Definitely would buy if discounted ☐ Definitely would not buy
☐	Extremely Unappealing ——————— Extremely Appealing	☐ Definitely would buy ☐ Definitely would buy if discounted ☐ Definitely would not buy
☐	Extremely Unappealing ——————— Extremely Appealing	☐ Definitely would buy ☐ Definitely would buy if discounted ☐ Definitely would not buy
☐	Extremely Unappealing ——————— Extremely Appealing	☐ Definitely would buy ☐ Definitely would buy if discounted ☐ Definitely would not buy

NB: this is one of several sheets per consumer for appraisal of all of the samples required.

11.4 Consumer sensory testing questionnaire sheets

TPB TPB

Thank you for your participation today with our meat tasting

Our team is here to help you during your session and make this easy for you.

Before you start please listen to the instructions on how to use the scales contained in this questionnaire

Please use a black pen to fill in the form and where asked:

write crosses in boxes like this........... ☒

mark on the line scale like this...

In between each sample please cleanse your palate by:

* first......... taking a sip of diluted apple juice
* then.......... chew a piece of bread
* and then..........take another sip of diluted apple juice

We are after **YOUR** opinion and therefore ask that you do not talk to anyone else in the room during the research session.

Now just a few questions about yourself (All this information is strictly confidential)

Date ☐☐☐☐☐☐

Your Group's Name ________________________

1. Please write in the boxes the postcode you normally live in ☐☐☐☐

2. Age Group: *(Use **X** in one box only)*

18,19 ☐ 20-25 ☐ 26-30 ☐ 31-39 ☐ 40-60 ☐ 61-70 ☐

3. Gender: *(Use **X** in one box only)*

Male ☐ Female ☐

4. What is the occupation of the main income earner in your household?:

*(Use **X** in one box only)*

☐ Manager ☐ Professionals (includes health professional etc.)

☐ Technicians and Trade Workers ☐ Community and Personal Services Workers

☐ Clerical and Administrative workers ☐ Sales Workers (includes retail sales etc.)

☐ Machinery operators and Drivers ☐ Labourers

☐ Home Duties ☐ Student

☐ Other

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Please use a black pen to fill in the form and write crosses in boxes like this ☒

5. How often do you eat Beef?
(in any form such as steaks, roasts, stews, casseroles, kebabs, BBQ etc.?
*(Use **X** in one box only)*

- ☐ Daily
- ☐ 4-5 times a week
- ☐ 2-3 times a week
- ☐ Weekly
- ☐ Fortnightly
- ☐ Monthly
- ☐ Never eat beef

6.1. How many adults (18 and over) normally live in your household ?
*(Use **X** in one box only)*

- ☐ 1 Adult
- ☐ 2 Adults
- ☐ 3 Adults
- ☐ 4 Adults
- ☐ 5 Adults
- ☐ 6 Adults
- ☐ 7 Adults
- ☐ 8 and over adults

6.2 How many children under 18 years normally live in your household??
*(Use **X** in one box only)*

- ☐ 0 Children
- ☐ 1 Child
- ☐ 2 children
- ☐ 3 Children
- ☐ 4 Children
- ☐ 5 Children
- ☐ 6 Children
- ☐ 7 and over children

7 Please read the following statements
and use X in one box only for the one statement that applies to you

- ☐ I enjoy red meat. It's an important part of my diet
- ☐ I like red meat well enough. It's a regular part of my diet
- ☐ I do eat some red meat although, truthfully it wouldn't worry me if I didn't
- ☐ I rarely / never eat red meat

8. When you eat beef, such as steaks, what level of cooking do you prefer?
*(Use **X** in one box only)*

- ☐ Blue
- ☐ Rare
- ☐ Medium / Rare
- ☐ Medium
- ☐ Medium / Well done
- ☐ Well done

9. What level of income best categorises your combined household income ?
*(Use **X** in one box only)*

- ☐ Below $ 25,000 per year
- ☐ $ 25,001 - $$ 50,000 per year
- ☐ $ 50,000 - $ 75,000 per year
- ☐ $ 75,001 - $ 100,000 per year
- ☐ $ 100,000 - $ 125,000 per year
- ☐ $ 125,000 - $ 150,000 per year
- ☐ More than $ 150,000 per year
- ☐ Prefer not to say

10. What level of education have you reached? *(Use **X** in one box only for the highest level achieved)*

- ☐ Did not complete Secondary School
- ☐ Completed Secondary School
- ☐ A College/ TAFE course
- ☐ University Graduate

11. What is your cultural heritage ?
*(Use **X** in one box only)*

- ☐ Australian
- ☐ British descent
- ☐ European descent
- ☐ Asian descent
- ☐ Other
- ☐ Prefer not to say

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TPB TPB

All information collected in this survey is strictly confidential

PRODUCT:

Tenderness

Not Tender — Very Tender

Juiciness

Not Juicy — Very Juicy

Liking of Flavour

Dislike Extremely — Like Extremely

Overall Liking

Dislike Extremely — Like Extremely

Please mark **X** in one of the following boxes to rate the quality of the beef sample you have just eaten

Choose **one** only (you must make a choice)

- ☐ Unsatisfactory
- ☐ Good everyday quality
- ☐ Better than everyday quality
- ☐ Premium quality

TPB TPB

TPB TPB

Based on the beef you have just consumed:
Please mark the line at the price per Kg you believe best reflects the value for each category.

Unsatisfactory Quality

$0/kg $10/kg $20/kg $30/kg $40/kg $50/kg $60/kg $70/kg $80/kg

Good Everyday Quality

$0/kg $10/kg $20/kg $30/kg $40/kg $50/kg $60/kg $70/kg $80/kg

Better Than Everyday Quality

$0/kg $10/kg $20/kg $30/kg $40/kg $50/kg $60/kg $70/kg $80/kg

Premuim Quality

$0/kg $10/kg $20/kg $30/kg $40/kg $50/kg $60/kg $70/kg $80/kg

Are you the regular purchaser for your family ? *(Use* **X** *in one box only)*

- ☐ Yes
- ☐ No

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