final report

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Stage 1 – Enhancing capability to understand the relationship between meat colour, pH and retail meat colour

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Executive Summary

Meat colour and pH, has a significant impact on increasing or decreasing value both up and down the value chain from producers to customers. Recent observations have shown a condition where carcasses have a pH <5.7 however may have a meat colour of 4 or 5. These carcasses are non-compliant with MSA on meat colour but pass on pH. This means that the whole carcase is classified as ungraded and as a result producer returns decrease. Teys Australia hosted Dr Melvin Hunt, a world renowned scientist in the area of meat colour, to review typical Australian processing practices and to provide recommendations. The visit included a seminar with leading Australian Meat Scientists, the MSA Pathways Committee, Teys and MLA representatives to discuss his findings and recommendations. These included the need to understand meat colour science to be able to address concerns through the supply chain with meat colour, the need to allow meat to 'bloom' prior to packaging, the opportunity to use the Near-infrared Oximeter to assess cattle at ante-mortem for their potential to dark-cut, and the need for further research in the disconnect identified between pH and meat colour.

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1 Background

1.1 The relationship between meat colour, pH and retail meat colour

Teys Australia strongly support the development and implementation of Meat Standards Australia (**MSA**) grading of meat across the industry and have worked with retailers to ensure adoption.

Teys Australia have a history of conducting research, in partnership with MLA and AMPC, into meat science to improve industry practices and test new technology.

Meat colour and pH have a significant impact on MSA grading and customer purchasing. Despite research showing no impact on eating quality, meat colour can impact consumer purchase decisions at retail due to consumer perception that meat colour affects eating quality. Only carcasses that have a meat colour score of 3 or below meet MSA and are acceptable to retailers. When meat is outside of customer specifications (i.e. dark cutters, meat colour score 4) there is significant economic loss to producers and processors. Meat colour and pH affect meat value both up and down the supply chain from producers to customers and is a significant cost to the Australian Red Meat Industry.

Recent observations have shown a condition where carcasses have a pH <5.7 however may have a meat colour of 4 or 5. These carcasses are non-compliant with MSA on meat colour but pass on pH. This means that the whole carcase is classified as ungraded and as a result no MSA information is available. In addition, in recent months Teys Australia has observed meat colour change due to variations in packaging procedures.

This stage 1 project was aimed at starting to address these observations by enhancing capability in understand the relationship between meat colour, pH and retail meat colour.

2 Projective Objectives

A review of assessment of meat colour and pH at grading and subsequent relationship to retail display colour including the factors that influence it.

Specific advice and recommendations regarding:

- The recently highlighted issue of carcasses having Meat Colour >3 while being below pH5.71 in principally grass fed animals
- Packaging interactions with colour and shelf life and recommendations
- Pre-slaughter identification of dark cutting and potential technologies
- A seminar session with leading Australian Meat Scientists, the MSA Pathways Committee, Teys and MLA representatives to discuss meat colour science and developments

Review the research methodology for the meat colour, pH and packaging trial (project proposal being developed). Participate in the analysis of the project data to ensure international acceptance of the information.

3 Methodology

3.1 Review and Site Visits

Teys Australia hosted Professor Melvin Hunt from Kansas State University, USA to conduct an expert initial review of the relationship between meat colour, pH and retail meat colour. Dr Hunt assessed available Australian data whilst visiting three Teys Australia sites, where he held discussions and question and answer sections with management and production teams on Australian processing and packaging techniques and their effects on meat colour.

Dr Hunt also met with the project team for stage 2 of this work on understanding the relationship between meat colour, pH and retail meat colour. He provided advice and recommendations regarding the detailed design of the proposed meat colour, pH and packaging trial project, which was further discussed in the seminar.

3.2 Seminar

A seminar was held on 28 July 2015 at the Teys Australia, Eight Mile Plains Office in Brisbane. Leading Australian meat scientists including the MSA Pathways Committee, Teys and MLA representatives discussed meat colour science and developments from Dr Hunt's visit. The working documents associated with the seminar are available in Appendix 1.

3.3 Dr Melvin Hunt

Professor Melvin Hunt of Kansas State University has a long and very distinguished career as a researcher and teaching professor. For the majority of his career he has been based at Kansas State University, a very well respected Land Grant University in the USA. Kansas State University has a particular focus on Meat and Animal Science along with other agricultural and food disciplines.

Professor Hunt is acknowledged within the Meat Science community as the global expert on meat colour chemistry and practical application. His specific areas of research include: Cooked meat color and safety, Enhancement of fresh beef and pork, Case-ready packaging (CO-MAP, Lo-O2 MAP, Hi-O2 MAP and vacuum), Myoglobin color stability and lighting, Discoloration of bone, Color stabilizing mechanisms in meat, Color measurement methodology, and Dry-aging of beef. Aside from his direct research contribution he has conducted multiple reviews of the subject area and made numerous presentations to International and USA scientific forums such as the International Congress of Meat Science and Technology, the principal annual international meat science forum and to the American Meat Science Association, Reciprocal Meat Conference. Dr. Hunt has received numerous awards for teaching, research and student services. He has been Chair of the Muscle Foods division of the Institute of Food Technologists, Chair of the Meat Science-Muscle Biology Section of the American Society of Animal Science, Chair of the Reciprocal Meat Conference, and President of the American Meat Science Association.

Aside from many other publications he was the principal author of the American Meat Science Association AMSA Meat Colour Measurement Guidelines, the primary text and standard used globally for colour study. Professor Hunt's full curriculum vitae is available in Appendix 2.

4 Result and Discussion

The objectives of the project where met in full.

4.1 Visit to Teys Australia establishments

During the visits to Teys Australia's establishments Dr Hunt worked through the basics of meat colour as explained in his presentation (Appendix 3) and also put this into practical/operation situations. Examples of these practical situations follow.

4.1.1 Relationship between a meat colour >3 and pH <5.71

Through a tour of the establishment Dr Hunt, reviewed and assessed typical industry practices to try to identify reasons for the recently highlighted issue of carcasses having meat colour >3 while pH being below 5.71. Dr Hunt raised the production speeds within Australia, i.e. time between slaughter, chilling, grading, boning and packaging as a consideration in the cause and effect of this problem. He recommended that an extension in the chilling time might be beneficial whilst noting the commercial limitations that prevent this alteration in practice. He suggested that customer taste testing of this product (as included in the stage 2 project proposal) would provide valuable data to support any changes to the MSA grading parameters or customer specifications as it is expected that this increase in colour has no significant effect on taste.

4.1.2 Packaging interactions with colour and shelf life

Dr Hunt reviewed and assessed the typical industry packaging processes, Teys Australia had identified that there was a meat colour/shelf life issue occurring, especially at their Wagga Wagga establishment where shelf life was reduced based on meat colour compared to what was expected. Professor Hunt commended the establishment on their highly efficient and effective packaging of meat. However he explained that the cold chain management was actually too good. Not withstanding food safety and the potential for microbial growth, the cut meat surface must have the required time and temperature to bloom, i.e. let the meat colour chemistry occur so that oxidation of the outer millimetres of the pieces of meat occurs. This can be fixed with minor process flow changes, once the colour chemistry is understood to ensure that the customer colour specifications are achieved.

4.1.3 Identification of pre slaughter dark cutting and potential identification technologies

Prior to and throughout his visit, Dr Hunt considered the question of how and why some cattle dark cut? Even though they have been reared (i.e. breed, handled, fed, transported) in the same way. Sensibly Dr Hunt also inverted the question whilst assessing common industry practices demonstrated at the Teys Australia establishments and during conversations with researchers, why don't some cattle dark cut? Although this practice can sometimes help find the answer quicker in this case the answer is going to take more consideration, as Professor Hunt saw no direct evidence for an answer from his experience. His areas of consideration were production practices, genetics of the cattle and stimulation that the cattle have through the rearing process up to the point of slaughter. If the problem walking in could be identified then the Industry is one step closer to identify more of the factors causing dark-cutting and to prevent it from occurring. The suggestion from Dr Hunt

was to look at using the oximeter to try and identify cattle that may dark cut prior to slaughter, that could be turned off for a period of time.

4.2 Seminar

Teys Australia hosted a Seminar at their Head Office with leading Australian meat scientists, the MSA Pathways Committee, Teys and MLA representatives. At the seminar Professor Hunt, John Thompson and Rod Polkinghorne presented. Full copies of the presentations are provided in Appendix 3. Discussion was held on current meat colour science practices, research and thinking and the project design for stage 2.

4.3 Summary of the Presentations

4.3.1 Practical Strategies and Mechanisms for Controlling Meat Colour

Dr Hunt started by running through the basics of meat colour including the oxygenation of the iron particles in the myoglobin in meat that affect the colour of the meat (as per slide 10). He then went on to explain the biochemical pathway in this reaction in practical terms and the steps required for the meat to

a) 'bloom' i.e. hold an oxymyoblobin or red colour with initial exposure (hours) to oxygen at high concentrations (20%) and
b) brown or aged look i.e. metmyoglobin that develops with over exposure (days) to low oxygen concentration (<3%), oxidizing the Fe2+ to Fe3+. As demonstrated through slide 16 where only the top and left side of the meat is exposed to oxygen concentrations of 20%.

The major factors of meat colour were raised noting that there are still unknown factors. The basic science behind muscle metabolism and the dark-cutting of muscle was then explained including the build-up on lactic acid, the animals glycogen, glucose and ATP reserves at ante mortem and the affect this has on pH and colour of the meat. The effect that electro stimulation has on the carcase was briefly discussed noting that at a pH of 5.7.-5.8, immediate electro stimulation if correctly applied i.e. positioning, voltage and time, can denature proteins to lower a dark cutter (DFD) to within normal pH and colour levels. The many factors that affect meat colour stability were provided (as per slides 21 and 22). The oxygen consumption and metmyoglobin reduction steps of the biochemical pathway were explained as to their effect on meat colour. The effect of the practical application of this biochemical pathway was than summarised into temperature guidance for cold chain management.

In order to test everyone's understanding of the topic, Dr Hunt posed the question of whether premature browning was a food safety issue? He raised this in relation to manufactured products such as hamburgers or meatballs and the cooking of products to ensure an adequate time and temperature combination to kill microorganisms such as the Shiga toxin E.coli. Common practice is to cook meat till the inside is cooked through or brown. Here in lines Dr Hunt's point according to meat colour science the inside of the product could already be prematurely brown due to metmyoglobin and therefore a set time-temperature combination (and thermometer) should always be used. The mixing of muscles/meat cuts for grinding mince was also raised as meat colour changes occur at differing rates between the muscles and could therefore provide an inconsistent colour in mixed muscle products (mince

or trimmings). Packaging of product was discussed and the importance of calibrating machines now that the importance of the oxygen concentration was understood in relation to meat colour.

Professor Hunt then introduced Near-infrared Oximetry, which through infrared technology measures the level of oxymyoglobin, metmyoglobin and deoxymyoglobin in skeletal muscle.

The summary of Professor Hunt's presentation was that knowing the basics of meat colour science allows you to address meat colour issues with a practical strategy because you know what the meat should be doing, you know what the meat can do and you know the factors that affect what the meat is doing.

Dr Hunt also advised that one of the best texts on meat colour is the American Meat Science Association (AMSA) Meat Colour Measurements Guideline which is freely available on the web (http://www.meatscience.org/publications-resources/printed-publications/amsa-meat-color-measurement-guidelines).

4.3.2 The disconnect between pH and meat colour

This presentation provided a summary of the analysis of grading data from five abattoirs with approximately 1 million head of cattle, the analysis covered research on meat colour at grading and re-blooming and the use of the hunter meter to predict meat colour scores. The summary was that there is a disconnect between pH and meat colour, which may be due to carcase traits and/or the time to grading. The grader, feed type and supplier all have important effects on the pH and meat colour.

4.3.3 Proposed Meat Colour & Packaging Trial Design

This presentation was on the experimental design of stage 2 of this project Teys Australia – Impacts on consumer acceptance of beef from interactions between pH, meat colour and packaging. The discussion around the design was dominated by the question of academics acceptance verses practicality of collection and cost with regard to the cell size. It was also suggested that it might be of value to collect additional samples of meat for possible future chemical analysis testing during the experiment. This suggestion where taken into account and the project design has now been finalised and submitted to MLA.

5 Conclusions/Recommendations

Meat colour and pH, has a significant impact on increasing or decreasing value both up and down the supply chain from producers to customers. Professor Hunt showed how understanding meat colour science allows processors to address meat colour concerns that arise. Examples of these concerns include variation in animals at ante-mortem with the suggested use of Near-infrared Oximetry, and discolouration of meat throughout the supply chain at packaging or at retail with the time-temperature combination for 'blooming' to occur.

Dr Hunt's review of typical Australia systems recommended future research into the relationship between meat colour, pH and retail meat colour (i.e. stage 2) as it could hold great value to producers and processor through the potential consumer acceptance of meat that would otherwise by down-graded out of MSA.

This project improved the industries understanding and capability in meat colour through the seminars held and provided excellent resources for future reference in the form of Dr Hunt's presentation and the AMSA Meat Colour Measurements Guideline. Inviting either Dr Hunt or an Australia meat scientist to present on this area at a wider industry forum such as the MINTRAC QA Conference should be considered.

6 Key Messages

Meat colour is very significant in the Australian meat industry not just in Meat Standards Australia grading but in customer specification and consumer preference. As such understanding meat colour science is the key to fixing meat colour issues throughout the supply chain and should be a skill developed in quality control staff.

Notwithstanding the research completed and underway-in Australia, more research is required to understand and the association between meat colour, pH and retail colour.

7 Appendix 1 – Seminar details

7.1 Invitation for the seminar

File name: P.PIP0481_Invitation_ Dr_Hunt_Seminar.pdf

7.2 Agenda for the seminar

The Science of Meat Colour and its Application in a Commercial Environment

VENUE: The Boardroom, Teys Head Office, Logan Road, Eight Mile Plains

DATE: Tuesday, 28th July 2015-10-15

TIME: 2:00pm – 5:00pm

SEMINAR AGENDA

2:00 – 2:05pm	Welcome – Tom Maguire, Teys Australia, General Manager, Corporate Services
2:05 – 3:00pm	Professor Melvin Hunt The Science of Meat Colour and its Application in a Commercial Environment
3:00 – 3:30pm	John Thompson Australian results on the disconnect between ultimate pH and meat colour
3:30 – 4:00pm	Rod Polkinghorne A proposed trial design to investigate the disconnect between pH and meat colour and the implications for shelf life and eating quality
4:00 – 5:00pm	Open discussion

Followed by dinner in the Garden Bar at the Glen Hotel

7.3 Attendees for the seminar

Dr Melvin Hunt	KSU
Rod Polkinghorne	POLKINGHORNES PL
Judy Philpott	POLKINGHORNES PL
Dr Garth Tarr	POLKINGHORNES PL
Mary Porter	POLKINGHORNES PL
Dr John Thompson	JT CONSULTING
Dr Tomas Bolumargarcia	CSIRO
Dr Robin Shorthose	CSIRO
Janet Stark	CSIRO
Ian Lean	IBUS
Dr Robyn Warner	MELB UNIVERSITY
Glen Barker	AUSMEAT
Matt Cooper	AUSMEAT
Howard Smith	"MT PANORAMA"
David Hill	"CLARKWOOD"
Bec Kominsky	MELTON GRAZING
Dr Alex Ball	MLA
Edwina Greenham	MLA
Michael Crowley	MLA
Jessira Perovic	MSA
Janine Lau	MSA
Terry Farrell	MSA
Dr Peter McGilchrist	MURDOCH UNI
Honor Calnan (PhD student)	MURDOCH UNI
Dr Cameron Jose	MURDOCH UNI
Dr Dean Gutzke	VIC

8 Appendix 3 - Presentations

8.1 Presentation provided by Dr Melvin Hunt

File name: P.PIP0481_Practical_Strategies_for_Color_Control.pdf

8.2 Presentation provided by John Thompson

File name: P.PIP0481_The_disconnect_btw_pH_and_meat_colour.pdf

8.3 Presentation provided by Rod Polkinghorne

File name: P.PIP0481_Colour_and_packaging_Trial_Design.pdf