

FINAL REPORT

Educational Scholarship Pathways Program: Creating a Highly Skilled Meat Industry – Year 2

PROJECT CODE: 2016-1438

PREPARED BY: Dr Mandeep Kaur

DATE SUBMITTED: 18 April 2019

DATE PUBLISHED: XXX

PUBLISHED BY: XXX

The Australian Meat Processor Corporation acknowledges the matching funds provided by the Australian Government to support the research and development detailed in this publication.

Disclaimer:

The information contained within this publication has been prepared by a third party commissioned by Australian Meat Processor Corporation Ltd (AMPC). It does not necessarily reflect the opinion or position of AMPC. Care is taken to ensure the accuracy of the information contained in this publication. However, AMPC cannot accept responsibility for the accuracy or completeness of the information or opinions contained in this publication, nor does it endorse or adopt the information contained in this report.

No part of this work may be reproduced, copied, published, communicated or adapted in any form or by any means (electronic or otherwise) without the express written permission of Australian Meat Processor Corporation Ltd. All rights are expressly reserved. Requests for further authorisation should be directed to the Executive Chairman, AMPC, Suite 1, Level 5, 110 Walker Street North Sydney NSW.

TABLE OF CONTENTS

TABLE OF CONTENTS.....	2
1.0 EXECUTIVE SUMMARY	4
2.0 INTRODUCTION	6
3.0 PROJECT OBJECTIVES	7
4.0 METHODOLOGY	8
5.0 PROJECT OUTCOMES	9
6.0 CONCLUSIONS/RECOMMENDATIONS	14
7.0 APPENDICES	15
7.1 Appendix 1 – Educational Pathways (EP) project application	15
7.2 Appendix 2 – EP Project – Year 1 contract.....	15
7.3 Appendix 3 – EP Project – Year 2 original executed agreement	15
7.4 Appendix 4 – EP Project – Year 2 executed variation 1 agreement	15
7.5 Appendix 5 – Milestones 1 & 2 - Delivery to AMPC of evidence of acceptance of scholarship under this project by the 5 th and 6 th students selected for PhD/Master scholarships.....	15
7.6 Appendix 6 – Milestone 3 – Delivery to AMPC of evidence of 1 st year annual academic report for 1 st PhD student.....	15
7.7 Appendix 7 – Milestone 4 - Delivery to AMPC of evidence of acceptance of a scholarship under this project by the 1 st student selected for the Honours scholarship	15
7.8 Appendix 8 – Milestone 5 - Delivery to AMPC of evidence of acceptance of a scholarship under this project by the 2 nd student selected for the Honours scholarship	16
7.9 Appendix 9 – Milestones 6, 7 & 8 – Delivery to AMPC of evidence of 1 st , 2 nd and 3 rd awards for Undergraduate prizes	16
7.10 Appendix 10 – Milestone 9 - Delivery to AMPC of evidence of 1 st year annual academic report for 2 nd PhD student.....	16

7.11 Appendix 11 – Milestone 10 - Delivery to AMPC of evidence of year 2
Postdoctoral position funded under this project by the selected candidate..... 16

7.12 Appendix 12 – Milestone 11 - Delivery to AMPC of evidence of 1st year annual
academic report for 3rd PhD student 16

7.13 Appendix 13 – Milestone 12 - Delivery to AMPC of the 1st Honours student
research completion report/snapshot..... 16

7.14 Appendix 14 – Milestone 13 - Delivery to AMPC of the 2nd Honours student
research completion report/snapshot..... 17

7.15 Appendix 15 – Milestone 14 - Delivery to AMPC of evidence of 1st year annual
academic report for 4th PhD student 17



1.0 EXECUTIVE SUMMARY

The *Educational Scholarship Pathways Program: Creating a Highly Skilled Meat Industry* (EP Project) aims to create a holistic educational program at RMIT University to develop people that will have the skills and knowledge to contribute to the Australian meat industry over the coming decades. The project has been set up as three individual contracts (Year 1 / Year 2 / Year 3) with overlapping goals.

In Year two, the project aims were to: (1) recruit two new PhD students; and set project topics that benefit the red meat industry in Australia and that are in accordance with AMPC's stated research goals; (2) recruit two Honours level research students; (3) continue progress of four PhD students recruited in Year 1 of the EP program; (4) develop the skills of students with coursework at the bachelor degree level and recognition of top students (by providing three undergraduate student scholarships/awards).

The two PhD positions were advertised in November 2017. Following selection process Mr Robert Borcich and Ms Michelle Xu were recruited as successful PhD/Master candidates. Rob was enrolled to a PhD course and offered an AMPC scholarship starting 04/04/2018. However, after taking leave of absence Rob decided to discontinue his PhD candidature due to personal reasons (effective March 2019). Michelle is progressing with her Master (with potential to convert her Master to PhD) and is being funded through an RMIT School of Science Scholarship (started April 2018) as per EP project requirements. The topic of her research is "Biopreservation of meat products – microbial shelf-life extension using bacteriocins and bacteriocin-producing bacteria".

The two Honours students (Ms Alexandra van der Wolde and Mr Jeremy Landry) were recruited this year and have completed their research projects in November 2018. After completing his research project Jeremy applied for the Research Master / PhD at RMIT in meat science related field and was successful in getting RTP Stipend Scholarship for Master of Science (Food Science) with potential to convert into PhD, starting 1st February 2019. He is planning to continue his work on analysis of biomolecular determinants of food quality using Raman spectroscopy.

Three student prizes were awarded to top performing undergraduate students enrolled in their final year for completing a RMIT Bachelor of Science (Food Technology and Nutrition) degree, with best marks in RMIT's Food Manufacturing: Animal Products course. The Award recipients were: Mr Kevion Darmawan, Ms Sandra Salim and Ms Michelle Xu. Ms Xu is continuing her research interests in Meat Science as a Master student in this AMPC funded EP program.

The appointment of Dr Christopher Pillidge (Postdoctoral Fellow appointed on this project) to an academic role at RMIT in June 2018 warranted the Postdoctoral Fellow's position in this project to be re-filled. The position was re-advertised in July 2018. Following screening of 23 applicants by a panel of experts at RMIT, Dr Mandeep Kaur was selected and offered the position. Dr Kaur accepted the offer and started work at RMIT on 1st October 2018.

The 1st PhD student (Ms Patience Shoko) has made a significant progress developing and testing a Raman spectroscopy method for detecting different types of muscles in meat. Results of experiments using broiler chicken as a model system showed that Raman spectroscopy with chemometric analysis can be used to discriminate certain broiler chicken muscles and could discriminate up to four types of tissues. The work on red meat (beef) cuts is currently underway and showing promising results. This suggests Raman spectroscopy could be applied in the red meat processing industry to detect

authenticity of meat cuts.

The focus of Nelum Pematilleke's PhD (2nd PhD student) is to gain "Insights into Development and Processing of Texture Modified Meat Products for People with Dysphagia". This year Nelum studied the effect of cooking conditions on beef meat texture and suitability of instrumental and human sensory methods to evaluate meat textural changes. Results showed that cooking conditions significantly affect the ultimate meat texture, therefore must be considered when processing meat especially for people with swallowing difficulties. Strong correlation existed among instrumental and human sensory data for hardness, chewiness, adhesiveness, juiciness and % water loss. The next stage of the project is looking at the safe swallowing texture of the meat by bolus characterization (trials completed, intensive data analysis is in progress) and optimization of ingredients for texture modification is well underway.

Both Ms Nidhi Jindal (3rd PhD student) and Ms Elena Zafiris (4th PhD student) have successfully completed their RMIT Milestone 1 - Confirmation of Candidature with unanimous panel's decision. The focus of Nidhi's research is the development of oxygen sensitive packaging to extend the shelf-life of retail fresh beef. Ms Elena is planning to elucidate the effect of red meat consumption on human metabolic and gut health in her research.

The first Honours student (Ms Alexandra van der Wolde) investigated the dominating bacterial taxonomic groups of Melbourne retail lamb meat isolated by total viable counts testing. The potential of matrix assisted laser desorption ionisation – time of flight (MALDI-TOF) technology in identifying bacterial taxa associated with red meat was explored and compared with partial 16S rRNA gene sequencing approach. In this study the average TVC on lamb samples obtained from three butchers ranged from \log_{10} 4.4 cfu/g – \log_{10} 5.2 cfu/g. All samples were of good quality in terms of microbial counts, even being at the last point of sale to consumers after going through different stages of processing and storage in the supply chain. The common meat associated bacteria such as *Pseudomonas*, *Staphylococcus* and *Kocuria*, were observed though their dominance varied among three butchers. An excellent agreement was observed between MALDI-TOF and partial 16S rRNA gene sequencing analyses.

The second Honours student (Mr Jeremy Landry) examined the fatty acid composition of intramuscular fat (IMF) of beef eye fillet by gas chromatography (GC), comparing grain-fed and grass-fed animals. The results of GC analysis showed that the concentration of four IMF fatty acids C16:1 (palmitoleic acid), C16:0 (palmitic acid), C18:1 (oleic acid) and C18:0 (stearic acid) did not vary significantly between the grain and grass-fed beef samples. The potential of Spatially Offset Raman Spectroscopy (SORS) was also investigated as a rapid non-destructive alternative method of IMF analysis. Examination of IMF using SORS showed intensity differences among samples with high and low IMF, which may allow the development of SORS based tool to determine beef fat composition in future.

In terms of industry engagement, a presentation on the AMPC Educational Pathways project and progress was given by RMIT EP team members (Peter Torley, Chris Pillidge, Patience Shoko and Nelum Pematilleke) at MI&QA Network Meeting, Victoria, 1st March 2018. The 64th International Congress of Meat Science and Technology (ICoMST; www.icomst2018.com) was held in Melbourne from 12 - 17 August 2018. The conference was attended by the RMIT EP team members (Chris Pillidge, Patience

Shoko, Nelum Pematilleke, Nidhi Jindal, Robert Borcich, Elena Zafiris and Michelle Xu). Ms Shoko and Ms Pematilleke made poster and oral presentations, respectively on their work done in this program. Ms Patience Shoko also attended and presented at the *26th International Conference on Raman Spectroscopy*, 26 -31 August 2018, Jeju, Korea (ICORS 2018; www.icors2018.org). Patience visited Prof Roy Goodacre' lab, Manchester University, UK (15th September – 5th October 2018) to receive hands on training in Chemometrics and Multivariate data analysis. Prof Goodacre is a world leading spectroscopists and long-term collaborator with Prof Ewan. Patience joined the RMIT Europe study tour (15th October – 28th October 2018) to Barcelona and Berlin. This was an educational tour for PhD students to visit scientific centres in Europe and learn about their latest research. A series of workshops were attended during this tour.

Attendance and presentations by RMIT staff and students are planned for the upcoming MI&QA Network Meeting in Melbourne, 2nd May 2019.

Ms Nelum Pematilleke and Ms Nidhi Jindal will attend and present their work at the upcoming *13th International Congress on Engineering and Food*, 23 – 26 September 2019, Melbourne, Australia.

Professor Benu Adhikari, Dr Chris Pillidge and Ms Nidhi Jindal visited the Sealed Air's, the leader in packaging Melbourne site on 11th July 2018.

In consultation with AMPC number of local meat processors have been approached for collaborative work in this program.

An internal RMIT EP project meeting was held on 4th December 2018 to review project progress.

RMIT has expanded the undergraduate teaching component for its animal-based food technologies courses for its Bachelor of Science (Food Technology and Nutrition), Bachelor of Science (Food Technology)/Bachelor of Business (Management) and Bachelor of Science (Food Technology and Nutrition)/Bachelor of Engineering (Chemical Engineering).

Milestone reports 1 – 14 & 15 (current) Year 2 detailing program progress have been submitted to AMPC.

2.0 INTRODUCTION

The *Educational Scholarship Pathways Program: Creating a Highly Skilled Meat Industry* (EP Project) is a three-year program funded by the AMPC, with in-kind co-contributions from RMIT and the Australian Government. The project commenced following signing of the Year 1 Contract on 25 January 2017, following an application made by RMIT University (Request for Proposal #15-C03-04 Implementation of an Integrated Scholarship Program for the Red Meat Processing Industry) in 2015.

The 3-year project is divided into three separate 1-year contracts (the agreed AMPC funding component for year 2 totals \$342,694.00). The program is designed to attract top Australian graduates from a variety of educational backgrounds to gain skills and knowledge (both academic and via industry engagement), enabling and encouraging them to work for the Australian red meat industry of the future.

RMIT University is ideally placed to meet those needs, with a number of existing degree programmes that can supply the needs of the meat industry. Additionally, RMIT offers further options for vocational

training.

The scope of research fields in the original proposal includes the following areas: (1) Understanding the synergistic impacts of meat microbiomes and metabolomes on food safety and quality; (2) full profile characterization of meat product quality; (3) meat quality prediction from live animals to carcass; (4) intelligent active functional packaging for meat; (5) modified atmosphere packaging for beef; (6) automated visual inspection and measurement of whole carcass; (7) meat for an aging population; (7) effect of lairage time and stocking rate on microbial contamination, carcass value and meat quality.

The Year 2 EP project has focused on; (1) recruitment in three capacities - 2 PhD/Master students (3-year degree), 2 Honours students (1-year research project within a degree), and a Postdoctoral fellow; (2) progress the research activities of 4 PhD students recruited in Year 1; (3) rewarding high performance in RMIT undergraduate teaching courses involving Food Technology, by sponsoring 3 student awards.

3.0 PROJECT OBJECTIVES

The objectives of the "Educational Pathways" research program are:

1. To produce graduates that are skilled and experienced in research related to various aspects of meat science and technology. The programme will involve:
 - Research training for RMIT students drawn from various fields of science and technology. The research projects undertaken by these students will address topics of relevance to the meat processing industry.
 - The meat related research training will be at different levels, from honours to PhD.
 - Provide a research training pathway in meat related research for students, from honours to PhD.
 - Select and award undergraduate students a meat technology prizes.
 - Incorporate meat science and technology content into courses taken by bachelor and master's degree students studying food technology programmes at RMIT.
2. Provide incentives and support for students to join and continue the program at all stages of the educational pathway through:
 - The provision of a postdoctoral fellow dedicated to support students, contribute to research, student supervision and industry liaison.
 - The provision of undergraduate student prizes to promote opportunities in meat industry
 - Organizing and supporting industry placements for students.
 - Working with AMPC and meat organisations to identify research topics and provide support for students and industry placements.
 - Providing support to encourage students to continue their research along the educational

pathway from Honours to PhD and undertake meat industry placements.

- Ensuring research supervisors provide strong support and are familiar with meat research priorities and opportunities.
 - The provision of a stipend and consumables for students in the postgraduate scholarship program.
 - Developing and delivering meat science and technology content into bachelor and masters food technology programs.
3. To continue with the four PhD students.
 4. To recruit two new PhD students, two new Honours students and provide three undergraduate scholarships.

4.0 METHODOLOGY

The EP Project began following a successful application to AMPC on 1st May 2015 (Appendix 1). This was in response to AMPC's stating a problem facing the meat industry of the future:

"Minimal uptake of scholarships at the PhD and Postdoctoral level; Ineffective targeting of scholarships and research providers to address key industry capability gaps and achieving critical mass at individual institutions; Difficulties in transitioning tertiary scholarship holders into the industry; and Poor completion rates of industry-based scholarship recipients."

The Year 1 agreement was executed on 25th January 2017 between AMPC and RMIT (Appendix 2).

The project is being led (at RMIT) by Assoc Prof Peter Torley, working with Collaborative Investigators: Profs Benu Adhikari, Ewan Blanch, Harsharn Gill and Mark Osborn. The inaugural EP Project Steering Committee at RMIT comprised Assoc Prof Peter Torley, Prof Harsharn Gill, Prof Mark Osborn, and Ms Jennifer Dick (RMIT Senior Contracts Officer), and the first meeting was held at RMIT on 09/03/2017. Dr Christopher Pillidge (Postdoctoral fellow) joined the Steering Committee later after being appointed on 02/10/2017. The second Steering Committee meeting was held at RMIT on 19/02/2018. RMIT staff in attendance were: Prof Trevor Stevenson (Deputy Dean, Research & Innovation, School of Science), Assoc Prof Peter Torley, Prof Harsharn Gill, Dr Chris Pillidge and Ms Jennifer Dick. AMPC staff attending via teleconference link were: Margaret Tayar and David Lean. MLA staff attending: Ian Jenson.

As Year 1 Milestones 5-9 (for appointment of two Honours students and three undergraduate student awards) were not achieved in 2017 and were deleted from the EP Program (Year 1) by mutual agreement between RMIT and AMPC on 18/12/2017. Also, the appointment of Postdoctoral Fellow (Dr Christopher Pillidge) was delayed in the first year (happened on 02/10/2017 rather in April 2017) resulting in change in Milestones delivery. A formal contract variation was agreed at the 2nd Steering Committee meeting on 19/02/2018. An Executed Variation 1 Agreement came effective on 15th June 2018. The original Year 2 Executed Agreement and Year 2 Variation 1 Agreement are attached here as Appendices 3 & 4. As the change happened in the middle of the year thereby affecting the Year 2 Milestones' details especially Milestones 1, 2, 3, 9 and 10 (Year 2 Executed Variation 1 Agreement). As agreed Year 2 Executed Variation 1 Agreement Milestone numbering and corresponding detail have been reported for Year 2 reporting.

The appointment of Dr Chris Pillidge (Postdoctoral Fellow appointed on this project) to an academic role at RMIT in June 2018 warranted the Postdoctoral Fellow's position in this project to be re-filled. The position was re-advertised, and Dr Mandeep Kaur was selected after the interview and offered the position. Dr Kaur accepted the offer and joined the Steering Committee on 01/10/2018. Ms Jennifer Dick is on extended leave, in her absence Ms Naomi Pavlakis (Contracts Development Manager) is looking after this project.

The PhD and Honours positions were advertised to final-year food technology, biotechnology and engineering students on repeated occasions during 2017/2018, both in the RMIT School of Science (SSCI) and the School of Environmental Health and Engineering (SEH). Recruitment of students by due process proceeded with appointments made. The selected candidates are progressing in their respective industry relevant research projects as indicated in the Project Outcomes section.

5.0 PROJECT OUTCOMES

Milestones achievements for all project milestones are shown below.

Milestone 1: Delivery to AMPC of evidence of acceptance of a scholarship under this project by the 5th student selected for a PhD scholarship

The 5th PhD student (Mr Robert Borcich) was appointed on 04/04/2018. Rob was planned to explore how resident microbiota in abattoir environments change in response to application of cleaning and sanitiser agents using metagenomics techniques. The Milestone 1 report submitted to AMPC on 19/06/2018 (Appendix 5). However, after taking leave of absence Rob decided to discontinue his PhD candidature due to personal reasons (effective March 2019).

Milestone 2: Delivery to AMPC of evidence of acceptance of a scholarship under this project by the 6th student selected for a Master/ PhD scholarship

Ms Michelle Xu was interviewed on 15/02/2018 and selected as a Master student with potential to convert into PhD. Michelle is funded through a RMIT School of Science Scholarship as per EP project requirements, started April 2018. The Milestone report detailing this was submitted to AMPC on 19/06/2018 (Appendix 5). The topic of her research is "Biopreservation of meat products – microbial shelf-life extension using bacteriocins and bacteriocin-producing bacteria". Michelle has completed her literature review and successfully passed her RMIT Milestone 1 Candidature of Confirmation. She is being supervised by Assoc Prof Peter Torley and Dr Christopher Pillidge.

Milestone 3: Delivery to AMPC of evidence of 1st year annual academic report for 1st PhD student

The 1st PhD student (Ms Patience Shoko) started on an AMPC Scholarship on 20/3/2017. Since then she has been working with Prof Ewan Blanch, an expert at RMIT in physical chemistry and Raman spectroscopy. Her project this year has involved developing and testing a Raman spectroscopy method to determine the feasibility of this method for detecting different types of muscles in meat. This is important to establish authenticity of meat products sold, particularly for comminuted meats. Results of experiments using broiler chicken as a model system were reported in Milestone 3 report submitted on 22/05/2018 (Appendix 6). Briefly, results have shown that Raman spectroscopy with chemometric analysis can be used to discriminate certain broiler chicken muscles and could discriminate up to four types of tissues. This suggests Raman spectroscopy could be applied in the red meat processing

industry to detect authenticity of meat cuts. If so, hand-held (portable) Raman spectrometers will be the way of the future. The next stage in the project will involve extending product testing to red meat (beef) cuts.

Milestone 4: Delivery to AMPC of evidence of acceptance of a scholarship under this project by the 1st student selected for the Honours scholarship

Ms Alexandra (Alexa) Jenny Van Der Wolde was the 1st student selected for the Honours scholarship, reported in Milestone 4 report dated 15/05/2108 (Appendix 7). Alex's research project investigated the dominating bacterial taxonomic groups of Melbourne retail lamb meat isolated by total viable counts testing. The potential of matrix assisted laser desorption ionisation – time of flight (MALDI-TOF) technology in identifying bacterial taxa associated with red meat was also explored.

Milestone 5: Delivery to AMPC of evidence of acceptance of a scholarship under this project by the 2nd student selected for the Honours scholarship

Mr Jeremy Landry was the 2nd student selected for the Honours scholarship, reported in Milestone 5 report dated 22/06/2108 (Appendix 8). Jeremy's research project investigated the fatty acid composition of intramuscular fat (IMF) of beef eye fillet by gas chromatography (GC), comparing grain-fed and grass-fed animals. The potential of Spatially Offset Raman Spectroscopy (SORS) was also investigated as a rapid non-destructive alternative method of IMF analysis.

Milestone 6, 7 and 8: Delivery to AMPC of evidence of 1st, 2nd and 3rd awards for undergraduate prizes

The RMIT University School of Science Gala Awards Ceremony 2018 was held on 7th June 2018 at the Storey Hall Auditorium, RMIT University, Melbourne. The AMPC Program Manager for the EP program, Ms Amanda Carter, was invited to the Ceremony, and attended representing the AMPC. RMIT academic staff on the EP project who attended were Assoc Prof Peter Torley (EP program leader), Prof Harsharn Gill, Prof Mark Osborn and Dr Christopher Pillidge. AMPC-sponsored prizes (\$3,000 each) were awarded by Prof Russell Crawford (Executive Dean of the School of Science) to three RMIT students who had been prior selected by senior RMIT academic staff based on their academic performance. They were the top performing undergraduate students enrolled in their final year for completing a RMIT Bachelor of Science in Food Science and Technology degree, with best marks in RMIT's Food Manufacturing: Animal Products course. The Award recipients were: Mr Kevion Darmawan, Ms Sandra Salim and Ms Michelle Xu (combined milestone 6 - 8 report submitted 26/06/2018, Appendix 9).

Milestone 9: Delivery to AMPC of evidence of 1st year annual academic report for 2nd PhD student

The 2nd PhD student Ms Nelum Pematilleke started her studies part-time at RMIT in 2016 and was accepted into a PhD program at RMIT under the supervision of Assoc Prof Peter Torley and Prof Benu Adhikari. On 28th September 2017 she was admitted as a full-time PhD student to work on the EP project. The focus of Nelum's PhD is to gain "Insights into Development and Processing of Texture Modified Meat Products for People with Dysphagia". This year Nelum studied the effect of cooking conditions on beef meat texture and suitability of instrumental and human sensory methods to evaluate meat textural changes. Meat texture is a prominent meat quality attribute and its accurate objective measurement is important to ensure meat's safety and acceptability especially for people

with swallowing difficulties. Texture Profile Analyser (TPA) instead of Warner-Bratzler shear force method was used to measure texture as TPA evaluates not only the tenderness/hardness but also other textural parameters such as cohesiveness, chewiness, springiness and adhesiveness which are considered important quality attributes in determining the overall consumer acceptance of meat. Results showed that cooking conditions significantly affect the ultimate meat texture, therefore must be considered when processing meat especially for people with swallowing difficulties. Strong correlation existed among instrumental and human sensory data for hardness, chewiness, adhesiveness, juiciness and % water loss. However, correlations for springiness and cohesiveness were low, presumably mainly due to variability in the human panel assessments. Using both approaches i.e. instrumental and sensory panel to determine meat tenderness is (nonetheless) preferable. The next stage of the project is looking at the safe swallowing texture of meat by bolus characterization (trials completed, intensive data analysis is in progress) and optimization of ingredients for texture modification and is well underway. The project progress has been reported in Milestone 9 report submitted on 08/01/2019 (Appendix 10).

Milestone 10: Delivery to AMPC of evidence of year 2 Postdoctoral position funded under this project by the selected candidate

Dr Christopher Pillidge was appointed as Postdoctoral Fellow on 2nd October 2017. However, Dr Pillidge was appointed to an academic role at RMIT last year and left the AMPC Postdoctoral role on 29th of June 2018. He continues to be involved in the project through research student supervision. Due to Dr Pillidge's departure, the position had to be re-filled. The position was advertised in July 2018. There were 23 applicants. Following screening of these applicants by a panel of experts at RMIT, Dr Mandeep Kaur was selected and offered the position. Dr Kaur accepted the offer and started work at RMIT on 1st October 2018. Dr Kaur is playing an integral role in project management: organizing AMPC related internal RMIT meetings and follow up on actions; Milestone reporting; planning attending a local meat industry MI&QA network meeting; advertising of scholarships; key involvement in research and supervision for student projects and student mentoring. The report on this milestone achievement was submitted to AMPC on 25/10/2018 (Appendix 11).

Milestone 11: Delivery to AMPC of evidence of 1st year annual academic report for 3rd PhD student

Ms Nidhi Jindal started her PhD at RMIT on 27th November 2017, under the supervision of Prof Benu Adhikari and Assoc Prof Peter Torley. The focus of her research is the development of oxygen sensitive packaging to extend the shelf-life of retail fresh beef. Nidhi successfully completed her RMIT Milestone 1 – Confirmation of Candidature on 9th November 2018. This year Nidhi undertook a number of preliminary trials to evaluate the effect of different antioxidants on the colour stability of minced beef and trials on the effect of different antioxidant/antimicrobial compounds on the colour stability of beef steaks under modified atmosphere packaging (MAP). Preliminary results showed that under overwrap packaging conditions olive leaf extract (0.02% v/w) was more effective in stabilizing the colour of minced beef as compared to rosemary oil (0.02% v/w) and butylated hydroxytoluene (0.02% w/w). However, under high oxygen MAP (80% O₂, 20% CO₂) both olive leaf extract (5% v/v) and chitosan (2% w/v), alone and in combination and lactoferrin (10% w/v) did not have any significant effect on meat colour stability. The project will continue to look at various natural antioxidants to formulate an edible

coating along with different packaging systems to improve the shelf-life of retail beef (Milestone 11 report submitted on 08/01/2019, Appendix 12).

Milestone 12: Delivery to AMPC of the 1st Honours student research completion report/snapshot

Ms Alexandra van der Wolde successfully completed her research project in November 2018 (Milestone 12 report submitted on 08/01/2019, Appendix 13). Alex's research project investigated the dominating bacterial taxonomic groups of Melbourne retail lamb meat isolated by total viable counts testing. The potential of matrix assisted laser desorption ionisation – time of flight (MALDI-TOF) technology in identifying bacterial taxa associated with red meat was also explored. MALDI-TOF is a faster, cheaper and widely used technology for microbial identification. Further, results of MALDI-TOF were compared with widely used partial 16S rRNA gene sequencing approach. Multiple samples from three butchers were analysed on two occasions using Total Viable Counts (TVC) method, as is used by the industry, to determine total bacterial numbers. In this study the average TVC on lamb samples obtained from three butchers ranged from \log_{10} 4.4 cfu/g – \log_{10} 5.2 cfu/g. All samples were of good quality in terms of microbial counts, even being at the last point of sale to consumers after going through different stages of processing and storage in the supply chain. Overall quality of retail lamb meat seemed high. Colonies isolated from TVC plates were selected at random and analysed using MALDI-TOF and partial 16S rRNA gene sequencing. The identification of bacterial taxa was as expected, as common meat associated bacteria such as *Pseudomonas*, *Staphylococcus* and *Kocuria*, were observed though their dominance varied among three butchers. An excellent agreement was observed between MALDI-TOF and partial 16S rRNA gene sequencing analyses. Therefore, MALDI-TOF can be a faster, cheaper and reliable alternative for bacterial identification in red meat provided a dedicated food database is ensured.

Due to time constraints this project looked only a limited number of retailers/samples. Future work targeting extensive lamb retailers could help in establishing a baseline data for retail lamb meat quality in Australia which is overdue for quite a long time now, especially in the wake of changes in processing, storage and supply chain. Further, work on building a MALDI-TOF database dedicated to red meat would be advantageous for maintaining and testing red meat microbial safety and quality as most of the MALDI-TOF data bases currently being populated with clinical isolates rather than food.

Milestone 13: Delivery to AMPC of the 2nd Honours student research completion report/snapshot

Mr Jeremy Landry successfully completed his research project in November 2018 (reported on 08/01/2019, Appendix 14). Jeremy's research project investigated the fatty acid composition of intramuscular fat (IMF) of beef eye fillet by gas chromatography (GC), comparing grain-fed and grass-fed animals. The potential of Spatially Offset Raman Spectroscopy (SORS) was also investigated as a rapid non-destructive alternative method of IMF analysis. The results of GC analysis showed that the concentration of four IMF fatty acids C16:1 (palmitoleic acid), C16:0 (palmitic acid), C18:1 (oleic acid) and C18:0 (stearic acid) did not vary significantly between the grain and grass-fed beef samples. Higher inter sample variance was observed among grass-fed beef. Examination of IMF using SORS showed intensity differences among samples with high and low IMF, which may allow the development of SORS based tool to determine beef fat composition in future. This project also complemented the work being done by Ms Patience Shoko in the EP program on developing Raman spectroscopy to assess different meat muscle types (see Milestone 3 report, submitted to AMPC on 22/05/2018, Appendix 6). It is

anticipated that this integrated research approach will lead to the development of new rapid non-destructive Raman-based methods for red meat quality assessment for industry.

Jeremy applied for the Research Master / PhD at RMIT and was successful in getting RTP Stipend Scholarship for Master of Science (Food Science) with potential to convert into PhD, started early February 2019. He is planning to continue his work on analysis of biomolecular determinants of food quality using Raman spectroscopy.

Milestone 14: Delivery to AMPC of evidence of 1st year annual academic report for 4th PhD student

There was delay in Elena's CoC because of leave of absence (30th October 2018 - 3rd January 2019) due to medical reason, thereby AMPC Year 2 Milestones 14 and 15 (current) reports. The original due dates for Milestones 14 and 15 were 01/02/2019 and 15/02/2019, respectively. This had been discussed with AMPC (Amanda Carter, Program Manager). Elena started her PhD at RMIT on 1st February 2018, under the supervision of Prof Harsharn Gill and Dr Christopher Pillidge. The focus of her research is "Investigations into the immunometabolic modulatory effects of regulated red meat intake in the human holobiont". She has completed critical review of the literature pertaining to the association of dietary red meat and chronic inflammatory disease, dietary red meat and metabolic response in healthy adults and red meat intake and gut health. Research study design has been planned. She has successfully completed the Blood Collection and First Aid trainings. Elena also attended the Metabolomics workshop that covered GC-MS, LC-MS, experimental design, sample preparation, data acquisition and multivariate analysis. She has completed the RMIT Ethics documentation for the Human Research Ethics Committee (HREC) and waiting for Ethics approval for her first study. Elena successfully completed her RMIT Milestone 1 – Confirmation of Candidature on 16th April 2019. The Milestone 14 report has now been submitted to AMPC (Appendix 15).

Milestone 15: 2nd year milestone report, including evidence of industry engagement, and snapshot submitted to and approved by AMPC

The current report. There was delay in submitting this report along with Milestone 14 report as stated above. The reports have now been submitted.

Industry engagement

In terms of industry engagement, a presentation on the AMPC Educational Pathways project and progress was given by RMIT EP team members (Peter Torley, Chris Pillidge, Patience Shoko and Nelum Pematilleke) at MI&QA Network Meeting, Victoria, 1st March 2018. The 64th *International Congress of Meat Science and Technology* (ICoMST; www.icomst2018.com) was held in Melbourne from 12- 17 August 2018. The conference was attended by the RMIT EP team members (Chris Pillidge, Patience Shoko, Nelum Pematilleke, Nidhi Jindal, Robert Borcich, Elena Zafiris and Michelle Xu). Ms Pematilleke and Ms Shoko made oral and poster presentations on their work done in this program, respectively. Ms Patience Shoko also attended the 26th *International Conference on Raman Spectroscopy*, 26 -31 August 2018, Jeju, Korea (ICORS 2018; www.icors2018.org). Patience gave an oral presentation entitled "*Raman Spectroscopy for the differentiation of muscles and tissues in meat using chicken as a model system*". This conference focused on the molecular basis of and latest technological developments in Raman spectroscopy. Like ICoMST it was a major international conference and a

showcase for the latest Raman instrumentation and computer (data analysis) software. This was an opportunity for the team at RMIT to hear of the latest developments in Raman from international experts in the field, and further consider how this can be applied to benefit the Australian meat industry. Like ICoMST AMPC was acknowledged for their support. RMIT funded this conference visit.

During September – October 2018 Patience visited the Manchester University, UK and attended a RMIT funded Europe study tour. Patience visited Prof Roy Goodacre' lab, Manchester University, UK, 15th September – 5th October 2018. Prof Goodacre is a world leading spectroscopists and long-term collaborator with Prof Ewan. While there she received hands on training in Chemometrics and Multivariate data analysis for spectroscopy data, using Matlab software. She also ran experiments using the lab's SORS handheld Raman spectrometer to differentiate British rump steak, Irish rump steak and British organic rump steak. Patience joined the RMIT Europe study tour (15th October – 28th October 2018) to Barcelona and Berlin. This was an educational tour for PhD students to visit scientific centres in Europe and learn about their latest research. A series of workshops were attended during this tour.

Attendance and presentations by RMIT staff and students are planned for the upcoming MI&QA Network Meeting in Melbourne, 2nd May 2019.

Ms Nelum Pematilleke and Nidhi Jindal will attend and present their work at the upcoming 13th International Congress on Engineering and Food, 23 – 26 September 2019, Melbourne, Australia.

Professor Benu Adhikari, Dr Chris Pillidge and Ms Nidhi Jindal visited the Sealed Air, the leader in packaging, Melbourne site on 11th July 2018.

In consultation with AMPC number of local meat processors have been approached for collaborative work in this program. Currently, the program is sourcing research meat samples from two Victorian processors; Gippsland Natural Beef and PJ meats.

RMIT has expanded the undergraduate teaching component for its animal-based food technologies courses for its Bachelor of Science (Food Technology and Nutrition), Bachelor of Science (Food Technology)/Bachelor of Business (Management) and Bachelor of Science (Food Technology and Nutrition)/Bachelor of Engineering (Chemical Engineering) during this year.

Milestone 16: Steering Committee meeting (face to face or video conference)

The Steering Committee meeting was due on 28/02/2019. Due to delay in 2nd Year Milestone reporting the date for this meeting is yet to be confirmed in consultation with AMPC.

Milestone 17: Major Milestone Review – 2nd year review of program progress by AMPC and RMIT

The Major Milestone Review was due on 04/03/2019. Due to delay in 2nd Year Milestone reporting the date for this review is yet to be confirmed in consultation with AMPC.

6.0 CONCLUSIONS/RECOMMENDATIONS

All Milestones for Year 2 have been completed successfully. The Year 3 contract for the project should continue as planned with appropriate AMPC funding.

7.0 APPENDICES

7.1 Appendix 1 – Educational Pathways (EP) project application



AMPC

Full-Research-Propos:

7.2 Appendix 2 – EP Project – Year 1 contract



17100-Torley-AMPC
2016-1027 Yr 1_EXEC

7.3 Appendix 3 – EP Project – Year 2 original executed agreement



19506-Torley-AMPC
2016-1438 Yr 2_EXEC

7.4 Appendix 4 – EP Project – Year 2 executed variation 1 agreement



2016-1438
EXECUTED Variation 1

7.5 Appendix 5 – Milestones 1 & 2 - Delivery to AMPC of evidence of acceptance of scholarship under this project by the 5th and 6th students selected for PhD/Master scholarships



AMPC - 2016-1438 -
Milestones 1 & 2 - 19

7.6 Appendix 6 – Milestone 3 – Delivery to AMPC of evidence of 1st year annual academic report for 1st PhD student



AMPC - 2016-1438 -
Milestone 3 - 220518.

7.7 Appendix 7 – Milestone 4 - Delivery to AMPC of evidence of acceptance of a scholarship under this project by the 1st student selected for the Honours scholarship



AMPC - 2016-1438 -
Milestones 4 - 150518

7.8 Appendix 8 – Milestone 5 - Delivery to AMPC of evidence of acceptance of a scholarship under this project by the 2nd student selected for the Honours scholarship



AMPC - 2016-1438 -
Milestone 5 - 220618.

7.9 Appendix 9 – Milestones 6, 7 & 8 – Delivery to AMPC of evidence of 1st, 2nd and 3rd awards for Undergraduate prizes



AMPC - 2016-1438 -
Milestones 6 7 & 8 - 2

7.10 Appendix 10 – Milestone 9 - Delivery to AMPC of evidence of 1st year annual academic report for 2nd PhD student



AMPC-2016-1438 -
Year 2 Milestone 9 report

7.11 Appendix 11 – Milestone 10 - Delivery to AMPC of evidence of year 2 Postdoctoral position funded under this project by the selected candidate



AMPC - 2016-1438 -
Milestone 10 report_2

7.12 Appendix 12 – Milestone 11 - Delivery to AMPC of evidence of 1st year annual academic report for 3rd PhD student



AMPC-2016-1438 -
Year 2 Milestone 11 report

7.13 Appendix 13 – Milestone 12 - Delivery to AMPC of the 1st Honours student research completion report/snapshot



AMPC-2016-1438 -
Year 2 Milestone 12 r

7.14 Appendix 14 – Milestone 13 - Delivery to AMPC of the 2nd Honours student research completion report/snapshot



AMPC-2016-1438 -
Year 2 Milestone 13 r

7.15 Appendix 15 – Milestone 14 - Delivery to AMPC of evidence of 1st year annual academic report for 4th PhD student



AMPC-2016-1438 -
Year 2 Milestone 14 r

