



**Australasian
Pork Research
Institute Ltd**
APRIL

**DEVELOPMENT OF A ‘HEALTHY PORK’
RESOURCE FOR USE BY CONSUMERS, HEALTH
PROFESSIONALS AND REGULATORY BODIES:
SUMMARY AND DISSEMINATION OF PORK CRC
HUMAN NUTRITION RESEARCH**

3B-114

**Final Report prepared for the
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Executive Summary

The global prevalence of obesity continues to rise and what is of major health concern is that obesity clusters with other conditions including type 2 diabetes, hypertension, hypercholesterolemia, and chronic diseases like cardiovascular disease, depression, cancers and non-alcoholic fatty liver disease. Coronary heart diseases and dementia are the leading killers in Australia and are largely modifiable by diet and lifestyle choices (1). In the latter part of the decade, there has been a push in Western countries to move towards a pre-dominantly plant-based diet. The United States Dietary Guidelines adopted the Mediterranean diet (MedDiet), a predominantly plant-based diet rich in vegetables, fruit, grains, nuts, fish, olive oil with moderate amounts of dairy, poultry and low levels of red meat and discretionary foods, as one of three healthy dietary patterns in their recent 2015-2020 dietary guidelines (2). Similarly, Canada's Dietary Guidelines released in 2019 reflects a predominantly plant-based eating pattern (3). In Australia in August 2019, the Heart Foundation released revised guidelines for heart-healthy eating (4). These guidelines were largely based on robust scientific evidence from research focused around plant-based diets including the MedDiet and the DASH diet (Dietary Approaches to Stop Hypertension), a pattern designed for healthy blood pressure (5).

The Heart Foundation introduced a recommendation of < 350g (or 1-3 serves) a week for fresh, unprocessed red meat including pork, beef, lamb and veal, together with encouraging consumption of legumes, nuts, fish and lean poultry as well as choosing healthy unsaturated fats like olive oil, a combination of regular and low-fat dairy foods and limiting the amount of discretionary foods.

Despite the recent push towards the consumption of predominantly plant-based diets for greater benefits to overall human health and environmentally friendly diets, lean fresh meat offers key nutrients and does not have to be eliminated from plant-based dietary patterns. Pork is the most commonly consumed meat globally. It has a lower carbon footprint than beef, and contains protein, amino acids, thiamine, niacin, zinc and vitamin B12, key nutrients important for human growth and development and healthy ageing. Whilst dietary recommendations advise us to lower or eliminate consumption of processed meats due to the link with heart disease and cancers, there is no valid reason why unprocessed fresh lean pork from our diets should be excluded. Interestingly, Australians prefer beef and chicken and eat very little fresh pork. Whilst the reason is not entirely clear, it could be a result of myths related in general to the pork industry, unfamiliarity with cooking pork, as well as (perceived) taste and preference.

The Pork Cooperative Research Centre funded 16 projects under the Healthy Pork Consumption program from 2005 to 2019 with the aim to explore potential health benefits of pork and drivers and barriers to consumption. Together this research shows that there were no adverse effects of pork consumption, but may help with cardiometabolic health, type 2 diabetes mellitus, weight loss and maintenance and preservation of cognition as part of healthy dietary patterns.

The aim of this project was to summarise the 16 funded projects and to subsequently develop resources presenting key information on fresh pork consumption for dissemination to key stakeholders.

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1. Introduction

Background and rationale for conducting the research

Despite being the most commonly consumed meat in the world, in Australia, the consumption of pork is behind that of chicken and beef/veal (OECD) [1]. Pork has typically received a poor reputation towards human nutrition and good health in the past. Considered in the past a fatty unhealthy meat, concerns around housing of animals, use of antibiotics, queries relating to the inhumane treatment of pigs and taste and olfactory issues could well have influenced the lower consumption of fresh pork. However, poor consumer knowledge of the nutritional value of fresh pork together with inexperience in cooking pork for optimal enjoyment may have also played significant roles in consumption rates.

The Pork CRC has made a significant financial investment in nutrition research over the life of the Pork CRC resulting in 16 reports on the effects of pork consumption on various aspects of human nutrition and health. In this regard, it is timely to summarise and disseminate this information to the wider community to:

- 1) Offer Australian consumers an informed opportunity to choose to eat fresh pork;
- 2) Educate dietitians and health professionals on the benefits and lack of adverse effects of consuming fresh lean pork as part of a healthy dietary pattern; and
- 3) Provide scientifically substantiated information to regulatory bodies on the health benefits of including fresh lean pork in diet for consideration when revising dietary guidelines and diet and health-related messages.

What is also necessary is education on the safe preparation and handling of pork and methods for cooking fresh pork to provide a tasty tender product to enhance the dining experience.

There is no reputable simple resource for dietitians and health professionals to refer to on the health benefits of fresh pork.

Nutrition and health information is constantly evolving and nutrition messages are changing, leaving the simple message of what constitutes an ‘optimal diet’ sometimes unclear. Despite the specialised role dietitians play with delivering simple and condition-specific dietary information, general practitioners are still a source of nutritional advice for many patients. The GPs, cardiologists, allergists, rheumatologist etc. are often plagued with many questions around diet and lifestyle; however, doctors receive limited training in diet and nutrition. They are likely to obtain their dietary knowledge from the National Health and Medical Research Council’s Australian Guide to Healthy Eating or websites like the Heart Foundation of Australia to provide general dietary information. They are not up to date with the latest nutrition research.

Similarly, whilst dietitians have access to far greater resources relating to the delivery of dietary advice for general healthy eating or medical nutrition therapy, many are not up to date with the latest research findings. This identifies an ideal opportunity to provide a resource highlighting research outcomes showing the health benefits of consuming fresh lean pork, comparing pork with other meat proteins; the role including pork in a dietary pattern plays with disease management and disease risk; and information on how to prepare and cook pork and reference on where to find more information.

2. Methodology

A summary of the 15 available Pork CRC funded projects (3A-106 could not be obtained) was prepared. From this summary, research findings and conclusions accurately drawn and relevant to health care professionals and the general consumer were summarised in a resource booklet. The booklet was prepared to be a standalone resource for health professionals to read to understand the latest health evidence around the nutritional benefits of including fresh lean pork in the diet. Relevant information was provided by Australian Pork Limited relating to cooking methods and recipe ideas.

The following projects were summarised:

3A-106 (final report not available, summary only)

3A-111

3B-102

3B-103

3B-104

3B-105

3B-106

3B-107

3B-108

3B-109

3B-110

3B-111

3B-112

3B-113

3B-114

3C-105

3. Outcomes

Introduction

Nutritional composition of Pork (Project 3B-112)

Changing pig production management systems, such as breeding practices and nutrition and feeding regimes, brings potential changes to the nutritional composition of pork meat. Given that pork is part of a key food group that delivers important nutrients, there is a need to track the nutrient content of pork to maintain accurate data in Australian food composition databases to support health and nutrition claims as well as for consumer education and for health professionals including dietitians and nutritionists in practice. Project 3B-112 sought to determine the current nutrient composition of pork meat for comparison with previous analyses over a decade ago (6). Raw and cooked portions of pork fillet, loin steak and scotch fillet were obtained from four different producers across Australia. Pork pieces were cut according to current specifications for retail customers, vacuumed packed and stored chilled prior to analyses. Pork samples were analysed according to standardised international procedures to determine moisture, ash, protein, minerals, thiamine, fat and fatty acids, and cooked pork was prepared to reflect general household practice. Results from *raw* pork samples only are summarised below.

Current composition of fresh (raw) pork

Overall, there was little difference in energy and nutrients between the three cuts of pork (Table 1). Moisture content varied slightly between raw cuts due to the different fat content, but was not significantly different and there was no real difference in ash, nitrogen or protein content between all cuts.

Interestingly, iron varied significantly amongst pork samples most likely due to the different types of muscle fibres seen in each cut. Scotch fillet contained the highest amount of iron followed by pork fillets then loin steaks.

Similar to iron, thiamine varied between the pork fillet, loin steak and scotch fillet where fillets had the highest level followed by loin steak and scotch fillet. As expected, there were difference in fat content between the three pork cuts, with the pork fillets being the leanest.

Saturated fatty acids (SFA) and monounsaturated fatty acids (MUFA) were the predominant fats in pork cuts. Palmitic acid was the most prominent SFA in all three raw pork cuts, followed by stearic acid and myristic acid. Oleic acid was the predominant MUFA and omega-6 linoleic acid was the predominant polyunsaturated fatty acid (PUFA).

Table 1. Summary of energy, moisture, ash and nutrient content of pork samples.

	Unit	Pork Fillet	Loin Steak	Scotch Fillet
Energy	kJ/100g	560±27	993±55	934±33
Moisture	g/100g	74±2	67±4	70±1
Ash	g/100g	1.2±0.03	1.0±0.1	1.1±0.1
Nitrogen	g/100g	3.4±0.1	3.2±0.2	3.0±0.1
Protein	g/100g	20.9±0.6	19.7±1.4	18.8±0.5
Fat	g/100g	5.6±0.5	17.8±0.9	16.6±0.7
Iron	mg/100g	1.62±0.32	0.83±0.15	1.74±0.15
Zinc	mg/100g	1.57±0.19	1.05±0.10	2.85±0.22
Sodium	mg/100g	48.7±3.7	45.2±5.4	56.7±5.4
Thiamine	mg/100g	1.22±0.04	1.03±0.12	0.82±0.07
SFA	%	44±1	43±2	43±1
MUFA	%	43±1	48±1	45±1
PUFA	%	12±2	9±2	12±1

Values are mean ± SD wet weight, n=4, with the exception of SFA, MUFA, PUFA which are % and n=3.

Compared with previous analyses

Project 3B-112 compared current results with previous compositional analyses conducted in 2006 by Greenfield and colleagues (6).

Moisture content was similar to previous analyses from 2006, with the exception of the loin steak most likely due to the variable fat content. Similarly, ash was no different except for pork fillet which was lower in the more recent analyses. Small but insignificant differences in nitrogen and protein content were noted compared with previous analyses.

There was a notable increase in iron levels in pork cuts compared with previous analyses which is possibly attributable to affirmative pig farming practices over the last decade, including new feeding regimes to deliberately increase the nutritional value, particularly the iron content of pork. Similarly, thiamine content was ~122% higher in the loin steak and scotch fillet compared with previous analyses, despite the higher fat content seen in the pork cuts. Since the last analyses, there appears to be an increase in the fat content of pork, but the amount of trimming in sample preparation could likely explain some of this difference.

Notably since 2006, SFA had increased and MUFA decreased in the pork fillet. SFA and MUFA both increased in loin steak whilst SFA was lower in the scotch fillet.

Summary note:

The nutritional profile of pork meat over the last decade doesn't appear to have changed significantly with changing pig production management systems. Difference between iron and thiamine have significantly changed possibly due to affirmative pig farming practices to enhance the nutritional content of pork. Pork remains a key source of protein, is lean depending of cut and extent of trimming and contributes to recommended dietary intakes for iron, zinc and thiamine.

Pork Consumption in Australia (Project 3B-109)

Two projects were conducted to determine level of pork consumption of Australian men, women and children through a secondary analysis of the Australian Health Survey.

The 2011-2013 Australian Health Survey (AHS) (7) is the first representative nutrition and health survey to be conducted in Australia since the 1995 National Nutrition Survey. Whilst considered somewhat outdated now by dietitians and other health professionals, it is the most recent information available that reports food and nutrient intake for a representative population of Australians. In brief, the AHS consists of a National Nutrition and Physical Activity Survey (NNPAS) component with detailed food consumption data from 12,153 individuals aged 2 years and over. To explore pork consumption levels, the authors conducted a secondary analysis of the dietary data splitting pork into fresh pork, processed pork and mixed dishes. They further identified individuals who were pork consumers and non-pork consumers.

On the day of the survey, 37% of the population (n=4,501) reported consuming pork. Of those individuals that reporting consuming pork, 21% reported consuming fresh pork, whilst 86% reported consuming processed pork. The mean consumption of all participants (n=12,153) of total pork on that day was 22 g (SD 29 g) or 0.3 serves of pork (1 serve = 65 g raw), fresh pork 7 g (SD 36 g), processed pork 10 g (SD 29 g), mixed dishes with fresh pork 2 g (SD 13 g) and mixed dishes with processed pork 5 g (SD 16 g). For pork consumers (n=4,501), the mean consumption of total pork on that day was 59 g (~1 serve) (SD 64 g), fresh pork 21 g (SD 57 g), processed pork 38 g (SD 44 g), mixed dishes with fresh pork 5 g (SD 21 g) and mixed dishes with processed pork 12 g (SD 24 g).

Men consumed significantly more pork than women, and when restricted to pork consumers, men consumed significantly higher amounts of total pork and processed pork than women. Two-to-three-year-olds consumed the least amount of pork, whilst 14-18-year olds consumed the highest amount of pork. Interestingly, processed pork like ham (78 ± 46 g) and bacon (30 ± 29 g) were the most commonly consumed pork product. Of fresh pork, loin pork was the most commonly consumed fresh pork cut on the day of the survey (110 ± 64 g). Of interest, those individuals who were fresh pork consumers were more likely to meet their dietary requirements for protein, fibre, thiamine, niacin, vitamin B6, iron, zinc and selenium, than those who were non-consumers.

Summary note:

Overall, 37% of the population reported consuming pork, of which less than a quarter consumed fresh pork (average 21 g/d) and just over three quarters consumed processed pork (average 38 g/d). Pork consumers were more likely to be men, aged between 4 and 50 years, reside in major cities and born in Australia. Those who were fresh pork consumers were more likely to meeting dietary recommendations for protein, fibre and several other micronutrients.

Pork Consumption in the Diets of Australian Children

(Project 3B-106)

Childhood is a period of growth and development requiring vital nutrients including protein, fats, carbohydrate as well as vitamins and minerals to facilitate this process. Pork contains many of these key nutrients for growth and development but previous outdated estimates of pork intake in children indicate, like in adults, is not commonly consumed.

Previous estimates of pork consumption in children between 1983 and 2003 have ranged from an average of 7-44 g per day; however, dietary habits of children have changed together with the Australian food supply. To gain a better understanding of eating habits including fresh and processed pork consumption in children, Project 3B-106 undertook a secondary analysis of the 2007 Australian National Children's Nutrition and Physical Activity Survey in 4,487 children aged 2-16 years. Further, the project sought to explore relationships between children's pork consumption and body composition.

The 2007 Australian National Children's Nutrition and Physical Activity Survey is the most recent and representative survey of children aged 2-16 years (8). The survey was conducted in 2007 and randomly selected children to participate via random digit dialing. Dietary data was collected via two standardised, computer-based; 24-hour recalls which collected dietary information over the 24 hours prior to the assessment. For children aged 2-8 years, the 24-hour recall was completed by their primary care-giver, whilst children aged 9 years and older completed the 24-hour recall themselves. To explore pork intake, the authors conducted a secondary analysis of the dietary data splitting pork into fresh pork, processed pork and mixed dishes. They further identified children who were pork consumers and non-pork consumers.

A total of 4,487 children was randomly surveyed. Nearly half of the children ($n=2,245$) reported eating some type of pork; however, only 14% of these consumers reported consuming fresh pork compared with 93% consuming processed pork. Of the children who ate pork, most reported eating processed pork, most commonly eaten was ham and bacon, whilst only 7% of children reported eating fresh pork. Pork was most commonly consumed for lunch, within the home.

The average consumption of all participants (n=4,487) of total pork was 16g (SD 27 g), fresh pork 3 g (SD 16 g), processed pork 13 g (SD 21 g), mixed dishes with fresh pork 0.3 g (SD 5 g) and mixed dishes with processed pork 1 g (SD 5 g). However, when only pork consumers were included (n=2,245), the amount of pork consumed doubled. The average consumption of total pork was 32 g (SD 30 g), fresh pork 6 g (SD 22 g), processed pork 26 g (SD 24 g), mixed dishes with fresh pork 0.7 g (SD 8 g) and mixed dishes with processed pork 2 g (SD 6 g). The most common pork that was eaten by children, was ham (43%) and bacon (16%).

Boys appeared to consume significantly higher amounts of total pork and processed pork than girls and children aged 4-8 years were the highest consumers of total pork. In pork consumers only, those aged 14-16 years were the highest consumers of total pork.

Where cultural background of carers was explored, fewer children who consumed pork had a primary carer born in Africa or the Middle East, compared to Australia, Europe and the United Kingdom. Further, more children who reported eating fresh pork had a primary carer born in Asia compared to Australia, Europe and the UK.

Children who reported eating pork had greater intakes of protein, phosphorous and zinc than children who did not eat pork. Moreover, in children that ate pork, pork contributed substantially to the intake of thiamine (15% of recommended intake), protein (13%), long chain omega-3 polyunsaturated fats (12%), niacin (10%), zinc (9%) phosphorous (7%) and potassium (6%). When looking at the contribution to childrens' estimated average dietary requirements (EAR), children who ate pork were more likely to meet their nutritional requirements for protein, calcium, iron, thiamine, riboflavin, phosphorous, zinc and iodine than children who did not eat pork. Fresh pork contributed to 53% of the EAR for niacin, 45% for protein, 41% for thiamine, 21% for zinc, 14% for long chain omega-3, 13% for phosphorous and 12% for riboflavin.

Despite finding that children who ate pork had a greater energy, total fat and saturated fat intake than children who did not eat pork, there was no difference in weight, waist circumference, or prevalence of overweight/obesity (categorised using body mass index) between children who ate pork and those who did not.

Summary note:

Overall, 50% of the children surveyed reported consuming pork, mostly ham and bacon, of which only 14% consumed fresh pork whilst 93% consumed processed pork. Of the children that consumed pork, fresh pork and processed pork was consumed in daily amounts of 6 g and 26 g, respectively. Pork consumers were more likely to be boys, aged 14-16 years, and have a primary carer born in Asia. Those who were fresh pork consumers were more likely to meeting dietary recommendations for protein, omega-3 fats, and several other micronutrients. Even though children who were consuming pork had higher energy and fat intake, they did not have higher weight or adiposity than children who did not consume pork. The demographic of the population of pork consumers and non-consumers, for men, women and children, is of interest to explore and target further marketing and education opportunities.

Cardiometabolic Health

(Projects 3A-104, 3A-111, 3B-102, 3B-113, 3B-107, 3B-110)

Weight loss and body composition

Historically, pork has received an unhealthy image as a fatty meat which could raise blood cholesterol and lead to heart disease, which may in part have influenced the low levels of consumption reported in Australia. However, the nutritional profile of fresh pork is comparable to that of beef and is leaner than lamb. Despite a global push towards recommendations for predominantly plant-based diets, most current dietary guidelines recommend moderate consumption of lean meat to deliver key nutrients like protein and vitamins and minerals including thiamine, niacin, zinc and vitamin B12. In the last 20 years, high protein diets have been used as a weight loss strategy as they appear to promote greater satiety, reduce energy intake and also improve overall cardiometabolic health. Much of the focus of high protein diets was around beef, with little attention given to other meats including pork.

Several studies have now shown that fresh pork has no adverse effects on health, but in contrast can help with weight loss, type 2 diabetes management of glycaemic control, blood pressure and metabolic response following regular consumption (Pork CRC Research outcomes).

The Pork Health Study (3A-104) explored the effect of regular fresh pork consumption on body composition and cardiometabolic health in 144 overweight men and women. Half the participants incorporated up to 1 kg of fresh lean pork into their habitual diet weekly for 6 months by substituting for mainly beef and chicken, whilst the other half followed their habitual diet. There was no change in cardiometabolic parameters, but after just 3 months, without energy restriction or change to physical activity levels, the pork group had significant reductions in weight, body mass index (BMI), waist circumference, % body fat, fat mass and abdominal fat compared with the control group, which was maintained at 6 months. What could not be confirmed from this study, if the results were specific to pork.

To further explore this outcome, a subsequent study was undertaken (3A-111) comparing regular consumption fresh lean pork with the two then most commonly consumed meats in Australia, beef and chicken. Forty-nine middle-aged (50 ± 2 yrs), overweight (BMI 30.5 ± 0.5 kg/m²) men and women consumed between 5-7 serves of each meat into their diet weekly. Women consumed 5 serves and men 7 serves weekly of pork for 3 months, then beef and chicken for a further 3 months each. Following the intervention, pork was equally as healthy as beef and chicken as there was no difference between meats on indices of adiposity nor were there any differences in energy or nutrient intakes.

Similarly, in Project 3B-110, 5-7 serves of fresh lean pork (750 g for women, 1 kg for men), was incorporated into the habitual diets of 26 men and women with type-2 diabetes mellitus (T2DM) (67.8 ± 6.4 years; BMI 32.4 ± 5.2 kg/m²), weekly for 4-weeks. Whilst there was no change in glycaemic control or blood lipid levels, there was a small but significant reduction in percentage body fat (-1.1%) and a concomitant increase of muscle mass (+0.6 kg) after 4-weeks of the intervention. This change in body composition was despite a significant increase in energy intake from 7.6 MJ to 8.7 MJ per day as well as saturated fat and carbohydrate and non-significant increases in protein (104 g to 118 g per day) and total fat. It is possible that the increase in protein may have led to small insignificant increases in muscle hormones like irisin, or peptides promoting muscle synthesis, but further research in this area is required.

Type 2 Diabetes Mellitus

Cornerstone management for T2DM is weight loss combined with regular physical activity. High-protein diets have been successfully used to promote weight loss particularly when combined with resistance training (9). Commonly high-protein energy restricted diets include around six 200 g portions of lean red meat (beef or lamb); however, pork has similar nutritional properties to beef, but has not been studied until now. The EDDi study, Project 3B-102, compared energy-restricted high-protein diets with either high-pork protein or low-pork protein for 12-weeks for weight loss then again for 12-weeks for maintenance of weight that was lost, combined with regular moderate physical activity in 61 overweight individuals (BMI 34 ± 5 kg/m²) with borderline poor glycaemic control (HbA1c $8.1 \pm 1.4\%$). Forty-four volunteers completed the trial and analyses were conducted on an intention-to-treat basis.

Individuals following the high-pork protein weight loss diet (31% protein: 33% carbohydrate: 30% fat) consumed 200 g fresh lean pork four times a week whilst the low-pork protein weight loss diet (22% protein: 52% carbohydrate: 20% fat) consumed 100 g fresh lean pork four times a week. With high compliance to both diets (>90%), the high-pork protein diet group lost nearly 7 kg (SD 0.7 kg) over the 12 weeks and was maintained during the weight maintenance period. Similarly, the low-pork protein group lost 5.5 kg (SD 0.6 kg) over the 12 weeks which was also maintained for a further 12-weeks. Both groups also achieved improvements in glycaemic control (HbA1c, insulin and blood glucose levels), blood pressure, inflammatory marker C-reactive protein, total cholesterol, low density lipoprotein cholesterol and triglycerides during the weight-loss phase.

The results from the EDDi study showed that energy-restricted, high- and low-pork protein diets, combined with regular moderate exercise, results in improvements in body weight, glycaemic control and cardiometabolic health outcomes in individuals with T2DM. This also provides further evidence that pork can be part of a healthy dietary pattern, one that contains not only fresh pork, but grains, dairy foods, fruit and vegetables, as well as legumes, nuts and healthy oils and result in improvements to cardiometabolic health.

Summary note:

Fresh pork can be included as part of a healthy dietary pattern and appears to be no different to beef or chicken. Regular consumption of fresh pork can help with improvements to cardiometabolic health such as adiposity, body composition, glycaemic control, blood pressure, blood lipids and inflammation.

Amino acid response (Project 3B-103)

Weight loss as well as improved cardiometabolic health as a result of following a high protein diet, as seen in the EDDi study, may be due to reduced oxidative stress and inflammation, increased satiety and influence on satiety related hormones as well as mobilisation of amino acids. Project 3B-103 explored the effect of consumption of a pork meal compared with a chicken meal on acute plasma amino acid responses post-prandially. In 10 young adults (average 25 years) with acceptable BMI (20.8 kg/m²), consumption of a chicken meal resulted in an increase in plasma amino acids valine and leucine+isoleucine. However, the pork meal resulted in a sustained increase in plasma histidine. Histidine may play a role in decreasing appetite but also in improved metabolic profile through reductions in oxidative stress and inflammation, which provides a potential mechanism of benefit for the use of high pork protein diets possibly for chronic disease management.

Pork and Predominantly Plant Based Diets (Project 3B-113)

In recognition of the push for predominantly plant-based diets with lower meat contents, Project 3B-113, the MedPork study, incorporated fresh lean pork into the world's current number one dietary pattern, the MedDiet (10). The Mediterranean diet is characterized by the high consumption of extra virgin olive oil, fruits, vegetables, grains, legumes and nuts; moderate consumption of fish, poultry, eggs and dairy; and low consumption of red meat and discretionary foods. Epidemiological and large clinical trial data confirm that the MedDiet is significantly associated with reduced risk of mortality, cardiovascular disease (CVD) and dementias (11). As a result, the United States Dietary Guidelines adopted the MedDiet as one of three healthy dietary patterns. Similarly, the Canadian dietary guidelines have moved towards plant based dietary recommendations and Australia's heart foundation has released new dietary recommendations based on the Mediterranean and DASH diets. Further, data from our Australian trials also confirm that the MedDiet is a feasible diet to follow in non-Mediterranean countries and can result in significant CVD risk factor reduction as early as 8-weeks and up to 6-months (MedLey and MedDairy). However, earlier research suggests that an Australian population may find red meat restrictions difficult, which could affect long-term sustainability of the diet in a Western population. Previous research has shown lean pork is equally as healthy as red meat and chicken, the two most commonly consumed meats in Australia, and there are no adverse effects to health with regular fresh pork consumption. It is lower in saturated fat than beef and may offer a suitable alternative meat protein source to red meat in a MedDiet pattern for Australians.

In this project, red meat and poultry was substituted with 2-3 weekly serves of fresh pork in a MedDiet pattern. Thirty-three men and women at risk of CVD followed the MedPork dietary pattern for 8-weeks followed by a low-fat diet for a further 8-weeks, separated by an 8-week washout period. Compliance to the MedPork diet was 93% and led to a significant improvement in diet quality with an increase in consumption of legumes, seafood, nuts and extra virgin olive oil and 2.7 serves of fresh pork per week. Whilst there were no statistically significant differences between the dietary groups, sensitivity analyses showed a significant reduction in systolic blood pressure and pulse pressure, leading risk factors for CVD, in participants who were overweight after the MedPork phase. Whilst these results look promising, it is possible that the current study failed to detect significant changes in cardiovascular measures due to the short duration of interventions despite evidence from other studies demonstrating changes in these outcomes over 8-weeks. Nevertheless, these findings indicate that 2-3 serves of fresh, lean pork can be included as part of a healthy Mediterranean dietary pattern without adverse health effects, but in fact could have beneficial health effects in overweight individuals on vascular function, particularly blood pressure, a key risk factor for CVD.

Lipemic Response (Project 3B-107)

Because pork has traditionally received an unfavourable image around its fat content and the link with fat, particularly saturated fat and heart disease, it may have been eliminated from Australian diets. Scientific evidence is building to show that pork appears to be no different to other meats like veal (12), beef, poultry and fish (12, 13) in terms of influence on blood cholesterol, triglyceride and lipoprotein cholesterol levels.

Project 3B-107 compared pork mince with lamb mince, matched for fat content, on the post-prandial lipemic response. The lipemic response is a transient accumulation of circulating blood lipids, mainly triglyceride-rich lipoproteins, in the post-meal state (14). An elevated and

prolonged response is associated with an induced pro-atherogenic state because of adverse effects on lipoprotein remodelling, inflammatory pathways, hemostatic variables and endothelial integrity (15). The Western diet, characterised by a pattern high in salt, added sugars and saturated fat, has been shown to elicit an elevated and prolonged lipemic response (16), a CVD risk factor that needs modification given coronary heart disease is the number one killer of Australian men.

The authors provided 18 men and women, mean age 31 ± 2 years, with normal blood cholesterol levels, a sandwich with either pork or lamb mince, matched for fat content, and collected blood samples over a 6-hour period. There was no difference between meats on the lipemic response, but there was a trend for a lower lipemic index following the pork meal compared with lamb. This trend was not significant most likely due to the small number of participants.

Summary note:

There was no adverse effect of regular fresh pork consumption on blood lipid and lipoprotein levels. Moreover, regular fresh pork consumption may promote a sustained increase in plasma histidine and contribute to reduced oxidative stress and inflammation which are key pathways in the pathogenesis of chronic disease including CVD. Further, fresh pork as part of a predominantly plant-based dietary pattern could improve vascular function including blood pressure in overweight individuals. These findings add further support for potential health benefits of lean fresh pork and to dispel the myths that pork is a fatty unhealthy meat and should be avoided.

Cognition and Wellbeing

(Projects 3B-102, 3B-104)

Natural age-related changes in cognitive function is expected across the lifespan; however, accelerated cognitive decline or mild cognitive impairment may increase the risk of dementia or Alzheimer's disease. Long-term pharmacological therapy to treat cognitive decline and dementia is almost non-existent, but healthy lifestyle choices can help maintain cognition and prevent premature cognitive decline. In addition to healthy lifestyle choices, there are many dietary components which are thought to maintain or improve cognitive function. These include B-group vitamins including folate and thiamine, Vitamin E, C, selenium, flavonoids, carotenoids and omega-3 fats (17). Further, the presence of chronic conditions like T2DM and CVD is thought to reduce cognitive performance and increase risk of dementia. Moreover, research has suggested that individuals with T2DM may experience cognitive decline, poorer memory and psychomotor speed, than their non-diabetic counterparts.

Fresh pork contains B group vitamins including thiamine as well as selenium which may help to maintain or improve cognition. Three studies explored the effect of pork consumption on cognition and wellbeing. The EDDi study, Project 3B-102, as described above, provided 61 diabetics with either a high or low-pork protein diet for 12-weeks on a hypocaloric diet, then a further 12-weeks to maintain weight loss. Project 3B-104 provided retired living individuals with pre-prepared meals for 12 weeks and measured cognition. The MedPork Study, Project 3B-113, compared a MedDiet containing fresh pork with a low-fat diet for 8-weeks in a cross-over design. The EDDi study and 3B-104 found no improvement or decline in cognitive performance over the duration of the studies. This was most likely due to the cognitively healthy nature of the individuals, trial duration in both studies and perhaps due to somewhat adequately

controlled blood glucose levels in the EDDi study. Despite no changes in cognition in the EDDi study, participants on both pork protein diets resulted in improved diabetes related stress, quality of life, general health, vitality and quality of sleep.

Interestingly, when pork was included as part of a MedDiet in high CVD risk individuals, in the MedPork study, there was change in cognition. After 8 weeks, compared with a low-fat diet, the MedPork group which was supplemented with on average 2.7 serves of fresh pork per week within the MedDiet, resulted in better processing speed, a cognitive domain of attention following the MedPork intervention, but worsened following the low-fat intervention. Positive trends were observed for mood following the MedPork intervention, with improvements in Depression and Total Mood Disturbance, approaching statistical significance. It is difficult to say that a single food or nutrient is responsible for improvements in health outcomes as foods are eaten as part of a whole diet and not in isolation. The nutrients in fresh pork, combined with a MedDiet pattern rich in nutrients that are 'brain-healthy', could result in maintained or improved cognitive performance and potentially significant reduced risk for development cognitive impairment or dementia later in life.

Summary note:

Fresh pork as part of a dietary pattern may help preserve cognition to avoid cognitive impairment and may help improve mood, quality of life, vitality and quality of sleep.

Muscle and Strength

(Project 3B-104)

Loss of both muscle mass and muscle strength are prominent features of the aging process, and it has been shown that adequate protein intake, together with maintenance of resistance exercise training are important predictors of muscle strength in older adults. With ageing comes a reduction of total body protein including skeletal muscle and physiologic proteins (18). In previous research in elderly populations, a high intake of protein, especially when combined with adequate physical exercise, is associated with a higher proportion of skeletal muscle mass and improved functional performance (19). The quality and type of protein is an important consideration for optimising protein intake for an older population. Animal proteins contain a relatively high proportion of essential amino acids, and are more effective than vegetable proteins at stimulating protein synthesis (20).

The nutritional profile of pork offers a food-based strategy to improve the physical function of older individuals. However, little research has been done exploring the consumption of pork in the diets of older individuals. Project 3B-104 sought to determine if a diet with fresh pork as the main protein source in meals, four times a week for 12 weeks, resulted in improved muscle mass and body strength in community-living older adults, compared with consumption of chicken. Forty-eight well-nourished and generally healthy men and women aged 78 ± 6 yrs, with an acceptable/overweight BMI of $28.9 \pm 5.3\text{kg/m}^2$, were recruited for the study. There was no difference between chicken or pork meals on muscle mass or body strength, but most likely due to the lack of prescribed physical activity in both groups. Building muscle not only requires a dietary source of protein and amino acids, but also requires the muscle to be exercised to promote protein synthesis (21). Participants did express a desired to remain independent as they age which includes undertaking diet and lifestyle strategies to promote this. Seeing nutritional status and protein intake were important predictors of strength and functional ability in this study, there is a place for fresh pork as part of a healthy diet and lifestyle for healthy ageing.

Summary note:

A combination of fresh pork protein and exercise training may help with maintaining and building muscle mass to help with functional ability and independence in older age.

Drivers, Barriers and Enablers to Pork Consumption

(Projects 3C-105, 3B-105, 3B-108)

What would enable increased consumption of fresh pork in Australia?

Globally, pork meat is consumed one and a half times more than beef, offering lucrative potential for Australia to expand its pork export markets. However, exploring opportunities also requires understanding of consumer taste, preferences and demands, concerns and affordability. According to Project 3C-105, when exploring potential for growth of export markets for Australian pork, consumers from countries including like Korea, Japan, China and Hong Kong rated safety and quality as the top two attributes of importance when considering purchasing pork meat, followed by country of origin, welfare and environmental standards (3C-105). Of course, when considering what drives consumption of pork, taste and preference for cuts are leading drivers. For example, South Korean consumers prefer consuming pork that is higher in fat and therefore have a high demand for cuts like pork belly and shoulder blade. However, they are also receptive to foods that are healthy and nutritious. In contrast, Japanese consumers demand leaner cuts like loin and tenderloin. Thus, there is likely no single preferred pork meat covering all consumers markets, therefore a targeted approach that is country and consumer-type specific is required to increased pork consumption relative to the population's needs and preferences.

In Australia, pork has been reported to have very low exposure in the media (compared with other meats) and is reported to be less visible in shopping outlets than beef or chicken (3B-108). Project 3B-105 was designed to explore if participation in a dietary intervention trial where pork was provided together with recipes, cooking tips and health information, would influence individuals' perception and knowledge of pork but also change consumption. Prior to participating in the dietary intervention trials, reasons behind meat selection for these 104 men and women respondents included versatility, taste, price, convenience and lastly, health. Interestingly around 40% of respondents thought pork was fattier than beef and chicken, with less than 10% believing pork was leaner than beef and chicken. This was in contrast to 3B-108, where 31 parents (of children 2-16 years) thought fresh pork was a healthy meat because of its leanness.

Following participation in the dietary intervention trials, volunteers who were in the group receiving pork meat, recipes and information felt more positive about pork after participation. However, those in the control group who received no pork or information felt no different. Reasons why their attitudes might have changed related to the receipt of health information, opportunity to taste different cuts of pork, provision of recipes and cooking instructions, and de-bunking misconceptions around pork, and volunteers found they could enjoy pork as much as other meats. As a result, these volunteers reported eating less beef, chicken and lamb compared with pork and increased their fresh pork intake. Further, the 31 parents thought pork was an acceptable meat to include in children's diets, but parents felt they lacked the confidence regarding the preparation and cooking of fresh pork and needed more recipes and inspiration. Parents also considered meal planning and convenience when purchasing pork, which highlights an opportunity to provide resources and education in this area.

In Project 3A-111, volunteers consumed fresh lean pork, beef and chicken for 3 months each and reported at the conclusion of the study that fresh pork was the preferred meat to chicken and had significantly greater satisfaction than beef. They particularly enjoyed the pork steak. Extrinsic (price and brand) and intrinsic (appearance, taste) cues are major factors influencing consumers choices of meat. Sensory aspects like taste, tenderness and juiciness of pork are notably important attributes considered when purchasing pork. But more importantly it appears exposure to pork in the form of providing the opportunity to taste pork together with health information and pork recipes are keys to help change the unfamiliarity of pork meat to consumers. Greater exposure has subsequently translated into reported increased consumption of pork post participation in the trials.

4. Application of Research

Key points to consider when communication this research:

- How do we communicate research outcomes of trials?
- Why shouldn't pork be part of a healthy dietary pattern?
- Processed meats in general are linked to increase risk of cancer etc.; however, fresh meats are not.
- Fresh pork is similar to beef in nutritional profile, and it is rich in protein.
- Cooked appropriately, it tastes nice.
- Pork has a lower carbon footprint than beef and can still offer animal protein as part of a predominantly plant-based diet such as popular and heart healthy diets like the Mediterranean Diet.
- Based on this review, the opportunity exists for the employment, full time, of a Nutritionist or Dietitian within the pork industry teams to further push the human health/nutrition benefits of pork. This would be important for disseminating information, generating new health information around pork, development of new healthy recipes, and to provide fresh pork with a competitive market edge.
- This resource has the potential to be further developed to link to a webpage within APRIL and APL/New Zealand Pork Industry Board for the general public to visit to obtain this and further information.

Summary points:

- Lean fresh pork is a core food item of the meat, fish, poultry, nuts and legumes group (Australian Guide to Healthy Eating & Mediterranean Dietary Pattern).
- A 65 g serve of fresh pork provides 15 g of protein, 1 mg thiamine, 0.6 mg iron, 1.1 mg zinc.
- Fresh pork is rich in essential amino acids (leucine and isoleucine) for building muscle for body strength and functional capacity in the elderly.
- Fresh pork contains key nutrients important for growth and development.
- It can be included as part of a healthy dietary pattern for weight loss, diabetes and blood pressure management, mood, vitality, quality of life, quality of sleep and general health.
- Fresh lean pork can be included as part of a predominantly plant-based diet like the Mediterranean diet which may preserve cognitive function.
- When cooked appropriately, fresh pork is juicy and tender and provides excellent overall eating experience.
- 37% of Australian adults eat pork. Of those individuals less than a quarter (21%) ate fresh pork.
- 51% of Australian children eat pork. Of those children, only 14% ate fresh pork. There is room for improvement.
- Taken together, this research has identified specific population groups which required further education on fresh pork.
 - Parents – with family recipes, cooking tips, convenient packaging, meal planning guides and kid friendly recipes.
 - Low pork consumers,
 - Non-Asian consumers – more Western like dishes conforming with plant-based dietary recommendations.

5. Conclusion

Pork offers a valuable animal protein delivering key nutrients as part of the lean meats, poultry fish group of the Australian Guide to Healthy Eating. Pork is currently seen/perceived as a less healthy meat than red meat; however, lean fresh pork is no different in nutritional quality. A revitalised image of pork including dissemination of health information, cooking tips together with healthy recipes that fit within a predominantly plant-based diet, given the global push towards healthy low meat dietary patterns for health and sustainability, is suggested.

6. Limitations/Risks

To the application of the research findings

Recommendations in this Final Report are limited to the provision of information in each of the project reports.

7. Recommendations

Communicating the research

Options are presented in order of recommendation:

(1) Dietitians Association of Australia (DAA)

The DAA is the peak body for dietetic and nutrition professionals, representing more than 7,000 members around Australia and overseas. More than a professional association, DAA is a strong and inspiring community committed to supporting its members, advocating for the nutrition profession and building healthier communities. The DAA and its members both research and deliver evidence-based information on food and nutrition locally, nationally and internationally (<https://daa.asn.au/about-daa/>). The DAA is Australia's largest and most influential organisation for dietetic and nutrition professionals. It has a mission of supporting its members, advocating for the nutrition profession, and building healthier communities.

The DAA membership includes nutrition and dietetics professionals and students working in a range of settings including 1-to-1 consulting, group education, food service, research, policy, food industry and education, nationally and abroad.

<https://daa.asn.au/marketplace/advertise-with-us/>

Dissemination of information routes:

- **Direct Mail (this is a good option)**
 - \$3733.00 plus postage
- **Weekly email**
 - Standard banner \$3,621 per edition or
 - Flash banner animated \$4,227 (Size: 714x100px).
- **DAA Annual National Conference**
 - The DAA hosts our annual conference in May each year. There is an opportunity to host a stand, sponsor catering and advertise in conference satchels. Arinex is the secretariat (for more information sponsorship@arinex.com.au).
- **Branch and Interest Group events**
 - Events are held regularly each year, with potential topics from all fields of dietetics. There is an opportunity for trade exhibitions and sponsorship opportunities at Branch and Interest Groups events.

(2) Australian Healthy Food Guide (HFG) Magazine

This magazine is released monthly and aims to deliver up to date unbiased information about healthy eating. The guide explains the proven scientific links between nutrition and health in easy to understand language. It is an advertising medium for food and products and provides healthy recipes. The HFG team consists of dietitians, health and lifestyle journalists, nutritionists and scientists. The HFG has 316,006 average monthly page views, 347,000 print readership and >88,830 social media fans. Below is a link to the advertising team

<https://www.nextmedia.com.au/brand/healthy-food-guide/#brand-staff>

(3) Nutrition Society of Australia (NSA)

The NSA is a group of qualified, practising scientists and educators from diverse disciplines who are brought together by a common interest in the research and application of nutrition.

Founded in 1975, the Society is represented across Australia by Regional Groups and managed by the NSA Council. NSA has around 1,000 members which include human nutritionists, dietitians, medical practitioners, nurses, allied health professionals, agricultural scientists, veterinarians, food scientists, teachers and students. Specifically, a nutritionist is qualified to provide advice on matters relating to food and how it impacts on health. They can design, coordinate, implement and evaluate population health interventions that are designed to improve health and wellbeing through food and nutrition. Nutritionists may also work in a variety of other occupations including research, as nutrition consultants in public health or in industry as nutrition communicators and food technologists.

Dissemination of information routes:

- Monthly newsletter (1-2 emails per month)
 - NSA member newsletters cover news of NSA activities as a priority but do include other items such as non-NSA events, jobs and nutrition related news where space permits. Non-NSA items will only be included once and may be edited to fit our 100-150 word limit. Logos or attachments are not included but links to websites and/or flyers can be provided. Ads for food-related products are not accepted. <https://nsa.asn.au/newsletters/>.
 - No cost.
- Partnership
 - Current partnerships are not food industry, but they may consider it case by case basis. <https://nsa.asn.au/about-us/associated-organisations/>
- Annual Scientific Meetings
 - Each year the NSA holds a scientific meeting within Australia and jointly with the NZ Nutrition Society, in New Zealand. The meetings are generally end of November / early December.
 - There is the option to host a conference stand, sponsor catering, host a breakfast or lunch session and provide inserts for conference satchels.
 - There is also an opportunity for different level of sponsorship at the meetings.
 - Larger sponsorships and stands should be discussed with the conference secretariat a year prior to the meeting, smaller opportunities within 6-12 months prior to the meeting.

To discuss further and for pricing, contact NSA using the following address:
<https://nsa.asn.au/contact-us/>

(4) Royal Australian College of General Practitioners (RACGP)

The Royal Australian College of General Practitioners (RACGP) is Australia's largest professional general practice organisation and represents urban and rural general practitioners. It has over 40,000 members. The RACGP's mission is to improve the health and wellbeing of all people in Australia by supporting GPs, general practice registrars and medical students through its principal activities of education, training and research and by assessing doctors' skills and knowledge, supplying ongoing professional development activities, developing resources and guidelines, helping GPs with issues that affect their practice, and developing standards that general practices use to ensure high quality healthcare (<https://www.racgp.org.au/the-racgp/about-us/about-the-racgp>).

Dissemination of information routes:

- *Australian Journal of General Practice*
 - This is Australia's leading general practice journal and highest circulating medical title, distributed to more than 40,000 GPs. For more than 60 years, the GP-directed, edited and peer-reviewed Australian Journal of General Practice (AJGP) has informed and assisted GPs in their daily work. As the most valued and used publication for GPs, AJGP is the premium communication platform to reach GPs in Australia.

For further advertising information, contact Jonathon Tremain (02) 9988 4689, jonathon@tremedia.com.au (<https://www.racgp.org.au/advertising/advertising-opportunities-and-rates>).

(5) Social Media

Greater/more strategic and targeted use of Twitter handles and FaceBook.

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