A comparison of regular consumption of fresh lean pork, beef and chicken on body composition and energy intake

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Co-operative Research Centre for an Internationally Competitive Pork Industry

By

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Executive Summary

Pork is the most widely eaten meat in the world and is a substantial source of dietary protein but the perception of pork as a less healthy meat than other main meat sources may contribute to low consumption levels in Australia. In fact recent evidence shows that pork protein diets, with and without energy restriction may have favourable effects on body composition.

Our previous trial showed following regular consumption of up to 1kg of fresh lean pork per week for 6 months, improvements in weight, body mass index and waist circumference, % body fat mass and abdominal fat ($P<0.05$) after only 3 months, compared with those who remained on their customary diet. There was no change in lean mass indicating that the reduction in weight was due to loss of fat mass. These improvements in body composition were achieved without any apparent changes in total energy or protein intake. However, we are unable to say if the improvements were specific to pork or whether consumption of other high protein meat diets may have had the same effect. Therefore that aim of this trial was to demonstrate that regular consumption of pork is no worse, and possibly better, than beef or chicken, the main alternative meat options in Australia in terms of improving indices of body composition.

This was a 9 month cross-over intervention trial, where 49 overweight adults were randomly assigned to consume up to 1kg of either pork, chicken or beef/wk, in the form of steak or (chicken) breast, diced, mince and stir fry, *ad libitum* and without energy restriction. At baseline and then at 3, 6 and 9 months weight, body mass index, waist/hip circumference and measures of body composition including % body fat, abdominal fat and lean mass using dual energy x-ray absorptiometry was assessed.

Results show that regular consumption of lean pork was equally healthy as beef or chicken consumption. After statistical analyses using random effects GLS regression, there was no difference between the pork, beef or chicken diet for weight or any other index of adiposity. Similarly there was no difference in energy intake or macro or micronutrient intakes. Volunteers reported that pork was the preferred meat to chicken ($P=0.229$) and had significantly greater satisfaction than beef ($P=0.018$). The most enjoyed type and cut of meat was pork steak.

Regular consumption of lean fresh pork is equally healthy as consumption of beef or chicken. Given the increasing prevalence of obesity in Australia, such evidence will reassure consumers that lean pork is a healthy choice, which should strengthen its market relative to its chief competitors. The current observations provide further evidence that the perception of pork as a less nutritious meat should be reconsidered. Australian Pork Limited is the most appropriate organisation to deliver this evidence to producers, food industry, regulatory bodies and the consumer.

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Introduction

The global prevalence of obesity is increasing and what is of major health concern is that obesity clusters with other cardiovascular (CV) risk factors including type 2 diabetes, hypertension, hypercholesterolemia, poor mental health and physical disability increasing risk of mortality. Key strategies employed to reduce weight involve lifestyle intervention including caloric restriction and regular exercise. Particular dietary strategies that have been effective for weight loss include energy restricted high protein diets [18; 5; 14; 15] and using lean red meat as the major protein source [15; 16]. Until recently there has been an almost complete absence of research examining the consumption of pork and potential health benefits. This is surprising given it is the most widely eaten meat in the world.

Pork is a rich source of protein, vitamins and minerals and recent evidence has shown that lean pork may provide CV and metabolic health benefits [21; 13]. Wycherley and colleagues [21] demonstrated that an energy restricted high protein pork diet combined with resistance exercise training achieved the greatest loss of weight (-13.8kg) and fat mass (-11.1kg) and reduction in waist circumference (-13.7cm) compared with a standard carbohydrate diet (control) with and without exercise and a high protein diet without exercise over 16 weeks. There were also improvements in CV risk factors such as blood pressure, lipids, insulin and glucose with no difference between groups.

We have previously shown that regular *ad libitum* consumption of lean pork for 6 months, without energy restriction led to greater improvements in body composition compared with a habitual diet for 6 months (weight [pork diet: -0.8±0.3kg, habitual: 0.2±0.5kg], fat mass [pork diet: -0.5±0.2kg, habitual: 0.4±0.3kg], waist circumference [pork diet: -0.6±0.4cm, habitual: 0.8±0.4cm], abdominal fat [pork diet: -69±24g, habitual: 22±26g], %body fat [pork diet: -0.4±0.2%, habitual: 0.2±0.2%]). These improvements were evident after only 3 months of eating pork (compared with habitual diets) and were achieved without restricting energy intake. Over time dietary intake of total energy, total fat, saturated fat, carbohydrate and protein decreased in both the pork group and control group but this was not significantly different. Despite these reductions in dietary intake in both groups, there were only improvements in body composition in the pork group. However, we were unable to say if the changes in body composition were specific to pork or to pork protein or another factor or whether consumption of other high protein meat diets may have had the same benefit.

Therefore the aim of the current study was to conduct a 9 month crossover dietary intervention trial to compare the effect of regular consumption of lean pork with that of two other commonly consumed meats in the Australian diet, namely chicken and beef, on body composition.

Methodology

Subjects, design and dietary groups

Free-living overweight/obese, non-smoking men and women were recruited through local media advertisements to participate in a 9 month, randomized, cross-over trial. Subjects were excluded if they reported one of the following: diagnosed diabetes or CV disease; history of myocardial infarction or stroke; peripheral vascular disease; blood pressure >160/100mmHg; liver or renal disease; anti-inflammatory, antihypertensive or hypocholesterolemic drug therapy that was not stable in the previous 3 months; eating >100g fresh pork per week; inability to consume pork as required. Eligible volunteers were stratified according to gender, BMI and age by the process of minimization [2] and allocated to one of three starting diets. This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by the Human Research Ethics Committee (22/06/2010) at the University of South Australia, Adelaide, Australia. Written informed consent was obtained from all subjects. The trial was registered on the Australia New Zealand Clinical Trials Register (ACTRN12610000612011, 28/07/2010).

STUDY DESIGN

Of a total of 118 volunteers who were screened for eligibility, 75 were randomized to either commence the intervention in the pork, beef or chicken group for the initial 3 months (Figure 1). At the end of this period volunteers crossed over to another meat for 3 months and then to the remaining meat for the final 3 month period thus each volunteer acted as their own control. Volunteers attended the research centre at baseline and after 3, 6 and 9 months of intervention and the following assessments were made at each time point unless stated otherwise; weight and height (to calculate BMI (kg/m^2),

waist and hip circumference, body composition (assessed using dual energy x-ray absorptiometry), dietary intake and physical activity levels.

Dietary Intervention

All volunteers were provided with 5 serves (women) or 7 serves (men) of their respective meat and asked to incorporate it into their habitual diet for each 3 month period. As the meats were matched on energy per serve, the portion sizes varied slightly (pork 140g/serve, chicken 150g/serve, beef 150g/serve). All volunteers were seen fortnightly to monitor body weight, discuss any issues arising in the intervention and collect a selection of frozen meat products including lean beef or pork steak or chicken breast, stir fry, diced and mince. All volunteers kept a weekly log of study meat consumption.

OUTCOMES MEASURES

The primary outcome measure was % body fat. Secondary outcomes were weight, BMI, waist/hip circumference, fat mass, abdominal mass.

Clinical Assessments

Dietary intake

Volunteers were asked to record their dietary intake in a semi-quantitative 3-day weighed food record at baseline and then at the mid-point of each 3 month period. Volunteers were asked to weigh and measure their food using scales provided. Dietary composition was analysed using a computerized database (Foodworks Professional Edition, version 4, 1998; Xyris Software, Highgate Hill, Australia) where updated nutrient profiles of the study pork, beef and chicken were added to generate values for energy, macro and micronutrient consumption. The energy, moisture, ash and macronutrient composition of the meats were initially analysed by the National Measurement Institute (Victoria, Australia) for matching energy composition and fat content was monitored from batch to batch using a modification of the Bligh & Dyer [3] method for fat determination in our laboratory throughout the intervention. Frequency of consumption of energy and macro and micronutrients were estimated using a 74-item food frequency questionnaire from the Cancer Council of Victoria, Australia (FFQ) [8] which requested information relating to food choices, frequency, portion size, quantity and consumption rate of different food and beverage items. The FFQ has been validated by Xingying and colleagues [22] for use in human dietary intervention trials. For the purpose of reporting meat intake the following categories of meat were used: pork, beef, chicken, lamb, veal, fish, sausages, bacon, ham and 'other' meat intake (sum of salami, meat pies, hamburger, pasta/lasagne, pizza).

Meat preferences

At volunteers final clinic visit at 9 months, they were asked to complete an exit survey which requested information regarding preferences of the meat supplied. Questions included preference for pork, beef or chicken, enjoyment of eating the study meats, comments on the type and quantity of meat supplied, change of meat preference since commencing the study and overall management of consumption of meat for 3 months.

Physical activity

Subjects recorded a diary of all physical activity conducted in a 24h period over 3 days (2 weekdays and 1 weekend day) [4]. Energy expenditure (kcal) was then calculated for every 15 minute period in a 24 h day according to 9 categories of different types of activity (eg. sleeping, playing sports, gardening etc) and multiplied by the appropriate physical activity level factor for the reported intensity of exercise. This was multiplied by body weight and then averaged for 3 days.

Weight, height, Body Mass Index and Body composition

Anthropometric measures followed the protocols of the International Society for the Advancement of Kinanthropometry [17]. Height was measured with a wall-mounted stadiometer (Heightronics, QuickMedical, Issaquah, USA, or SECA 22, Hamburg, Germany) to the nearest 0.1 cm with participants barefoot. Body mass was measured using electronic digital scales (Tanita BWB 600 or TANITA ultimate scale 2000 scales, Tanita Corporation, Tokyo, Japan) to the nearest 0.1 kg with participants wearing light clothing and barefoot. Waist and hip measurements were taken using a metric tape measure to the nearest 1mm and the ratio of these calculated (WHR). Subjects had their percentage of body fat, fat mass, abdominal fat and lean mass assessed using DEXA (Lunar Prodigy, General Electric, Madison, WI, USA). Repeated assessments made on consecutive days in 11 overweight or obese subjects gave the

following standard errors for measures of body composition: 0.87% for percentage body fat, 0.53 kg for fat mass and 1.05 kg for lean mass.

Statistical analysis

Based on previous determinations of the variance in the primary outcome measure (change of % body fat from baseline to 6 months), we estimated that a total of 51 subjects would give 80% power to observe significant 1% difference in % body fat at an alpha level of 0.05. Data of subjects who completed the trial were analysed using Random-effects GLS Regression to identify differences between means where significant main effects were seen. Analysis focused on changes in indices of adiposity at the end of each dietary phase. Meat preferences were analysed using log binomial generalized linear models. Where this would not converge, a robust Poisson regression model was used instead. Univariate models were first conducted, followed by a multivariate model using backwards elimination. The statistical package was STATA Statistics Data analysis 11 (StataCorp, Texas, USA) and significance was set at $P<0.05$ unless otherwise stated.

Compliance

Compliance to the dietary intervention was assessed at baseline, 3, 6 and 9 months using meat consumption logs where subjects recorded their daily consumption of provided meat and meat intake from food frequency questionnaires. Subjects were asked to maintain their normal physical activity throughout the study which was assessed at the same time-points as dietary intake using 3-day physical activity diaries.

Outcomes

Subject characteristics

Of the 75 subjects who were enrolled in the intervention, 11 withdrew prior to commencement (due to change of mind and increased personal commitments) and 15 withdrew after commencement (Figure 1). 5 withdrew as they could no longer commit to the study, 4 withdrew due to a personal illness, 2 relocated interstate, 3 had increased commitments and 1 was withdrawn as they no longer complied with the protocol. Thus 49 subjects completed the full 9-month intervention period. Characteristics of volunteers are presented in Table 1. This population were on average middle aged (50±2 ys), obese (BMI 30.5±0.5kg/m^2) and had around 40±1% body fat.

Pork, beef and chicken consumption

According to the Cancer Council of Victoria Food Frequency Questionnaire, on average daily consumption of pork, beef and chicken in the relevant phase was 87g (609g/wk), 138g (966g/wk) and 102g (714g/wk), respectively. Total meat intake and consumption of other meats and fish did not change during the intervention (Figure 2). Total meat intake (sum of pork, chicken, beef, lamb, veal, ham, bacon, sausages) for the pork group was 137g/d, was 173g/d for the beef group and 151g/d for the chicken group.

Consumption of provided pork, beef and chicken was calculated from the weekly meat consumption logs. This indicated that on average consumption of pork, beef and chicken in the relevant phase was 119±21g/d (832±146g/wk), 129±23g/d (900±161g/wk) and 129±26g/d (900±180g/wk), respectively.

Dietary intake & physical activity

Total energy and macronutrient intakes were adjusted for the nutrition profile of the provided pork, beef and chicken. There was no difference in energy intake (kJ) (Table 2) or macronutrients (total fat, protein or carbohydrate) in either group over time. This indicates that all volunteers were substituting meats in their diet without impacting on total energy or total protein intake. There was no difference in total energy expenditure (kJ/d) according to the physical activity diaries, indicating that volunteers did not change their physical activity levels and subsequent energy expenditure during the intervention.

Body composition

There was no difference in any index of adiposity between groups over time (Table 3). While there was a trend for slight reduction in WHR in the pork group compared to beef and chicken groups this was not significant (P=0.046) when allowing for multiple comparisons.

Figure 1 - Consort diagram

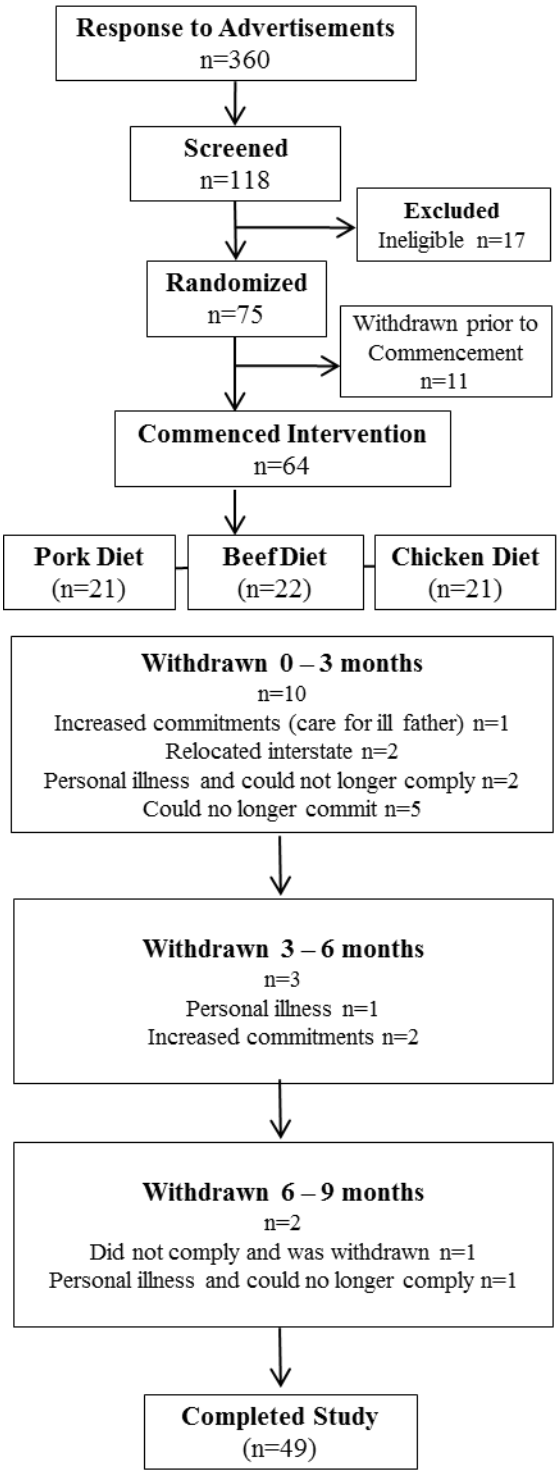

Table 1 - Gender, age, anthropometric measurements, body composition, daily dietary intake and energy expenditure of study population at baseline

	Mean±SD
Gender *n*	24 M / 25 W
Age (yrs)	50±2
Height (m)	1.72±0.1
Weight (kg)	90±14
BMI (kg/m^2)	30.5±3.6
WC (cm)	102.6±11.3
HC (cm)	110.3±10.1
WHR	0.93±0.1
% Fat Mass	39.9±6.9
% Body Fat	49.4±6.3
Fat mass (kg)	35.3±8.5
Abdominal fat (g)	3655±1075
%Lean Mass	60.2±6.9
Lean mass (kg)	50.1±9.8
Energy Expenditure	
EExp (MJ)	16.3±3.2
Dietary Intake	
Energy (MJ)	9.5±3.0
Protein (g)	105±31
%en Protein	19±3.6
CHO (g)	228±74
%en CHO	40±6.4
Fat (g)	91±40
%en Fat	35±6.4
SFA (g)	35±14
MUFA (g)	34±17
PUFA (g)	14±10
Alcohol (g)	10±13
%en Alcohol	3±4
Iron (mg)	14±5
Zinc (mg)	21±47
Thiamine (mg)	2.0±1.1
Folate (µg)	505±705
Sodium (mg)	3197±1386

*Dietary intake was captured using 3-day weighed food records and energy expenditure was estimated using 3 day physical activity diaries.

Figure 2 - Average meat and fish consumption (grams per day ± SEM) from the Cancer Council of Victoria Food Frequency Questionnaire at baseline and for each dietary phase (beef, pork, chicken) n=49.

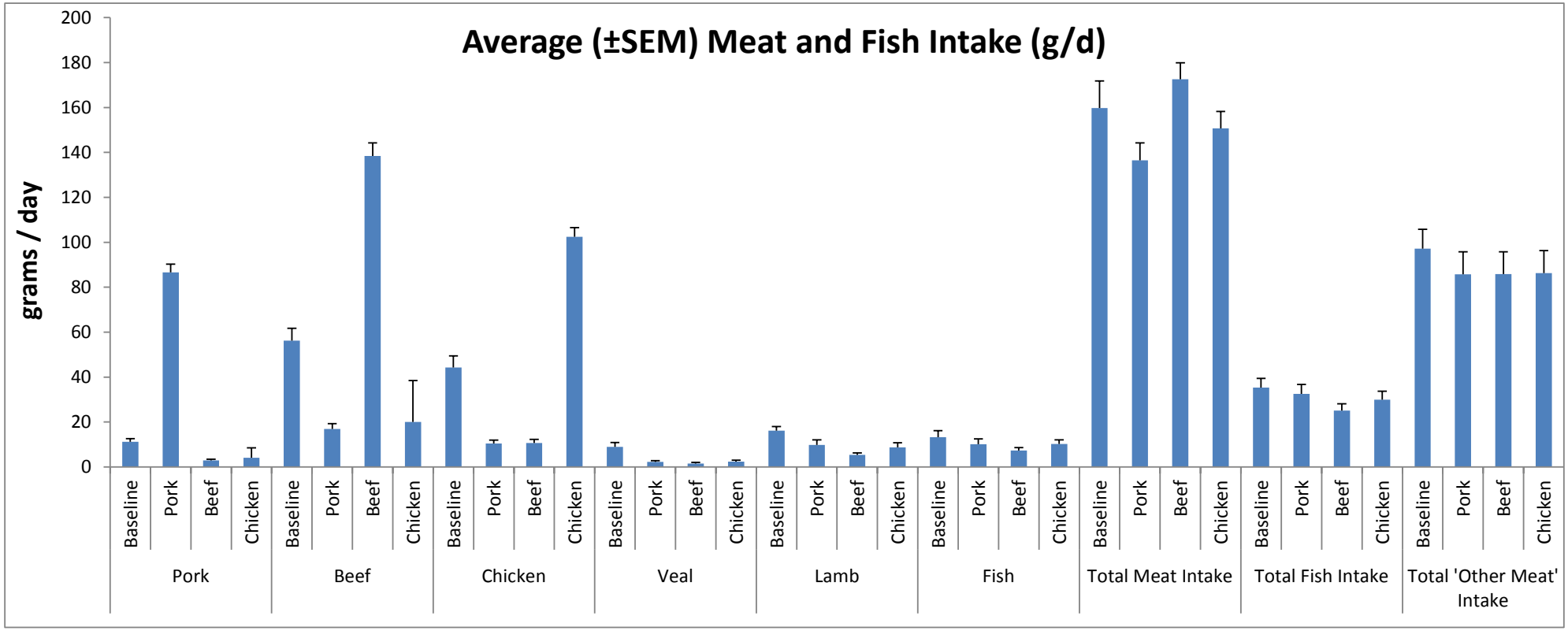

Table 2 - Mean values for energy and nutrient intake from weighed food records * at the end of each diet phase (Pork, Beef, Chicken), n=49 and difference between meats (95% confidence intervals)

	Pork	Beef	Chicken	ΔPork-Beef[1]	P value	ΔPork-Chicken[2]	P value
Energy (kJ)	8645±351	8420±394	8549±405	-225 (-941, 490)	0.537	-96 (-812, 619)	0.792
Protein (g)	104±4	104±4	105±5	-5.8 (-13.8, 2.2)	0.157	1.2 (-6.8, 9.2)	0.762
%en Protein	21±0.6	20±0.5	21±0.4	-0.9 (-2.0, 0.2)	0.124	0.3 (-0.8, 1.5)	0.558
CHO (g)	211±11	213±12	202±10	2.4 (-19.4, 24.2)	0.830	-9.3 (-31.1, 12.5)	0.404
%en CHO	40±1	41±1	39±1	1.6 (-0.6, 3.7)	0.154	-0.7 (-2.9, 1.4)	0.504
Fat (g)	76±4	71±5	76±5	-1.5 (-3.5, 0.6)	0.161	0.1 (-1.9, 2.2)	0.895
%en Fat	32±1	30±1	32±1	0.76 (-2.8, 1.27)	0.463	-1.46 (-0.57, 3.5)	0.158
SFA (g)	29±2	29±3	28±2	-0.57 (-5.16, 4.03)	0.809	-1.11 (-5.70, 3.49)	0.637
MUFA (g)	30±2	26±2	30±2	-4.3 (-8.3, -0.27)	0.036	-0.19 (-4.21, 3.83)	0.926
PUFA (g)	12±0.7	11±0.8	13±1	-0.15 (-1.71, 1.42)	0.856	1.15 (-0.42, 2.71)	0.151
Alcohol (g)	11±2	12±2	12±3	1.3 (-2.5, 5.0)	0.515	1.2 (-2.6, 4.9)	0.549
%en Alcohol	3.8±0.8	4.5±0.9	3.9±0.8	0.7 (-0.4, 1.8)	0.203	0.06 (-1.0, 1.1)	0.913
Iron (mg)	12.9±0.5	12.5±0.7	12.9±0.6	-0.43 (-1.69, 0.84)	0.511	-0.03 (-1.29, 1.24)	0.970
Zinc (mg)	13.5±0.7	12±0.8	13.3±0.8	-1.51 (-3.4, 0.39)	0.120	-0.27 (-2.17, 1.63)	0.784
Thiamine (mg)	2.3±0.3	2.0±0.1	2.3±0.2	-0.36 (-0.97, 0.25)	0.242	0.002 (-0.61, 0.61)	0.995
Sodium (mg)	2761±182	2486±146	2763±180	-276 (-639, 88)	0.138	-1.4 (-362.4, 365.2)	0.994

*Mean ± standard error. [1]Difference between pork and beef adjusting for chicken (95% Confidence Intervals) according to random-effects GLS regression; [2]Difference between pork and chicken adjusting for beef (95% Confidence Intervals) according to random-effects GLS regression.

Abbreviations: kJ, kilojoule; %en, percent energy; SFA, saturated fatty acid; MUFA, monounsaturated fatty acid; PUFA, polyunsaturated fatty acid; g, grams; mg, milligrams; µg, micrograms.

P<0.003 was considered significant to allow for multiple comparisons. No significant differences were reported for any variable.

Table 3 - Mean values for anthropometric measurements and body composition* at the end of each diet phase (Pork, Beef, Chicken), n=49 and difference between meats (95% confidence intervals).

	Pork	Beef	Chicken	Difference between Pork and Beef[1]	P value	Difference between Pork and Chicken[2]	P value
Weight (kg)	89±2	89±2	89±2.0	-0.003(-0.609, 0.602)	0.991	-0.018(-0.624, 0.587)	0.953
BMI (kg/m^2)	30.1±0.5	30.1±0.5	30.1±0.5	-0.009 (-0.223,0.205)	0.934	-0.006 (-0.220, 0.208)	0.957
WC (cm)	101.0±1.6	101.3±1.6	101.3±1.6	0.360 (-0.455, 1.18)	0.387	0.314 (-0.501, 1.13)	0.450
HC (cm)	109.8±1.5	109.3±1.5	109.7±1.4	-0.475 (-1.064, 0.115)	0.115	-0.148 (-0.738, 0.441)	0.622
WHR	0.925±0.016	0.932±0.016	0.929±0.016	0.007 (0.0001, 0.014)	0.046	0.004 (-0.003, 0.011)	0.222
% Fat Mass	39.7±1.0	39.7±1.0	39.7±1.0	0.078 (-0.327, 0.482)	0.707	0.008 (-0.397, 0.413)	0.968
% Body Fat	49.0±0.9	48.9±0.9	49.0±0.9	-0.02 (-0.558, 0.518)	0.942	0.052 (-0.486, 0.590)	0.850
Fat mass (kg)	35.3±1.3	35.4±1.3	35.4±1.3	0.098 (-0.418, 0.613)	0.710	0.057 (-0.459, 0.573)	0.828
Abdominal fat (g)	3495±149	3486±149	3500±147	-8.68 (-82.15, 64.79)	0.817	5.47 (-68.0, 78.94)	0.884
% Lean Mass	60.4±1.0	60.3±1.0	60.4±1.0	-0.078 (-0.482, 0.327)	0.707	-0.008 (-0.413, 0.397)	0.968
Lean mass (kg)	53.7±1.5	53.6±1.5	53.6±1.5	-0.096 (-0.445, 0.253)	0.590	-0.07 (-0.419, 0.280)	0.696

*Mean ± standard error. [1]Difference between pork and beef adjusting for chicken (95% Confidence Intervals) according to random-effects GLS regression; [2] Difference between pork and chicken adjusting for beef (95% Confidence Intervals) according to random-effects GLS regression.
Abbreviations: BMI, body mass index; WC, waist circumference; HC, hip circumference; WHR, waist/hip ratio.
P<0.006 was considered significant to allow for multiple comparisons. No significant differences were reported for any variable.

Meat preferences

Out of 49 surveys sent, 35 completed surveys were returned. Overall, volunteers rated pork as the most preferred meat to chicken (P=0.229) and had significantly greater satisfaction than beef (P=0.018). Of the 35 volunteers who commenced the study, 12 were randomly allocated pork as their first study meat, 10 had beef as their first meat and the remaining 13 had chicken as their first meat. Meat preference may have been slightly influenced by the of the order of which meat was consumed.

Enjoyment of eating study meat

Table 4 presents outcomes relating to enjoyment of the type and specific cut of study meat. Volunteers were asked to complete the table by ticking 'yes' or 'no' if they enjoyed the specific meat and cut of meat the most. Each 'yes' tick equalled 1 point. Overall steak/ chicken breast was the most preferred cut of meat. There was no significant difference between enjoyment of cuts however steak/chicken breast was enjoyed significantly more than mince (P=0.004).

The most enjoyed type and cut of meat was pork steak. This was enjoyed significantly more than pork mince (P=0.012). For beef, mince was the preferred cut and was enjoyed significantly more than diced (P=0.028) and stir fry beef (P=0.002). There was no difference in enjoyment between beef steak and mince. For chicken, breast was the most preferred cut and was enjoyed significantly more than mince (P=0.002), while stir fry was enjoyed significantly more than mince (P=0.041).

Comments about the cuts of meat

Overall all volunteers were happy with the taste, tenderness, quality and the ease of cooking the study meat. Volunteers were given the option to provide general comments on the cuts of meat provided. Of the 35 questionnaires returned, 9 volunteers indicated they were satisfied with the meat while a further 6 left no comment. Of the remaining 20 surveys, 6 volunteers provided negative feedback about the beef indicating that they disliked the taste, the beef was grisly, stringy and harder to digest and specifically the diced beef was tough. Other comments were mostly individual complaints based on cooking problems. Two volunteers noted complaints about the diced meat in general, irrespective of meat type while 2 volunteers had no comment about the meat.

Preference of meat post-study

Out of 35 respondents 18 indicated that their meat preferences have not changed since undertaking the study. Of the 17 volunteers who experienced a change in preferences, 14 of them now like and /or enjoy and / or appreciate pork more since undertaking the study. One volunteer indicated they enjoyed beef less, whereas in contrast 2 volunteers indicated they enjoyed beef more. None of the respondents indicated they liked pork or chicken less since participating in the study.

Management of meat consumption during each diet phase

Twenty-one of the 35 respondents said they had no difficulty eating the meat for each 3 month diet phase and shared strategies they utilised to maximise compliance to the allocated meat. Four out of 21 respondents indicated the variety of cuts of meat provided assisted in helping them comply with the study protocol. Five of the 35 respondents said they found it difficult to consume chicken only for 3 months, while two out of 35 respondents had difficulty consuming just beef for 3 months. No one reported difficulties with consuming pork for 3 months. Seven volunteers indicated common difficulties in maintaining consumption of a specific meat for 3 months included boredom of consuming just one meat and difficulty in preparing separate meals for the family.

Interestingly 9 out of 35 respondents indicated they did not struggle with one type of meat more than another however 12 volunteers found beef was the most difficult phase mainly because they thought it was poorer quality to the other meats. Eight volunteers said chicken was the most difficult phase because it was less versatile while only 4 volunteers found the pork phase the most difficult to maintain, mainly because pork was the most unfamiliar meat and it was being consumed in the final meat phase (6-9 mths).

When volunteers were asked about the portion size of the meat, 80% of respondents were satisfied with the serving size and were quite surprised at how satiated they felt following its consumption especially given that the study meat portions were smaller than what they would normally consume in their habitual diet. Four volunteers thought the portions could have been larger, 1 volunteer thought the portions were too big and 1 volunteer was not satiated with the chicken phase.

Volunteers were provided with recipe books specific to each meat and cut of meat for each meat phase. Recipes were low in fat and sodium and were designed to be quick and easy to prepare. 66% of the volunteers used and liked the recipes however most volunteers indicated they only used a few recipes from the books. 34% of respondents did not use the recipes but admitted the recipes appeared and sounded good.

Table 4 - Enjoyment of meat

PORK			BEEF			CHICKEN		
MINCE	**YES**	**NO**	**MINCE**	**YES**	**NO**	**MINCE**	**YES**	**NO**
Taste	31	4	Taste	33	2	Taste	28	7
Tenderness	33	2	Tenderness	33	2	Tenderness	32	3
Quality	33	2	Quality	34	1	Quality	30	5
Ease of cooking	32	3	Ease of cooking	34	1	Ease of cooking	32	3
Total	**129**	**11**	**Total**	**134**	**6**	**Total**	**122**	**18**
DICED			**DICED**			**DICED**		
Taste	33	2	Taste	32	3	Taste	33	2
Tenderness	33	2	Tenderness	28	7	Tenderness	32	3
Quality	33	2	Quality	31	4	Quality	29	6
Ease of cooking	34	1	Ease of cooking	33	2	Ease of cooking	34	1
Total	**133**	**7**	**Total**	**124**	**16**	**Total**	**128**	**12**
STIR-FRY			**STIR-FRY**			**STIR-FRY**		
Taste	33	2	Taste	30	5	Taste	33	2
Tenderness	32	3	Tenderness	27	8	Tenderness	34	1
Quality	31	4	Quality	30	5	Quality	30	5
Ease of cooking	32	3	Ease of cooking	31	4	Ease of cooking	35	-
Total	**128**	**12**	**Total**	**118**	**22**	**Total**	**132**	**8**
STEAK			**STEAK**			**STEAK**		
Taste	35	-	Taste	33	2	Taste	35	-
Tenderness	35	-	Tenderness	32	3	Tenderness	34	1
Quality	34	1	Quality	32	3	Quality	32	3
Ease of cooking	34	1	Ease of cooking	34	1	Ease of cooking	35	-
Total	**138**	**2**	**Total**	**131**	**9**	**Total**	**136**	**4**
TOTAL SCORE	**528**	**32**	**TOTAL SCORE**	**507**	**53**	**TOTAL SCORE**	**518**	**42**

Table 4: participant votes for the total number of 'yes' and 'no' votes each meat cut received for four key attributes, taste, tenderness, quality and ease of cooking, followed by the most enjoyed meat cut and the most enjoyed meat.

Discussion

Pork and body composition

Previous research has focused on relationships between the consumption of lean red meat and increased satiety and weight loss [1] however most of these studies have utilised hypocaloric, high protein diets specifically designed for weight loss. Until recently there was little research investigating the cardiometabolic health benefits of eating fresh lean pork. Despite pork being the most frequently consumed meat in the world, it is often thought of as a less healthy meat than beef or chicken. In Australia, pork consumption is relatively low and beef and chicken are the major meats consumed, which probably reflects the less healthy perception that pork receives. We and others have recently shown that regular consumption of fresh lean pork may improve cardiometabolic health particularly body composition. However we were unable to say if improvements in body composition were specific to pork or to pork protein or whether consumption of other lean meats may have had the same benefit. Therefore we aimed to demonstrate that regular consumption of pork is no worse and potentially better than beef or chicken on body composition.

The present study found no significant difference in any measure of body composition between the pork, beef or chicken groups over time, nor was there any change in energy or macronutrient intake and

physical activity levels. Our study is in agreement with results from Melanson et al [11] who conducted a 12-wk randomized, controlled trial where overweight women consumed an energy restricted study with either lean beef or chicken as the major protein source together with undertaking moderate exercise. The authors reported no difference in weight loss or % body fat or blood lipid profiles following a beef or chicken diet. Similarly Mahon and colleagues [10] compared consumption of lean beef or chicken as the primary protein source in a hypocaloric diet in 61 obese females. The authors found no difference in the amount of weight loss, fat loss and reduction in low density lipoprotein cholesterol after 12 weeks consumption of either a chicken or beef diet. While a cholesterol-lowering study by Davidson et al [7] compared a NCEP Step 1 diet (National Cholesterol Education Program Step 1 diet) containing 170g of lean meat (pork, veal and beef) with a diet containing lean poultry and fish as the primary meat for 36 weeks. The authors showed no difference in the change in serum lipid levels between groups. Finally in an acute satiety study Charlton and colleagues [6] compared the consumption of pork, beef or chicken on acute satiety and appetite regulatory hormones and showed no difference between meats on satiety or satiety hormones.

There is conflicting perceptions around the health benefits of pork and while there does not appear to be any formal publication showing increased risk of cardiovascular disease or link with obesity, levels of consumption in Australia are still lower than other meats (72g/d in NNS). Whereas consumption of red meat and chicken are more widely accepted and appear to be the two most commonly consumed meats in the Australian diet (93g/d and 99g/d, respectively (http://www.chicken.org.au/page.php?id=4#Consumption). Perhaps it is because lean red meat has been shown to help with weight loss and lean chicken breast is a regular component of weight loss diets [14; 15]. However there is constant discussion about the association between meat consumption, most likely due to concern over the saturated fat content, and development of coronary heart disease (CHD). Recently Micha and colleagues [12] published a systematic review and meta-analysis of the evidence for relationships between unprocessed fresh meat from beef, hamburgers, lamb, pork or game and processed meat (salami, sausages, hot dogs, bacon or processed luncheon meats) found that the intake of unprocessed (fresh) meat intake was not associated with CHD, whereas processed meat intake was associated with 42% higher risk of CHD [12]. This study helps dispel the myth that meat intake increases risk of chronic disease and demonstrates the need for greater understanding of the potential health benefits of fresh lean meat and recognition in dietary recommendations especially from a consumer perspective as consumer's attitudes towards pork consumption is likely to be driven by the link between food and health [9].

Meat preferences

Pork was the most preferred meat, the most enjoyed meat, the best tolerated for 3 months and many volunteers found their pork consumption has increased as a result of the study. Few people found eating pork for three months a struggle compared to beef or chicken and the survey indicates the pork quality was rated the highest. The quality of the beef was the most criticized. The serving size of the meat (140g-150g) was generally well accepted.

We know that meat consumption patterns of the general consumer are influenced by a number of factors including price, taste, quality, animal welfare and link with health aspects [9]. Consumers are reported to be interested in two main areas which include the link between food and health and the origin and production of their food. Pork consumption is the most commonly consumed meat in the world however this is not reflected in Australia. Pork consumption has slowly increased in Australia since the mid 1940's however beef and chicken remain the most commonly consumed meats http://www.chicken.org.au/page.php?id=4#Consumption).

In Europe from the 1960s to 1990s there has been an increase in the supply of meat, particularly pork. However post 1990 the availability of meat decreased in some European countries due to changes in consumer taste and preference and safety of the meat supply together with negative media attention [20]. These are contributors to consumer's quality expectations and perceptions and if consumers are not satisfied with the product then it is unlikely that they will purchase and consume the product in the future.

Consumers choose products based on extrinsic (price and brand) and intrinsic (appearance, taste) cues [19] and it appears that Australians, particularly volunteers in our study, are unsure how to handle and prepare pork meat. Some of the comments returned in questionnaires said that pork was an unfamiliar meat which may have influenced the way volunteers cooked and ate the meat. We provided recipe books which contained instructions on how to prepare, store and cook the 3 meats to produce a juicy and tender product. This probably helped revitalize the poor image pork has received such as that it is a tough, fatty meat with a very strong taste as the majority of respondents preferred pork over beef and chicken.

It is unclear why pork consumption in Australia is low compared to beef and chicken. Perhaps it is due to the misconception that pork is less healthy than beef and chicken, perhaps consumers think that pork is a tough and dry meat or perhaps they do not know how to cook it. Information from the present study shows that when volunteers were provided with different meat cuts, recipe booklets and advice on how to cook the meat to produce a tender and tasty product, they ranked pork significantly higher than beef and chicken, the two main meats in the Australian diet. Therefore training consumers by providing recipes as well as cooking instructions together with advertising the potential health benefits of pork will help educate consumers which will hopefully boost pork sales and increase consumption rates. This is an extremely important finding for the Pork CRC.

Conclusion

The current study adds to emerging literature indicating regular consumption of fresh lean pork has no adverse effects on health including cardiovascular risk factors such as obesity. These findings demonstrate that lean fresh pork can be incorporated into the diet without impacting adversely on body composition. The perception that pork is a less superior meat in terms of nutrition than red meat or chicken should be reconsidered. The fact that pork was the most preferred meat, the most enjoyed meat and the best tolerated meat for 3 months shows that pork can be enjoyed in an everyday diet if consumers can be educated. Furthermore many volunteers indicated that their pork consumption has increased as a result of participating in the present study. Future studies are warranted to provide more information relating to the health benefits of pork or in fact the lack of adverse effects associated with eating pork to help increase consumers' trust in the pork industry and boost acceptance of pork products.

Application of Research

Application of the research findings in the commercial world

Commercialization/Adoption Strategies
Our research will be promoted through conference presentations at national meetings and through peer reviewed scientific journals indicating regular consumption of fresh lean pork has no adverse effects on health including cardiovascular risk factors including obesity. To communicate these results to the general public as well as health care providers including nutritionists and dietitians, industry and producers, a marketing campaign using media like radio, television and newspapers will help disseminate results from our previous trials and help revitalize the image of pork. The perception that pork is a less superior meat in terms of nutrition than red meat or chicken should be reconsidered. The fact that pork was the most preferred meat, the most enjoyed meat and the best tolerated meat for 3 months in this trial highlights that pork can be enjoyed in the diet without adverse health effects.

Opportunities uncovered by the research

This project is the first large scale randomized controlled trial to provide evidence that regular consumption of lean fresh pork is no worse than beef or chicken, the two most commonly consumed meats in the Australian diet in terms of impacting on body composition. In fact we have shown that inclusion of lean fresh pork in the diet for 3 months did not impact adversely on body composition. We have also shown using a simple questionnaire looking at meat preferences, that pork was the most preferred meat, the most enjoyed meat, the best tolerated meat for 3 months and many volunteers found their pork consumption had increased as a result of the study. These are extremely important findings for the Pork CRC as it will help revitalise the image of pork as a healthy meat choice and show that pork is not a less superior meat than beef or chicken. Re-educating consumers on the health benefits of pork together with tips for preparing and cooking pork will surely boost consumption rates and sales for the pork industry.

Impact of the research

This project is scientifically important, as it will provide the pork industry, regulatory authorities and Australians with further evidence that the regular consumption of pork has no adverse effects on cardiovascular risk factors such as obesity. Australian Pork Limited together with the Pork CRC are the most appropriate organisations to deliver this evidence to producers, food industry, regulatory bodies and the consumer. Given the current obesity epidemic in the developed world, this project will provide the Australian Pork industry with substantial new local and export marketing opportunities which will return financial benefit to producers.

Furthermore, this project has the potential to benefit all Australians. The primary target group to benefit from this project is the majority of Australians who consume meat including pork. As in most other

developed countries throughout the world, Australia is experiencing an obesity epidemic. This epidemic represents the greatest health crisis of our time. At the same time, this epidemic represents an enormous opportunity for producers, food manufacturers and distributors of products which can counter the adverse effects of obesity and improve overall health.

Limitations/Risks

n/a

Recommendations

For pork consumption to gain acceptance by consumers and health care providers, it is vital for the Pork CRC to continue to substantiate previous findings in the health and nutrition area by building on current research. Increasing the base of scientifically substantiated evidence will assist the Pork CRC in establishing a credible evidence base to support consumer communication which may lead to increased pork consumption. Hence we recommend **building on our previous research** and confirming the positive health benefits on cardiometabolic health, but also provide **new** evidence. Considering that our previous research (3-104 and 3A-111) have provided evidence that pork is no worse than beef or chicken, has no adverse effects on cardiovascular risk factors and may actually improve body composition with regular consumption, we would suggest undertaking a further long term trial to demonstrate that regular consumption of pork can be used as part of a weight loss and weight maintenance program to improve diabetes control as well as reduce food cravings and improve psychological wellbeing and overall quality of life. A study like this is of high relevance to the pork industry as not only is pork an important and nutrient dense protein source, there remains concerns about the metabolic impacts of higher meat diets in human health.

To build on our exciting outcomes which show that pork was the most enjoyed meat in our trial we suggest conducting a marketing campaign which will provide consumers not only with nutrition and health knowledge of pork, but new modern and healthy recipes with tips for cooking pork to generate a tender and tasty product.

Public dissemination of results together with a marketing campaign will help revitalize the image of pork together and help educate consumers and healthcare providers.

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