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Nutritional Composition of Kangaroo Meat

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Fat content and lipid composition

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Foreword

Food Science Australia (FSA) has recently completed a study for RIRDC, Composition of New Meats – Analyses and nutrient composition of innovative meat industries (RIRDC Publication No. 07/036). This research covered seven different genus types including buffalo, camel and crocodile. Through RIRDC, the kangaroo industry expressed interest in determining the nutrient composition of specific fat components in various muscle cuts of two different species from two different geographical locations.

The objective of this work was to collect commercially representative samples of meat from nominated kangaroo species from two geographical locations and analyse them using standard procedures, and provide the industry with information regarding specific lipid nutrients in their products.

This project was funded by RIRDC Core funds which are provided by the Federal Government.

This report, an addition to RIRDC's diverse range of over 1800 research publications, forms part of our New Animal Products R&D program, which aims to accelerate the development of viable new animal industries.

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Peter O'Brien
Managing Director
Rural Industries Research and Development Corporation

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The authors would like to thank Macro Investments Pty Ltd trading as Macro Meats Gourmet Game for supplying the kangaroo meat samples and Naomi Simpson from that company for organising the collection and arranging delivery of the samples to NMI. All lipid analyses were performed by National Measurement Institute (NMI), Melbourne.

Abbreviations

AOAC	Association of Official Analytical Chemists
AS	Australian Standard
CLA	Conjugated linoleic acids
NMI	National Measurement Institute
PUFA	Polyunsaturated fatty acids
RIRDC	Rural Industries Research and Development Corporation
NA	Not Available
α	Alpha
ω	Omega

Contents

Executive Summary

What the report is about
Information is frequently sought on nutritional composition of kangaroo meat as required by Food Standards Australia and New Zealand (FSANZ) Food Standards Code for Product labelling panels.

Who is the report targeted at?
The data can be used by people when they are preparing information for Nutritional Information Panels on Product labels and by wholesalers and retailers of kangaroo meat.

Background
Previous studies have revealed that kangaroo meat is very lean and is therefore ideal for low-fat diets. Aware of this, the Kangaroo Industry sought to determine if this was consistent over different species, individual muscle cuts and from different geographical locations.

The aims of the research project
In addition to fat content, information was sought on cholesterol contents, fatty acid profiles, omega-3 and CLA contents.

Method
In consultation with the nominated industry supplier (arranged by RIRDC) Food Science Australia undertook the organisation of collecting kangaroo samples for nutrient lipid analysis to be conducted by the National Measurement Institute (NMI). The species selected for analysis were:

- Red kangaroo (*Macropus rufus*)
- Grey kangaroo (*Macropus giganteus*)

The four muscle cuts selected for analysis were topside, fillet, rump and knuckle obtained from animals taken from two geographical locations, Wertaloona Station, South Australia and Blackall, Queensland with five replicate samples from each of these variates, making a total of 80 samples for analysis. The samples were supplied frozen to NMI for fat content determination and lipid compositional analysis. Information on product slaughter date, location, carcase weight, product trace back identity and company trading name was also obtained.

Results
The findings showed that the fat content and fat composition of the four commercial muscle cuts from two species of kangaroo from each of two geographical regions confirmed that kangaroo meat was very low in fat and the fat present was rich in polyunsaturated fatty acids. Meat samples obtained from carcases having mean weights of about 19 to 20 kg contained, generally, less than 1g ether-extractable fat/100g meat. This was made up of about 32% saturated fats, 31% mono-unsaturated fats and 37% polyunsaturated fats. The lipid content and composition of the four muscles tested was found to be very similar, and for lipid nutritional differences would not be regarded as different. There was a tendency for kangaroo meats from QLD, irrespective of species or cut, to be higher in saturates and lower in polyunsaturates compared with meats from SA. It was also found that meat from the Red kangaroo from QLD had lower cholesterol contents compared with the other samples measured.

Recommendations
These differences observed for polyunsaturation and cholesterol content should be re-investigated using a larger number of samples taken over a longer time period and from broader locations in each State in order to confirm the reported observations.

1. Introduction

Food Science Australia (FSA) has recently completed a study for RIRDC, Composition of New Meats – Analyses and nutrient composition of innovative meat industries (RIRDC Publication No. 07/036). This research covered seven different genus types including buffalo, camel and crocodile. Through RIRDC, the kangaroo industry expressed interest in determining the nutrient composition of specific fat components in various muscle cuts of two different species from two different geographical locations. The results of this study are included in this report.

1.1 Objectives

The objective of this work was to collect commercially representative samples of meat from nominated kangaroo species and meat cuts, analyse the samples for fat content and lipid composition using standard procedures and provide the industry with the information in a report.

2. Methodology

2.1 Sample collection protocol.

In consultation with the kangaroo industry Food Science Australia undertook the organisation of collecting kangaroo samples (Figure 1) for nutritional analysis to be conducted by the National Measurement Institute (NMI).

Samples were sourced and collected by Macro Investments Pty Ltd, individually packaged, labelled and frozen prior to shipment. Samples were shipped by same day courier, in insulated containers with ice to NMI Melbourne.

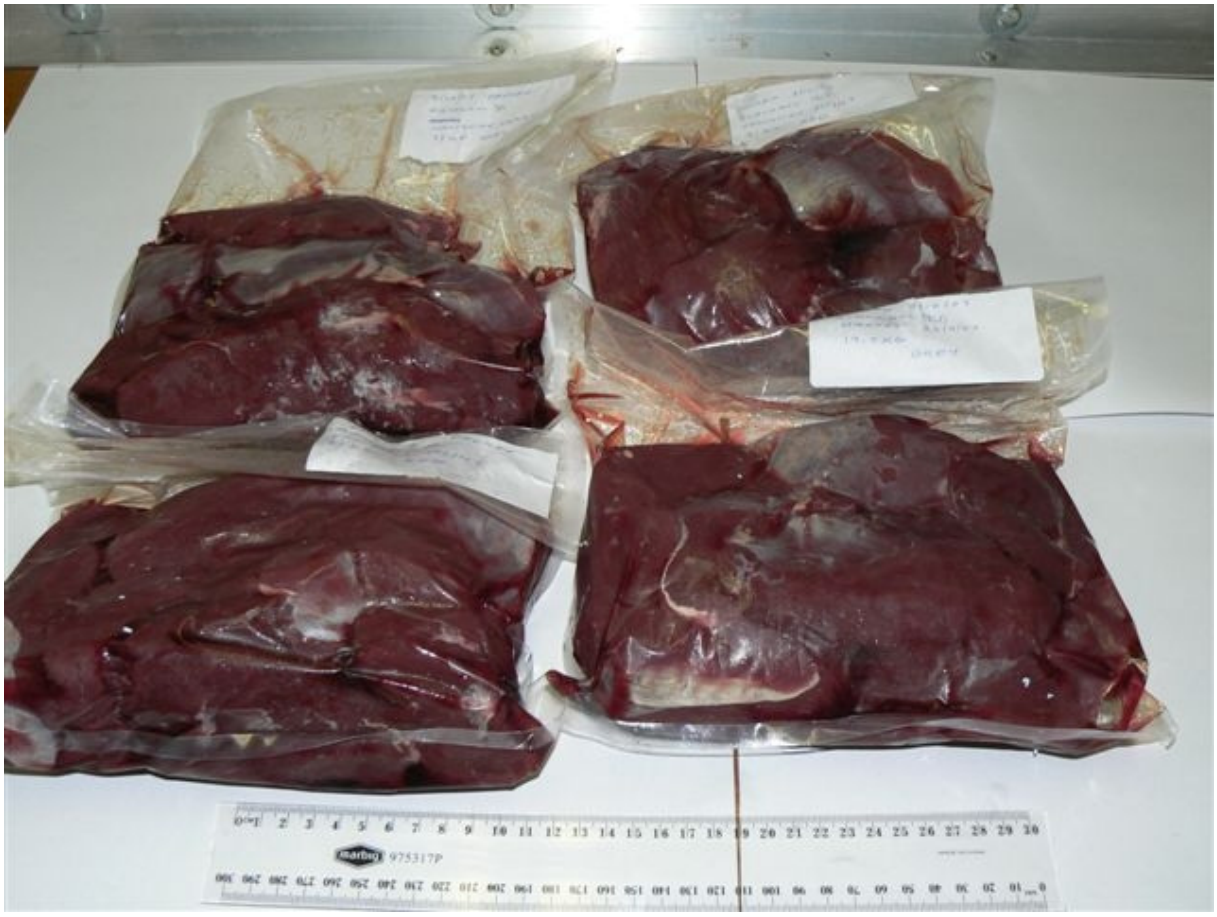

Figure 1: Example of vacuum packed Red and Grey kangaroo muscle samples from Queensland and South Australia supplied to NMI.

Two species were selected for analysis, Red kangaroo (*Macropus rufus*) and Grey kangaroo (*Macropus giganteus*) from each of two geographical locations, Wertaloona Station in South Australia and Blackall in Queensland using four muscle cuts from each. There were five replicates for each of these variates, giving a total of 80 samples for analysis (Table 1). The four cuts selected for analysis were topside (WK14), loin fillet (WK28), rump (WK15) and knuckle (Round - WK17) (Figure 2).

Mean carcase weights from each species and location were similar (Table 1) ranging from about 18 to 21 kg although individual weights varied significantly as is evident from the standard deviations (SD) of the mean (Appendix 2, Table 7).

The treatment histories and animal information was dependent upon the species and on management procedures. Information on product slaughter date, shooter, geographical location, species, carcase weight, cut, product trace back identity and company trading name was also obtained prior to shipment. Sample collections were made in the period from 25th October 2007 to 30th November 2007.

Table 1): Kangaroo species, mean carcase weights, standard deviation and muscles received for this survey.

Kangaroo Species	State	Weight (kg)	SD Weight	Muscle	No of samples provided
Grey Kangaroo	South Australia	20.0	4.1	Fillet	5
				Knuckle	5
				Rump	5
				Topside	5
Grey Kangaroo	Queensland	18.5	2.1	Fillet	5
				Knuckle	5
				Rump	5
				Topside	5
Red Kangaroo	South Australia	19.2	2.8	Fillet	5
				Knuckle	5
				Rump	5
				Topside	5
Red Kangaroo	Queensland	18.8	3.7	Fillet	5
				Knuckle	5
				Rump	5
				Topside	5
Total					80

SD: Standard Deviation

LOIN FILLET - SKIN ON WK28

Loin fillet is derived from a loin set (item WK26) and consists of 2 separate muscles situated on the dorsal edge of the carcase from the 3rd to 6th lumbar vertebrae.
Point requiring specification:
• Silver skin retained
or removed.

KNUCKLE (Round) WK17

Knuckle is prepared from a leg and is removed by following the natural seam between the topside and silverside.
Point requiring specification:
• Denuded: Remove silver skin/surface and accessible fats.

RUMP WK15

Rump is prepared from a leg and is removed by a straight cut commencing at the tip of the ilium bone, and parallel to the ventral and dorsal edges.
Point requiring specification:
• Denuded: Remove silver skin/surface and accessible fats.

TOPSIDE WK14

Topside is prepared from a leg and is removed by following the natural seam between the knuckle and silverside.
Points requiring specification:
• Denuded: Remove silver skin/surface and accessible fats.
• Cap muscle: Retained or removed

Figure 2: Primal cuts for kangaroo meat selected for this survey

2.2 Lipid Analysis

Chemical analysis of meat lipids was conducted on Red kangaroo and Grey kangaroo by the NMI on all samples according to Australian Standard methods. Lean and fat were not separated prior to chemical analysis, with sampling carried out on the respective whole meat cut. Analyses were determined on raw meat only and therefore the data are not applicable to cooked products due to moisture losses and other changes that would occur during cooking. Analysis was carried out for: Cholesterol content (mg/100g raw meat); Total omega-3 content (mg/100g raw meat) and CLA content (mg/100g raw meat). Detailed method descriptions are included in Appendix 1.

2.3 Statistical Analysis

2.3.1 Experimental design

A total of eighty (80) individual samples were collected from 2 states (SA and QLD) x 2 species (Grey and Red kangaroo) x 4 muscles (loin fillet-WK28, knuckle-WK17, rump-WK15 and topside-WK14 x 5 replicate samples from each cut.

For all analyses, determinations were made on duplicate sub-samples, resulting in 160 samples for each nutrient; 2 States x 2 species x 4 cuts x 5 replicates x 2 duplicate determinations.

2.3.2 Analysis of lipid data

Standard deviations of means were determined on all data and are presented in the Appendix 2.

For each of two variables, cholesterol and total polyunsaturated fatty acids, a two way analysis of variance was performed; 2 states (SA / QLD) and 2 species (Grey / Red kangaroo) x 4 cuts (loin fillet, knuckle, rump and topside). Arithmetic means and standard deviations associated with the chemical analyses have been calculated for each variate (Appendix 2, Tables 13 and 14).

3. Results & Discussion

3.1 Lipid Results

This report contains a summary presentation of the mean data for two kangaroo species, two geographical locations and four muscle cuts. Only analytical data is presented in this report and no nutritional interpretation relating to fat composition has been made or implied. This document provides information on data arithmetic means and standard deviations associated with the analyses. Because of the quantity of data obtained from these analyses, all the analytical data obtained has been summarised and presented in the appendices.

The analytical information relates to whole raw cuts, as supplied by the industry without further trimming. It should be noted that cooking would affect the data reported here on a weight basis through loss of moisture and possibly through decomposition.

3.1.1 Fat content

The contents of some of the major lipids of interest for raw samples are presented in Table 2. All mean data including standard deviations (SD) are presented in Appendix 2, Table 8.

The total fat content (as determined by Soxhlet using diethyl ether) was very low, ranging from a mean of just 0.2 g/100g for knuckle from SA Red kangaroo to 1.4 g/100g for knuckle from QLD Grey kangaroo. This extracted fat represents largely the triglyceride and other neutral lipid components of muscle and does not include the muscle membrane phospholipids which normally comprise about 0.6 to 0.9 g/100g muscle.

The mean total saturated fat contents obtained from analysis of fatty acid profiles were therefore also very low (0.1 to 0.7 g/100g) and there were essentially no differences between species, muscles or geographical locations (see means and SD in Appendix 2, Table 8).

3.1.2 CLA content

The content of total CLA was determined separately from the other fatty acids and is expressed as mg CLA/100g meat (Table 2). All mean data including standard deviations (SD) are presented in Appendix 2, Table 8. The variation in the content of CLA between individual samples was very high (see SD's) and it was not possible to see any differences between species, muscles or locations. The overall mean for all samples was 11.7mg/100g meat. In kangaroo, although not a true ruminant, CLA is a product of incomplete hydrogenation of polyunsaturated fatty acids in the fore gut, the amount of CLA present in the meat is likely to be higher than in non-ruminant species. Further, CLA or specifically *cis*-9, *trans*-11 CLA, also a product of the fore stomach, can also be formed in adipose tissue from *trans*-11 C18:1 (vaccenic acid) via a desaturase reaction. Engelke et al (2004) found that the percentage of CLA relative to all fatty acids from kangaroo fat was up to 4 times higher than that from lamb fat. However, because the fat content of beef and lamb is usually much higher than that found for kangaroo, the actual content of CLA in the kangaroo meat may not be very different from the more traditional meats.

3.1.3 Cholesterol content

The mean cholesterol content is presented in Table 2 and with standard deviations in Appendix 2, Table 8. The mean cholesterol contents for Grey kangaroo from SA and QLD were all relatively similar irrespective of muscle cut and were comparable to cuts of Red kangaroo from SA (mean value of 63.0 mg/100g). However, Red kangaroo originating from QLD had significantly lower cholesterol contents with a mean value of 41.6 mg/100g muscle (Table 2 and Appendix 2, Table 13). The significance of the muscle effect was $P<0.001$ and was also $P<0.001$ for the State/species effect. The reason for these differences is not known, but it should be mentioned that these analyses were performed on the samples collected over a fairly short time period during spring of one season. These observations need to be supported by further studies before any definitive statement of differences can be made.

Individual mean values (± SD, n=20) for combined cuts are shown in the following tabulation:

Grey kangaroo, SA	65.3 ± 9.94 mg/100g muscle
Grey kangaroo, QLD	65.0 ± 15.9 mg/100g muscle
Red kangaroo, SA	63.0 ± 7.64 mg/100g muscle
Red kangaroo, QLD	41.6 ± 8.70 mg/100g muscle

3.1.4 Fatty acid profiles

For simplicity, data on the fatty acid composition of the various meats have been presented as individual tables for the major saturates, mono-unsaturates and polyunsaturates (Tables 3, 4 and 5 respectively). All mean data including standard deviations has been presented in Appendix 2, tables 9a, 9b, 10a, 10b, 11a and 11b)

3.1.4.1 Major saturated fatty acids

The percentage distribution of major saturated fatty acids in the raw kangaroo samples are given in Table 3. Saturated fatty acids comprised about 30 % of all fatty acids present in the kangaroo meat, with palmitic and stearic acids accounting for more than 90% of the total saturates. The percentage of palmitic acid in kangaroo meat was low (15 to 20 %) compared with many other meats. In beef it is commonly 22 to 30 % (Yang et al, 2002) and similar values have been reported for meat from camel, rabbit, emu and crocodile (RIRDC Report No 07/036, January 2007). For stearic acid, the percentages were largely similar for all muscle cuts within a kangaroo species (10 to 15 %), however, there does appear to be a trend that it is higher in those species from QLD, particularly for Red kangaroo. These values for kangaroo are similar to those found for crocodile, ostrich and emu, but significantly lower than reported for buffalo and camel (RIRDC Report No 07/036, January 2007). Overall, the saturated fat content of kangaroo is very low, particularly when the meat contains such a low total fat content.

3.1.4.2 Major mono-unsaturated fatty acids

The percentage distributions of the major mono-unsaturated fatty acids of kangaroo meat samples are shown in Table 4. Oleic acid was the major fatty acid of this group (25 to 30%), accounting for more than 95% of total mono-unsaturates. The only other significant contributors to this group were the *trans* fatty acids, together with lesser amounts of palmitoleic and heptadecenoic acids. The content of *trans* fatty acids in the meats was as expected for ruminant or pre-ruminant animals. The *trans* fatty acid, originating in the fore gut, is largely the trans-11 isomer, known as vaccenic acid as found in sheep and beef meats. These *trans* fatty acids differ from those found in hydrogenated vegetable oils.

Unless there are differences in fat contents between muscle cuts, it would not be expected that the composition of the fatty acids would differ markedly between the individual muscles.

3.1.4.3 Major polyunsaturated fatty acids

The polyunsaturates comprised the largest group of fatty acids in the meat of the kangaroo samples having an overall mean of 37.5% compared with 31.5% for the saturates and 30.7% for the mono-unsaturates. The major polyunsaturated fatty acids are presented in Table 5. Linoleic acid was the predominant fatty acid (approximately 15 to 20%) followed by arachidonic acid (6 to 10%) and α-linolenic acid (3 to 7%). Other significant polyunsaturated fatty acids were eicosapentaenoic acid (EPA (2 to 3%) and docosapentaenoic acid (2 to 3%).

The percentages of total polyunsaturates were similar for Grey and Red kangaroo when they were sourced from the same location but those from SA were significantly higher ($P<0.01$) than those from QLD (see Appendix 2, Table 14). There were no differences between muscles ($P>0.05$). Mean values (± SD, n=20) for all four combined muscles are shown in the following tabulation:

Grey kangaroo, SA	40.3 ± 8.63 %
Red kangaroo, SA	41.1 ± 7.77 %
Grey kangaroo, QLD	33.1 ± 9.91 %
Red kangaroo, QLD	35.6 ± 8.36 %

As pointed out above for apparent differences in cholesterol contents, these values obtained for total polyunsaturates were obtained from samples over just one short period of time. Verification of these differences would require further investigation. However, for the samples obtained here it is apparent that, irrespective of species, kangaroo meat from SA had a higher percentage profile of polyunsaturated fatty acids than that from QLD. Generally, as the fat content of meat increases, the percentage of total polyunsaturated fatty acids decreases (Sinclair and O'Dea, 1987). Differences in Soxhlet fat contents between samples were small however but the differences may have contributed to the percentages of polyunsaturates observed.

Although the total fat content in kangaroo meat is very low and therefore the contribution to total dietary fat intake is low, nevertheless, the ratio of omega-6 to omega -3 fatty acids is approximately 2.5:1 which is considered good compared with standard Western diets of about 15:1 (Simopoulos, 2002).

3.1.4.4 Overall unsaturation

The overall degree of unsaturation of the fatty acids in the kangaroo samples is presented as a ratio of polyunsaturates: mono-unsaturates: saturates (P:M:S) and is given in Table 6. As indicated previously, the polyunsaturates were the essentially the largest group irrespective of species, State or muscle cut. The ratio of polyunsaturates to other fatty acid groups appeared to be higher for those meat samples originating from SA (give means here), for both Grey and Red kangaroo. Environmental factors that may have been involved here include different feeds, ambient temperatures (samples collected in spring from each location) and differences in fore-stomach micro-flora.

4. Conclusion

An investigation of the fat content and fat composition of four commercial muscle cuts from two species of kangaroo from each of two geographical regions confirmed that kangaroo meat was very low in fat and the fat present was rich in polyunsaturated fatty acids. Meat samples obtained from carcases having mean weights of about 19 to 20 kg contained, generally, less than 1g ether-extractable fat/100g meat. This was made up of about 32% saturated fats, 31% mono-unsaturated fats and 37% polyunsaturated fats. The lipid content and composition of each of the four muscles tested was found to be very similar, and any lipid nutritional differences would not be regarded as different. There was a tendency for kangaroo meats from QLD, irrespective of species or cut, to be higher in saturates and lower in polyunsaturates compared with meats from SA. It was also found that meat from the Red kangaroo from QLD had lower cholesterol contents compared with the other samples measured. These differences observed for polyunsaturation and cholesterol content should be re-investigated using a larger number of samples taken over a longer time period and from broader locations in each State in order to confirm the reported observations.

Table 2: Mean total fat, saturated fat, total CLA and cholesterol of raw samples from two kangaroo species.

SPECIES	STATE	MUSCLE	Fat (Soxhlet)	Saturated Fat	Total Conjugated Linoleic Acids (CLA)	Cholesterol mg/100g meat
		Units	g/100g meat	g/100g meat	mg/100g meat	
Grey Kangaroo	SA	Fillet	1.1	0.4	17.2	78.8
		Knuckle	0.8	0.2	16.3	58.2
		Rump	0.5	0.2	8.4	62.8
		Topside	0.6	0.2	11.5	61.2
	QLD	Fillet	1.1	0.4	3.2	77.2
		Knuckle	1.4	0.7	16.4	52.4
		Rump	0.7	0.3	19.7	63.0
		Topside	0.6	0.2	9.0	67.2
Red Kangaroo	SA	Fillet	0.7	0.2	13.8	65.8
		Knuckle	0.2	0.1	10.3	54.6
		Rump	0.8	0.2	9.6	62.2
		Topside	0.8	0.3	16.0	69.2
	QLD	Fillet	0.7	0.2	11.4	37.6
		Knuckle	0.8	0.3	11.1	40.6
		Rump	1.0	0.4	5.6	39.4
		Topside	0.7	0.2	8.1	48.8

Data shown are means of animal replicated samples for duplicate analyses as described in methods.
Appendix Table 8 contains all mean data including SD.

Table 3: Mean saturated fatty acid profiles (% of total fatty acids) of raw samples from two kangaroo species.

SPECIES	STATE	MUSCLE	MAJOR SATURATES					
			C14:0 Myristic	C15:0 Pentadecanoic	C16:0 Palmitic	C17:0 Margaric	C18:0 Stearic	Total Saturated
Grey Kangaroo	SA	Fillet	0.7	0.7	15.8	1.0	11.5	30.0
		Knuckle	0.7	0.8	15.1	1.1	12.2	29.9
		Rump	0.9	0.7	16.5	1.0	11.1	30.8
		Topside	0.5	0.8	15.2	1.2	11.5	29.5
	QLD	Fillet	0.6	0.9	18.2	1.6	15.4	36.9
		Knuckle	0.7	0.7	17.3	1.0	12.8	32.8
		Rump	1.0	1.0	15.8	1.4	12.4	31.8
		Topside	0.7	0.8	16.6	1.2	13.5	33.0
Red Kangaroo	SA	Fillet	0.7	0.8	14.7	1.1	11.5	29.0
		Knuckle	0.6	0.7	16.2	0.9	10.7	29.5
		Rump	0.6	0.8	14.3	1.0	11.6	28.4
		Topside	0.7	0.8	16.2	1.1	10.7	29.8
	QLD	Fillet	0.7	0.7	15.2	1.1	12.8	30.4
		Knuckle	0.5	0.8	17.3	1.2	13.4	33.3
		Rump	1.7	0.9	20.7	1.5	13.2	38.3
		Topside	0.5	0.7	15.2	1.1	13.2	30.7

Data shown are means of animal replicated samples for duplicate analyses as described in methods.

Appendix Tables 9 (a) and 9 (b) contain all mean data including SD.

Table 4: Mean mono-unsaturated fatty acid profiles (% of total fatty acids) of raw samples from two kangaroo species.

SPECIES	STATE	MUSCLE	MAJOR MONO-UNSATURATES				
			C16:1 Palmitoleic	C17:1 Heptadecenoic	C18:1 Oleic	Total *cis*-mono fatty acids	Total *trans*-mono fatty acids
Grey Kangaroo	SA	Fillet	1.8	1.3	31.0	34.2	3.5
		Knuckle	1.3	1.2	26.6	29.4	5.1
		Rump	1.5	1.4	25.3	28.5	3.2
		Topside	1.1	1.4	22.7	25.3	2.9
	QLD	Fillet	3.1	2.1	22.9	28.5	3.7
		Knuckle	1.8	1.8	30.0	33.9	3.9
		Rump	2.0	1.2	31.9	35.5	5.0
		Topside	3.6	2.0	28.3	34.2	5.1
Red Kangaroo	SA	Fillet	1.4	1.5	26.3	29.3	4.2
		Knuckle	1.2	1.4	23.0	25.9	3.4
		Rump	1.3	1.5	24.4	27.6	3.1
		Topside	2.0	1.4	31.0	34.7	4.0
	QLD	Fillet	1.7	1.4	30.0	33.3	4.5
		Knuckle	2.8	1.3	22.5	26.8	4.1
		Rump	4.3	2.4	28.4	35.0	5.1
		Topside	2.4	1.4	24.7	28.6	4.0

Data shown are means of animal replicated samples for duplicate analyses as described in methods.

Appendix Tables 10 (a) and 10 (b) contains all mean data including SD.

Table 5: Mean polyunsaturated fatty acid profiles (% of total fatty acids) of raw samples from two kangaroo species.

SPECIES	STATE	MUSCLE	MAJOR POLY-UNSATURATES									
			C18:2ω6 Linoleic	C18:3ω3 α-Linolenic	C20:3ω6 Eicosatrienoic	C20:4ω6 AA	C20:5ω3 EPA	C22:5ω3 DPA	C22:6ω3 DHA	Total ω 6 Fatty Acids	Total ω 3 Fatty Acids	Total PUFA
Grey Kangaroo	SA	Fillet	14.6	5.8	1.2	6.9	2.8	2.7	0.6	23.4	12.0	35.4
	SA	Knuckle	19.0	4.0	1.0	10.3	1.8	3.0	0.6	31.0	9.5	40.5
	SA	Rump	17.9	4.3	1.2	9.6	2.6	3.3	0.6	29.5	10.9	40.3
	SA	Topside	19.4	6.7	1.5	9.1	3.1	3.2	0.8	30.8	14.1	45.0
	QLD	Fillet	16.3	4.5	1.1	6.2	2.0	2.8	0.5	24.3	10.0	34.3
	QLD	Knuckle	15.7	3.3	1.0	7.4	1.7	2.7	0.5	24.7	8.2	33.0
	QLD	Rump	15.7	3.7	0.9	7.1	1.7	2.2	0.5	24.2	8.2	32.4
	QLD	Topside	14.4	4.6	1.2	6.0	2.4	2.5	0.6	22.3	10.3	32.5
Red Kangaroo	SA	Fillet	18.7	7.1	1.2	6.7	3.0	3.1	0.8	27.2	14.2	41.4
	SA	Knuckle	21.8	4.4	1.1	10.3	2.0	3.1	0.6	34.0	10.3	44.2
	SA	Rump	18.7	5.2	1.3	10.2	3.1	3.5	0.8	31.1	12.7	43.7
	SA	Topside	15.7	5.1	1.1	7.1	2.4	2.5	0.6	24.4	10.8	35.2
	QLD	Fillet	15.7	4.6	1.0	7.9	2.3	3.0	0.6	25.4	10.6	36.0
	QLD	Knuckle	16.9	3.7	1.1	9.9	2.4	3.9	0.9	28.8	11.0	39.7
	QLD	Rump	11.4	2.8	< 0.1	6.1	1.8	2.4	0.5	18.9	7.5	26.4
	QLD	Topside	18.2	4.8	1.2	8.9	2.4	3.3	0.8	29.1	11.4	40.4

Data shown are means of animal replicated samples for duplicate analyses as described in methods.

Appendix Tables 11 (a) and 11 (b) contains all mean data including SD.

Table 6: Mean P:M:S ratio of raw samples from two kangaroo species.

SPECIES	STATE	MUSCLE	P:M:S Ratio
Grey Kangaroo	SA	Fillet	1.2:1.1:1.0
		Knuckle	1.4:1.0:1.0
		Rump	1.3:0.9:1.0
		Topside	1.5:0.9:1.0
	QLD	Fillet	0.9:0.8:1.0
		Knuckle	1.0:1.0:1.0
		Rump	1.0:1.1:1.0
		Topside	1.0:1.0:1.0
Red Kangaroo	SA	Fillet	1.4:1.0:1.0
		Knuckle	1.5:0.9:1.0
		Rump	1.5:1.0:1.0
		Topside	1.2:1.2:1.0
	QLD	Fillet	1.2:1.1:1.0
		Knuckle	1.2:0.8:1.0
		Rump	0.7:0.9:1.0
		Topside	1.3:0.9:1.0

Data shown are means of animal replicated samples for duplicate analyses as described in methods.

5. References

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Cholesterol Determination in Foodstuffs by GC

AOAC (1995) Association of Official Analytical Chemists. Cholesterol in Food Gas Chromatographic Method 976.26, Ch 45 pp. 68-70
Punwar, J.K. (1975) JAOAC, 58, 804-810

Fat Determination in Meat samples by Soxhlet Extraction

AOAC (1995) Association of Official Analytical Chemists 16th Ed. 920.39, 960.39, 948.22

Fatty Acid Profile – including trans fatty acids

Bligh and Dyer. A Rapid Method of Total Lipid Extraction and Purification. Can. J. Biochem. Physiol., 37, 911-917
Badings and Dejong (1983). J.Chrom., 279, 493-506
McCance and Widdowson (1991). The Composition of Foods. 5th Ed. p 9.

6. Appendices

6.1 Appendix 1: Methods

6.1.1 VL 300 Fat Determination in Food by Soxhlet Extraction

Method Summary of	**VL300_Fat by Soxhlet**
Summary Issued	**6th October 2005**
Fat Determination in Food by Soxhlet Extraction	

Australian Government
National Measurement Institute

Analysis Description	**Fat Determination in meat and other foods by Soxhlet**
Matrix / Matrices	**Foods (Meats and Fish)**
Reference Method(s)	AOAC International.16th Edition, 1995, Sections 920.39, 960.39 and 948.22.
Limit of Reporting (LOR)	**0.2g/ 100g**
NATA Accredited	Yes
Preparation & procedure	**Preparation;** Samples are homogenised as thoroughly as possible. Occasionally dilution with water may be used to improve homogenisation efficiency. **Extraction:** Approximately 5g of prepared sample is accurately weighed into a soxhlet thimble and a loose plug of fat free cotton wool is inserted into the top of the thimble. The thimble containing sample is then dried in an air oven for at least 6 hours at 102°c. The thimble is then placed into a soxhlet extraction apparatus. The apparatus is then inserted into the top of a pre-weighed erlenmeyer flask containing approx. 150ml of diethy ether. The flask is heated on a boiling water bath. Extraction of fat by the diethyl ether occurs over a period of 16 hours. **Determination:** After 16 hours of extraction the apparatus is disassembled and all diethyl ether collected in the erlenmeyer flask. The ether is then evaporated from the flask on a water bath. Once all ether is visibly evaporated the erlenmeyer flask is placed in an air oven at 102°c for 1 hour. After 1 hour the flask is cooled under desiccation and weighed. This oven drying and weighing procedure is repeated until successive weighings agree to within 5mg. Calculation: % Fat = $\frac{\text{(Weight of flask)final – (Weight of flask)initial}}{\text{Weight of sample}} \times 100$
Comments, limitations or known interferences	Fat bound in complex matrices is usually only partially extracted using this technique. The method is, therefore, limited to matrices such as meat and fish. Non fat material, which is ether extractable, may be included in the determination.
Equipment used	Convection oven calibrated at 102°C, desiccator Analytical balance capable of weighing to 0.001gram Erlenmeyer flasks, Soxhlet Extraction apparatus, Multi-place heated water bath, fume cupboard, diethyl ether, soxhlet thimble and cotton wool.
QA Protocols per batch	1 Duplicate per batch, maximum batch size is 10 samples.
Mass of Sample required	5g per sample, depending on the fat content of the sample

6.1.2 VL 288 Determination of Cholesterol in Food and Liquids by Gas Chromatography

Method Summary of	**VL 288**
Summary Issued	**7th August 2006**
Cholesterol in Food and Beverages	

Australian Government
National Measurement Institute

Analysis Description	**Determination of Cholesterol in Food and Liquids by Gas Chromatography (GC)**
Matrix / Matrices	Food and Beverages
Reference Method(s)	1. Punwar, J.K. (1975) Journal of AOAC International, **58**, pp 804-810. 2. AOAC (1995). Official Methods of analysis of AOAC International. Cholesterol in Food. Gas Chromatographic Method 976.26, Ch 45 pp.68-70.
Limit of Reporting (LOR)	1 mg/100g
NATA Accredited	YES
Preparation & procedure	Preparation & Saponification: Approximately 1g of sample is accurately weighed into a 40 mL flask, cholestane added and 5 mL alcoholic KOH is added. The solution is then placed in a water bath at 80c for 30 minutes. Extraction: The saponification solution is then cooled to room temperature. 1 mL of MilliQ water is added, then the saponification mixture is extracted with 5 mL of Hexane. A portion of hexane is transferred to a GC vial, internal standard solution added and the vial is crimped ready for GC-FID analysis. Determination: Cholesterol within the extract is separated by GLC using an BPX-5 column. Detection is made using a Flame Ionisation Detection system. Quantitation is made against known cholesterol standards, cholestane is used as the internal standard. Results are expressed to two significant figures in units of mg/100g.
Comments, limitations or known interferences	Cholesterol related sterol compounds present in plant materials may interfere with chromatography when cholesterol is present at concentrations close to the LOR.
Equipment used	Glassware, Balance, GC system with Flame Ionisation Detector, Chemical Standards, Filters, water bath, heating block
QA Protocols per batch	One recovery per batch (10 samples) One duplicate per batch One Control determination per batch One sample blank per batch.
Mass of Sample required	For solid and liquid samples approximately 1 g is normally taken, depending on expected concentration of analyte.
Comments	

6.1.3 VL 289 Determination of Fatty Acids in Food Stuffs

Method Summary of	**VL 289**
Summary Issued	**26th February 2008**
Determination of Fatty Acids in Food Stuffs	

Australian Government
National Measurement Institute

Analysis Description	**Fatty Acid Profile – including trans fatty acids**
Matrix / Matrices	**Foods**
Reference Method(s)	**Bligh & Dwyer, "A Rapid Method of Total Lipid Extraction and Purification", Can.J. Biochem. Physiol., 37, 911-917** **Badings & Dejong (1983). J. Chrom., 279, 493-506.** **McCance & Widdowson (1991). The Composition of Foods. 5th Ed, p 9.**
Limit of Reporting (LOR)	**FAME's 0.1g/100g**
NATA Accredited	**Yes**
Preparation & procedure	**Preparation:** The sample is homogenised and a sub sample taken (usually 1 to 20g, depending on sample type). Fat is extracted from the sample using either Chloroform/Methanol or Petroleum ether/iso-propyl alcohol. The extract is evaporated under nitrogen. A minimum extracted mass of 0.2g fat is required. The extracted fat is esterified using a methanolic sodium methoxide solution and treatment with sulphuric acid in methanol. The solution is neutralised and re-extracted using n-hexane. The hexane layer is removed, dried using anhydrous sodium sulphate and made to volume, with hexane, in a 25ml volumetric flask. **Determination:** The relative proportion of each fatty acid methyl ester in the prepared sample is determined using gas chromatography with flame ionisation detection. Identification of the individual fatty acids is made by retention time against a standard of known fatty acid methyl esters including both cis and trans isomers. The amount of Conjugated Linoleic Acid (CLA) can be also determined from the FAME's chromatogram. **Calculation:** Integration and calculation of proportional methyl ester concentrations is made using instrument software. CLA is quantitated using a six point external standard calibration. CLA is usually expressed as mg CLA/g fat.
Comments, limitations or known interferences	The results obtained are proportional only, as a percentage (or g/100g) of the FAME's present in the fat extracted from the sample. If a FAME is required to be determined as a proportion of the total sample then a total fat determination of the sample is also required. For most foods FAMES comprise over 95% of the total fat determined using standard mojonnier or soxhlet fat methods. The FAMES reported range from C4 (Butyric acid) to C24:3 chain lengths. Trans fatty acids are also determined using this method.
Equipment used	Separating Funnels, vials and other glassware.Balance, Rotary Evaporator, Centrifuge. Gas Chromatograph equipped with a Flame Ionisation Detector. Software for interpretation/ calculation of results.
QA Protocols per batch	1 control plant oil and 1 control fat are run with each batch. Minimum of 1 duplicate analysis per batch – maximum batch size; 10 samples.
Mass of Sample required	10g
Comments	

6.2 Appendix 2: Mean and Standard Deviation Data Summary

Table 7: Mean and standard deviation (SD) for carcase weight for each state and the two kangaroo species received for this survey

SPECIES	STATE	Weight (kg)	SD Weight
Grey Kangaroo	South Australia	20.0	4.1
	Queensland	18.5	2.1
Red Kangaroo	South Australia	19.2	2.8
	Queensland	18.8	3.7

Table 8: Mean and standard deviation (SD) for total fat, saturated fat, total CLA and cholesterol of raw samples from two kangaroo species.

SPECIES	STATE	MUSCLE		Fat (Soxhlet)	Saturated Fat	Total Conjugated Linoleic Acids (CLA)	Cholesterol
		Method		VL300	VL289	VL289	VL288
		Units		g/100g meat	g/100g meat	mg/100g meat	mg/100g meat
Grey Kangaroo	SA	Fillet	Mean	1.1	0.4	17.3	78.8
			SD	0.3	0.1	10.1	6.9
		Knuckle	Mean	0.8	0.2	16.3	58.2
			SD	0.5	0.1	16.0	5.5
		Rump	Mean	0.5	< 0.2	8.4	62.8
			SD	0.2	NA	2.4	6.3
		Topside	Mean	0.6	< 0.2	11.5	61.2
			SD	0.4	NA	6.1	1.5
	QLD	Fillet	Mean	1.1	0.4	3.2	77.2
			SD	0.3	0.1	2.4	18.4
		Knuckle	Mean	1.4	< 0.7	16.4	52.4
			SD	1.5	0.6	20.6	4.1
		Rump	Mean	0.7	< 0.3	19.7	63.0
			SD	0.3	NA	12.1	7.9
		Topside	Mean	0.6	0.2	9.0	67.2
			SD	0.3	0.1	7.9	15.2
Red Kangaroo	SA	Fillet	Mean	0.7	0.2	13.8	65.8
			SD	0.3	0.1	10.6	6.1
		Knuckle	Mean	0.2	< 0.1	10.3	54.6
			SD	0.1	NA	8.2	3.6
		Rump	Mean	0.8	0.2	9.6	62.2
			SD	0.1	0.0	4.7	5.9
		Topside	Mean	0.8	< 0.3	16.0	69.2
			SD	0.3	NA	7.0	4.4
	QLD	Fillet	Mean	0.7	0.2	11.4	37.6
			SD	0.2	0.1	6.0	11.6
		Knuckle	Mean	0.8	0.3	11.1	40.6
			SD	0.0	0.0	6.6	7.6
		Rump	Mean	1.0	0.4	5.6	39.4
			SD	0.1	0.1	4.7	3.6
		Topside	Mean	0.7	0.2	8.1	48.8
			SD	0.1	0.0	4.0	2.7

Data shown are means of animal replicated samples from duplicated analyses as described in the methods section

Table 9 (a): Mean and standard deviation (SD) for saturated fatty acid profiles (% of total fatty acids) of raw samples for Grey kangaroo from two States.

SPECIES			Grey Kangaroo							
STATE			SA							
MUSCLE	Method	Units	Fillet		Knuckle		Rump		Topside	
			Mean	SD	Mean	SD	Mean	SD	Mean	SD
C4:0 Butyric	VL289	%	<0.1	NA	<0.1	NA	<0.1	NA	<0.1	NA
C6:0 Caproic	VL289	%	<0.1	NA	<0.1	NA	<0.1	NA	<0.1	NA
C8:0 Caprylic	VL289	%	<0.1	NA	<0.1	NA	<0.1	NA	<0.1	NA
C10:0 Capric	VL289	%	<0.1	NA	<0.1	NA	< 0.2	NA	<0.1	NA
C12:0 Lauric	VL289	%	<0.1	NA	<0.1	NA	< 0.3	NA	<0.1	NA
C14:0 Myristic	VL289	%	0.7	0.3	0.7	0.3	0.9	0.4	0.5	0.1
C15:0 Pentadecanoic	VL289	%	0.7	0.1	0.8	0.2	0.7	0.1	0.8	0.2
C16:0 Palmitic	VL289	%	15.8	1.1	15.1	1.4	16.5	1.9	15.2	1.0
C17:0 Margaric	VL289	%	1.0	0.1	1.1	0.2	1.0	0.1	1.2	0.2
C18:0 Stearic	VL289	%	11.5	1.3	12.2	0.6	11.1	1.6	11.5	1.0
C20:0 Arachidic	VL289	%	<0.1	NA	<0.1	NA	0.2	0.0	<0.2	NA
C22:0 Behenic	VL289	%	<0.1	NA	< 0.2	0.0	<0.1	NA	<0.1	NA
C24:0 Lignoceric	VL289	%	<0.1	NA	<0.1	NA	<0.1	NA	<0.1	NA
Total Saturated	VL289	%	30.0	1.0	29.9	2.6	30.8	1.1	29.5	0.8
STATE			QLD							
MUSCLE			Fillet		Knuckle		Rump		Topside	
			Mean	SD	Mean	SD	Mean	SD	Mean	SD
C4:0 Butyric	VL289	%	<0.1	NA	<0.1	NA	<0.1	NA	<0.1	NA
C6:0 Caproic	VL289	%	<0.1	NA	<0.1	NA	<0.1	NA	<0.1	NA
C8:0 Caprylic	VL289	%	<0.1	NA	<0.1	NA	<0.1	NA	<0.1	NA
C10:0 Capric	VL289	%	<0.1	NA	<0.1	NA	<0.1	NA	<0.1	NA
C12:0 Lauric	VL289	%	<0.1	NA	<0.1	NA	<0.1	NA	<0.1	NA
C14:0 Myristic	VL289	%	0.6	0.1	0.7	0.3	1.0	0.3	0.7	0.3
C15:0 Pentadecanoic	VL289	%	0.9	0.1	0.7	0.3	1.0	0.2	0.8	0.4
C16:0 Palmitic	VL289	%	18.2	1.7	17.3	2.7	15.8	1.4	16.6	1.8
C17:0 Margaric	VL289	%	1.6	0.1	1.0	0.3	1.4	0.2	1.2	0.3
C18:0 Stearic	VL289	%	15.4	2.1	12.8	1.3	12.4	1.1	13.5	1.7
C20:0 Arachidic	VL289	%	< 0.3	NA	< 0.2	NA	0.2	0.1	< 0.2	NA
C22:0 Behenic	VL289	%	< 0.2	NA	< 0.1	NA	< 0.1	NA	< 0.1	NA
C24:0 Lignoceric	VL289	%	< 0.2	NA	< 0.1	NA	< 0.1	NA	< 0.1	NA
Total Saturated	VL289	%	36.9	4.4	32.8	4.1	31.8	2.6	33.0	2.0

Data shown are means of animal replicated samples for duplicated analyses as described in the methods section.
Fatty acid data in grey printing is below limit of detection and/or of no significant interest.

Table 9 (b): Mean and standard deviation (SD) for saturated fatty acid profiles (% of total fatty acids) of raw samples for Red kangaroo from two States.

SPECIES			Red Kangaroo							
STATE			SA							
MUSCLE	Method	Units	Fillet		Knuckle		Rump		Topside	
			Mean	SD	Mean	SD	Mean	SD	Mean	SD
C4:0 Butyric	VL289	%	<0.1	NA	<0.1	NA	<0.1	NA	<0.1	NA
C6:0 Caproic	VL289	%	<0.1	NA	<0.1	NA	<0.1	NA	<0.1	NA
C8:0 Caprylic	VL289	%	<0.1	NA	<0.1	NA	<0.1	NA	<0.1	NA
C10:0 Capric	VL289	%	<0.1	NA	<0.1	NA	<0.1	NA	<0.1	NA
C12:0 Lauric	VL289	%	<0.1	NA	<0.1	NA	<0.1	NA	<0.1	NA
C14:0 Myristic	VL289	%	0.7	0.2	0.6	0.4	0.6	0.2	0.7	0.2
C15:0 Pentadecanoic	VL289	%	0.8	0.5	0.7	0.2	0.8	0.1	0.8	0.3
C16:0 Palmitic	VL289	%	14.7	1.5	16.2	2.1	14.3	1.4	16.2	1.6
C17:0 Margaric	VL289	%	1.1	0.3	0.9	0.1	1.0	0.1	1.1	0.4
C18:0 Stearic	VL289	%	11.5	1.3	10.7	0.9	11.6	1.0	10.7	1.2
C20:0 Arachidic	VL289	%	0.2	0.0	0.1	0.0	<0.1	NA	0.2	0.0
C22:0 Behenic	VL289	%	<0.1	NA	< 0.1	NA	<0.1	NA	<0.1	NA
C24:0 Lignoceric	VL289	%	<0.1	NA	<0.1	NA	<0.1	NA	<0.1	NA
Total Saturated	VL289	%	29.0	1.7	29.5	2.3	28.4	1.5	29.8	1.6
STATE			QLD							
MUSCLE			Fillet		Knuckle		Rump		Topside	
			Mean	SD	Mean	SD	Mean	SD	Mean	SD
C4:0 Butyric	VL289	%	<0.1	NA	<0.1	NA	<0.1	NA	<0.1	NA
C6:0 Caproic	VL289	%	<0.1	NA	<0.1	NA	<0.1	NA	<0.1	NA
C8:0 Caprylic	VL289	%	<0.1	NA	<0.1	NA	<0.1	NA	<0.1	NA
C10:0 Capric	VL289	%	<0.1	NA	<0.1	NA	< 0.2	NA	<0.1	NA
C12:0 Lauric	VL289	%	<0.1	NA	<0.1	NA	<0.3	NA	<0.1	NA
C14:0 Myristic	VL289	%	0.7	0.3	0.5	0.1	1.7	2.0	0.5	0.1
C15:0 Pentadecanoic	VL289	%	0.7	0.1	0.8	0.1	0.9	0.2	0.7	0.1
C16:0 Palmitic	VL289	%	15.2	1.1	17.3	1.1	20.7	2.8	15.2	0.9
C17:0 Margaric	VL289	%	1.1	0.2	1.2	0.2	1.5	0.2	1.1	0.1
C18:0 Stearic	VL289	%	12.8	1.8	13.4	0.8	13.2	1.4	13.2	0.8
C20:0 Arachidic	VL289	%	<0.1	NA	< 0.2	NA	< 0.1	NA	< 0.1	NA
C22:0 Behenic	VL289	%	<0.1	NA	< 0.2	NA	< 0.2	NA	< 0.1	NA
C24:0 Lignoceric	VL289	%	<0.1	NA	< 0.1	NA	< 0.1	NA	< 0.1	NA
Total Saturated	VL289	%	30.4	2.3	33.3	2.4	38.3	4.9	30.7	1.1

Data shown are means of animal replicated samples for duplicated analyses as described in the methods section.
Fatty acid data in grey printing is below limit of detection and/or of no significant interest.

Table 10 (a): Mean and standard deviation (SD) for mono-unsaturated fatty acid profiles (% of total fatty acids) of raw samples for Grey kangaroo from two States.

SPECIES			Grey Kangaroo							
STATE			SA							
MUSCLE	Method	Units	Fillet		Knuckle		Rump		Topside	
			Mean	SD	Mean	SD	Mean	SD	Mean	SD
C14:1 Myristoleic	VL289	%	<0.1	NA	<0.1	NA	<0.1	NA	<0.1	NA
C16:1 Palmitoleic	VL289	%	1.8	0.6	1.3	0.6	1.5	0.6	1.1	0.3
C17:1 Heptadecenoic	VL289	%	1.3	0.2	1.2	0.4	1.4	0.2	1.4	0.2
C18:1 Oleic	VL289	%	31.0	5.3	26.6	9.7	25.3	4.5	22.7	4.1
C20:1 Eicosenic	VL289	%	0.2	0.0	0.3	0.1	0.2	0.1	0.1	0.0
C22:1 Docosenoic	VL289	%	< 0.2	NA	<0.1	NA	<0.1	NA	<0.1	NA
C24:1 Nervonic	VL289	%	<0.1	NA	<0.1	NA	<0.1	NA	<0.1	NA
Total *cis*-mono-fatty acids	VL289	%	34.2	6.5	29.4	11.2	28.5	5.8	25.3	4.8
Total *trans*-mono fatty acids	VL289	%	3.5	1.1	5.1	2.5	3.2	1.0	2.9	1.1
SPECIES			Grey Kangaroo							
STATE			QLD							
MUSCLE	Method	Units	Fillet		Knuckle		Rump		Topside	
			Mean	SD	Mean	SD	Mean	SD	Mean	SD
C14:1 Myristoleic	VL289	%	<0.1	NA	<0.1	NA	<0.1	NA	< 0.1	NA
C16:1 Palmitoleic	VL289	%	3.1	1.0	1.8	0.9	2.0	0.5	3.6	0.7
C17:1 Heptadecenoic	VL289	%	2.1	1.2	1.8	0.6	1.2	0.4	2.0	0.4
C18:1 Oleic	VL289	%	22.9	5.2	30.0	9.2	31.9	6.8	28.3	7.4
C20:1 Eicosenic	VL289	%	0.2	0.0	0.3	0.1	0.3	0.0	0.2	0.0
C22:1 Docosenoic	VL289	%	< 0.2	NA	<0.1	NA	<0.1	NA	0.2	0.0
C24:1 Nervonic	VL289	%	<0.1	NA	<0.1	NA	<0.1	NA	<0.1	NA
Total *cis*-mono-fatty acids	VL289	%	28.5	3.5	33.9	10.6	35.5	7.9	34.2	8.7
Total *trans*-mono fatty acids	VL289	%	3.7	0.9	3.9	1.7	5.0	1.9	5.1	1.7

Data shown are means of animal replicated samples for duplicated analyses as described in the methods section.
Fatty acid data in grey printing is below limit of detection and/or of no significant interest.

Table 10 (b): Mean and standard deviation (SD) for mono-unsaturated fatty acid profiles (% of total fatty acids) of raw samples for Red kangaroo from two States.

SPECIES			Red Kangaroo							
STATE			SA							
MUSCLE	Method	Units	Fillet		Knuckle		Rump		Topside	
			Mean	SD	Mean	SD	Mean	SD	Mean	SD
C14:1 Myristoleic	VL289	%	<0.1	NA	<0.1	NA	<0.1	NA	<0.1	NA
C16:1 Palmitoleic	VL289	%	1.4	0.7	1.2	0.7	1.3	0.4	2.0	0.9
C17:1 Heptadecenoic	VL289	%	1.5	0.2	1.4	0.3	1.5	0.2	1.4	0.2
C18:1 Oleic	VL289	%	26.3	4.1	23.0	5.2	24.4	5.9	31.0	5.7
C20:1 Eicosenic	VL289	%	0.2	0.0	0.2	0.1	0.2	0.1	0.2	0.0
C22:1 Docosenoic	VL289	%	<0.1	NA	<0.1	NA	< 0.2	NA	<0.1	NA
C24:1 Nervonic	VL289	%	<0.1	NA	<0.1	NA	<0.1	NA	<0.1	NA
Total *cis*-mono-fatty acids	VL289	%	29.3	5.1	25.9	6.3	27.6	6.9	34.7	7.4
Total *trans*-mono fatty acids	VL289	%	4.2	1.0	3.4	1.5	3.1	1.7	4.0	1.0
SPECIES			Red Kangaroo							
STATE			QLD							
MUSCLE	Method	Units	Fillet		Knuckle		Rump		Topside	
			Mean	SD	Mean	SD	Mean	SD	Mean	SD
C14:1 Myristoleic	VL289	%	<0.1	NA	<0.1	NA	< 0.3	NA	< 0.1	NA
C16:1 Palmitoleic	VL289	%	1.7	0.7	2.8	1.7	4.3	1.2	2.4	0.9
C17:1 Heptadecenoic	VL289	%	1.4	0.3	1.3	0.2	2.4	NA	1.4	0.1
C18:1 Oleic	VL289	%	30.0	1.6	22.5	2.6	28.4	8.4	24.7	0.9
C20:1 Eicosenic	VL289	%	0.2	0.1	0.2	0.0	< 0.2	NA	0.2	0.0
C22:1 Docosenoic	VL289	%	<0.1	NA	< 0.2	NA	< 0.3	NA	<0.1	NA
C24:1 Nervonic	VL289	%	<0.1	NA	<0.1	NA	<0.1	NA	<0.1	NA
Total *cis*-mono-fatty acids	VL289	%	33.3	2.2	26.8	3.6	35.0	7.4	28.6	1.2
Total *trans*-mono fatty acids	VL289	%	4.5	1.6	4.1	0.6	5.1	0.9	4.0	1.1

Data shown are means of animal replicated samples for duplicated analyses as described in the methods section.
Fatty acid data in grey printing is below limit of detection and/or of no significant interest.

Table 11 (a): Mean and standard deviation (SD) for poly-unsaturated fatty acid profiles (% of total fatty acids) of raw samples for Grey kangaroo from two States.

SPECIES			Grey Kangaroo							
STATE			SA							
MUSCLE	Method	Units	Fillet		Knuckle		Rump		Topside	
			Mean	SD	Mean	SD	Mean	SD	Mean	SD
C18:2ω6 Linoleic	VL289	%	14.6	3.6	19.0	6.4	17.9	2.1	19.4	1.9
C18:3ω6 γ-Linolenic	VL289	%	0.1	0.0	< 0.1	NA	< 0.2	NA	0.1	0.0
C18:3ω3 α-Linolenic	VL289	%	5.8	1.3	4.0	0.6	4.3	1.2	6.7	0.8
C20:2ω6 Eicosadienoic	VL289	%	0.1	0.0	0.2	0.1	0.2	0.1	0.2	0.0
C20:3ω6 Eicosatrienoic	VL289	%	1.2	0.4	1.0	0.3	1.2	0.2	1.5	0.2
C20:3ω3 Eicosatrienoic	VL289	%	< 0.2	NA	0.1	0.0	< 0.1	NA	0.2	0.0
C20:4ω6 Arachidonic	VL289	%	6.9	1.7	10.3	3.7	9.6	1.6	9.1	2.1
C20:5ω3 Eicosapentaenoic	VL289	%	2.8	0.6	1.8	0.6	2.6	0.6	3.1	0.4
C22:2ω6 Docosadienoic	VL289	%	< 0.1	NA	<0.1	NA	<0.1	NA	<0.1	NA
C22:4ω6 Docosatetraenoic	VL289	%	0.4	0.2	0.4	0.1	0.4	0.1	0.4	0.1
C22:5ω3 Docosapentaenoic	VL289	%	2.7	0.8	3.0	1.0	3.3	0.8	3.2	0.6
C22:6ω3 Docosahexaenoic	VL289	%	0.6	0.2	0.6	0.2	0.6	0.2	0.8	0.2
ω 6 Fatty Acids	VL289	%	23.4	4.8	31.0	10.4	29.5	3.9	30.8	4.2
ω 3 Fatty Acids	VL289	%	12.0	1.5	9.5	2.2	10.9	2.7	14.1	1.1
Total *trans*-poly fatty acids	VL289	%	0.8	0.2	1.3	0.6	0.7	0.2	0.6	0.1
Total poly-unsaturated	VL289	%	35.4	7.0	40.5	13.1	40.3	6.9	45.0	5.4

SPECIES			Grey Kangaroo							
STATE			QLD							
MUSCLE	Method	Units	Fillet		Knuckle		Rump		Topside	
			Mean	SD	Mean	SD	Mean	SD	Mean	SD
C18:2ω6 Linoleic	VL289	%	16.3	1.6	15.7	6.3	15.7	5.0	14.4	4.1
C18:3ω6 γ-Linolenic	VL289	%	< 0.2	NA	< 0.2	NA	< 0.2	NA	< 0.1	NA
C18:3ω3 α-Linolenic	VL289	%	4.5	0.7	3.3	1.0	3.7	0.8	4.6	1.1
C20:2ω6 Eicosadienoic	VL289	%	0.3	0.0	0.2	0.1	0.2	0.1	< 0.3	NA
C20:3ω6 Eicosatrienoic	VL289	%	1.1	0.2	1.0	0.4	0.9	0.3	1.2	0.3
C20:3ω3 Eicosatrienoic	VL289	%	0.2	0.1	< 0.1	NA	< 0.1	NA	< 0.2	NA
C20:4ω6 Arachidonic	VL289	%	6.2	2.5	7.4	3.9	7.1	2.7	6.0	1.6
C20:5ω3 Eicosapentaenoic	VL289	%	2.0	1.0	1.7	0.8	1.7	0.6	2.4	0.8
C22:2ω6 Docosadienoic	VL289	%	<0.1	NA	<0.1	NA	<0.1	NA	<0.1	NA
C22:4ω6 Docosatetraenoic	VL289	%	0.4	0.1	< 0.4	NA	0.4	0.1	0.3	0.1
C22:5ω3 Docosapentaenoic	VL289	%	2.8	1.2	2.7	1.1	2.2	0.4	2.5	0.8
C22:6ω3 Docosahexaenoic	VL289	%	0.5	0.2	0.5	0.3	0.5	0.1	0.6	0.2
ω 6 Fatty Acids	VL289	%	24.3	3.7	24.7	10.7	24.2	7.8	22.3	6.2
ω 3 Fatty Acids	VL289	%	10.0	2.2	8.2	3.0	8.2	1.8	10.3	2.9
Total *trans*-poly fatty acids	VL289	%	1.0	0.4	0.9	0.3	1.0	0.3	1.3	0.1
Total poly-unsaturated	VL289	%	34.3	6.5	33.0	14.7	32.4	10.2	32.5	10.1

Data shown are means of animal replicated samples for duplicated analyses as described in the methods section.
Fatty acid data in grey printing is below limit of detection and/or of no significant interest.

Table 11 (b): Mean and standard deviation (SD) for poly-unsaturated fatty acid profiles (% of total fatty acids) of raw samples for Red kangaroo from two States.

SPECIES			Red Kangaroo							
STATE			SA							
MUSCLE	Method	Units	Fillet		Knuckle		Rump		Topside	
			Mean	SD	Mean	SD	Mean	SD	Mean	SD
C18:2ω6 Linoleic	VL289	%	18.7	3.0	21.8	4.9	18.7	3.1	15.7	3.4
C18:3ω6 γ-Linolenic	VL289	%	< 0.1	NA	< 0.1	NA	< 0.1	NA	< 0.1	NA
C18:3ω3 α-Linolenic	VL289	%	7.1	0.3	4.4	1.2	5.2	1.1	5.1	1.4
C20:2ω6 Eicosadienoic	VL289	%	0.2	0.1	0.3	0.1	0.3	0.1	0.2	0.1
C20:3ω6 Eicosatrienoic	VL289	%	1.2	0.3	1.1	0.2	1.3	0.2	1.1	0.1
C20:3ω3 Eicosatrienoic	VL289	%	0.2	0.0	0.1	0.0	< 0.2	NA	< 0.2	NA
C20:4ω6 Arachidonic	VL289	%	6.7	1.4	10.3	2.8	10.2	1.6	7.1	1.6
C20:5ω3 Eicosapentaenoic	VL289	%	3.0	0.7	2.0	0.3	3.1	1.5	2.4	0.8
C22:2ω6 Docosadienoic	VL289	%	<0.1	NA	<0.1	NA	< 0.1	NA	<0.1	NA
C22:4ω6 Docosatetraenoic	VL289	%	0.3	0.1	0.4	0.1	0.5	0.1	0.3	0.1
C22:5ω3 Docosapentaenoic	VL289	%	3.1	0.6	3.1	0.7	3.5	1.1	2.5	0.9
C22:6ω3 Docosahexaenoic	VL289	%	0.8	0.2	0.6	0.1	0.8	0.3	0.6	0.2
ω 6 Fatty Acids	VL289	%	27.2	4.3	34.0	7.9	31.1	4.7	24.4	4.9
ω 3 Fatty Acids	VL289	%	14.2	1.5	10.3	1.9	12.7	3.7	10.8	3.0
Total *trans*-poly fatty acids	VL289	%	0.8	0.1	0.7	0.4	1.0	0.3	0.9	0.1
Total poly-unsaturated	VL289	%	41.4	6.4	44.2	8.4	43.7	6.6	35.2	8.2

SPECIES			Red Kangaroo							
STATE			QLD							
MUSCLE	Method	Units	Fillet		Knuckle		Rump		Topside	
			Mean	SD	Mean	SD	Mean	SD	Mean	SD
C18:2ω6 Linoleic	VL289	%	15.7	2.5	16.9	3.2	11.4	4.3	18.2	2.2
C18:3ω6 γ-Linolenic	VL289	%	< 0.1	NA	0.1	0.0	< 0.1	NA	< 0.1	NA
C18:3ω3 α-Linolenic	VL289	%	4.6	1.1	3.7	1.0	2.8	0.9	4.8	1.4
C20:2ω6 Eicosadienoic	VL289	%	0.2	0.0	0.3	0.0	< 0.2	NA	0.2	0.0
C20:3ω6 Eicosatrienoic	VL289	%	1.0	0.1	1.1	0.1	< 0.1	NA	1.2	0.1
C20:3ω3 Eicosatrienoic	VL289	%	< 0.1	NA	< 0.1	NA	< 0.2	NA	0.2	0.0
C20:4ω6 Arachidonic	VL289	%	7.9	1.2	9.9	0.8	6.1	3.2	8.9	1.0
C20:5ω3 Eicosapentaenoic	VL289	%	2.3	0.3	2.4	0.4	1.8	1.0	2.4	0.5
C22:2ω6 Docosadienoic	VL289	%	<0.1	NA	<0.1	NA	<0.1	NA	<0.1	NA
C22:4ω6 Docosatetraenoic	VL289	%	0.4	0.1	0.5	0.0	< 0.4	NA	0.5	0.1
C22:5ω3 Docosapentaenoic	VL289	%	3.0	0.5	3.9	0.2	2.4	1.1	3.3	0.2
C22:6ω3 Docosahexaenoic	VL289	%	0.6	0.2	0.9	0.1	0.5	0.1	0.8	0.2
ω 6 Fatty Acids	VL289	%	25.4	3.2	28.8	3.2	18.9	7.7	29.1	2.4
ω 3 Fatty Acids	VL289	%	10.6	1.2	11.0	1.1	7.5	3.0	11.4	2.1
Total *trans*-poly fatty acids	VL289	%	0.9	0.3	1.1	0.3	1.2	0.2	1.0	0.2
Total poly-unsaturated	VL289	%	36.0	3.2	39.7	4.5	26.4	11.9	40.4	2.1

Data shown are means of animal replicated samples for duplicated analyses as described in the methods section.
Fatty acid data in grey printing is below limit of detection and/or of no significant interest.

Table 12 (a): Mean and standard deviation (SD) for proximate analysis of raw samples for Grey kangaroo from two States.

SPECIES			Grey Kangaroo							
STATE			SA							
MUSCLE	Method	Units	Fillet		Knuckle		Rump		Topside	
			Mean	SD	Mean	SD	Mean	SD	Mean	SD
Mono *trans* fats	VL289	g/100g	<0.1	NA	< 0.2	NA	<0.1	NA	<0.1	NA
Mono-unsaturated fat	VL289	g/100g	0.4	0.1	0.3	0.3	0.2	0.0	< 0.2	NA
ω 3 fats	VL289	g/100g	0.1	0.0	<0.1	NA	<0.1	NA	<0.1	NA
ω 6 fats	VL289	g/100g	0.3	0.1	0.2	0.1	< 0.2	NA	< 0.2	NA
Poly *trans* fats	VL289	g/100g	<0.1	NA	<0.1	NA	<0.1	NA	<0.1	NA
Poly-unsaturated fat	VL289	g/100g	0.4	0.1	0.3	0.1	< 0.2	NA	0.2	0.1
Trans fats	VL289	g/100g	<0.1	NA	< 0.2	NA	<0.1	NA	<0.1	NA
SPECIES			Grey Kangaroo							
STATE			QLD							
MUSCLE	Method	Units	Fillet		Knuckle		Rump		Topside	
			Mean	SD	Mean	SD	Mean	SD	Mean	SD
Mono *trans* fats	VL289	g/100g	<0.1	NA	< 0.3	NA	<0.1	NA	<0.1	NA
Mono-unsaturated fat	VL289	g/100g	0.3	0.1	0.8	0.8	< 0.3	NA	0.2	0.1
ω 3 fats	VL289	g/100g	<0.1	NA	<0.1	NA	<0.1	NA	<0.1	NA
ω 6 fats	VL289	g/100g	0.2	0.0	< 0.2	NA	0.2	0.0	<0.1	NA
Poly *trans* fats	VL289	g/100g	<0.1	NA	<0.1	NA	<0.1	NA	<0.1	NA
Poly-unsaturated fat	VL289	g/100g	0.4	0.1	< 0.4	NA	0.2	0.1	0.2	0.1
Trans fats	VL289	g/100g	<0.1	NA	< 0.4	0.0	<0.1	NA	<0.1	NA

Data shown are means of animal replicated samples for duplicated analyses as described in the methods section.
Fatty acid data in grey printing is below limit of detection and/or of no significant interest.

Table 12 (b): Mean and standard deviation (SD) for proximate analysis of raw samples for Red kangaroo from two states.

SPECIES			Red Kangaroo							
STATE			SA							
MUSCLE	Method	Units	Fillet		Knuckle		Rump		Topside	
			Mean	SD	Mean	SD	Mean	SD	Mean	SD
Mono *trans* fats	VL289	g/100g	<0.1	NA	<0.1	NA	<0.1	NA	<0.1	NA
Mono-unsaturated fat	VL289	g/100g	< 0.3	NA	< 0.1	NA	0.2	0.0	< 0.4	NA
ω 3 fats	VL289	g/100g	<0.1	NA	<0.1	NA	<0.1	NA	< 0.1	NA
ω 6 fats	VL289	g/100g	< 0.2	NA	<0.1	NA	0.3	0.1	0.2	0.0
Poly *trans* fats	VL289	g/100g	<0.1	NA	<0.1	NA	<0.1	NA	<0.1	NA
Poly-unsaturated fat	VL289	g/100g	0.3	0.1	<0.1	NA	0.4	0.0	0.3	0.1
Trans fats	VL289	g/100g	<0.1	NA	<0.1	NA	<0.1	NA	<0.1	NA
SPECIES			Red Kangaroo							
STATE			QLD							
MUSCLE	Method	Units	Fillet		Knuckle		Rump		Topside	
			Mean	SD	Mean	SD	Mean	SD	Mean	SD
Mono *trans* fats	VL289	g/100g	<0.1	NA	<0.1	NA	<0.1	NA	<0.1	NA
Mono-unsaturated fat	VL289	g/100g	0.2	0.1	0.2	0.0	0.4	0.1	0.2	0.0
ω 3 fats	VL289	g/100g	<0.1	NA	<0.1	NA	<0.1	NA	<0.1	NA
ω 6 fats	VL289	g/100g	0.2	0.0	0.2	0.0	< 0.3	NA	0.2	0.0
Poly *trans* fats	VL289	g/100g	<0.1	NA	<0.1	NA	<0.1	NA	<0.1	NA
Poly-unsaturated fat	VL289	g/100g	0.2	0.0	0.3	0.0	0.3	0.1	0.3	0.1
Trans fats	VL289	g/100g	<0.1	NA	<0.1	NA	<0.1	NA	<0.1	NA

Data shown are means of animal replicated samples for duplicated analyses as described in the methods section.
Fatty acid data in grey printing is below limit of detection and/or of no significant interest.

Table 13: Mean and significance levels for cholesterol contents of raw samples for Grey and Red kangaroo from two States.

Variate: Cholesterol (mg/100g)	SA-Grey	Qld-Grey	SA-Red	Qld-Red	Muscle Effect Significance	State/Species Effect Significance
Loin fillet	78.8	77.2	65.8	37.6		
Knuckle	58.2	52.4	54.6	40.6		
Rump	62.8	63.0	62.2	39.4		
Topside	61.2	67.2	69.2	48.8		
Mean	65.3	65.0	63.0	41.6	P<0.001	P<0.001

(n=20)
Level of significance P<0.05

Table 14: Mean and significance levels for total polyunsaturated fatty acids (%) of raw samples for Grey and Red kangaroo from two States.

Variate: Total PUFA (%)	SA-Grey	Qld-Grey	SA-Red	Qld-Red	Muscle Effect Significance	State/Species Effect Significance
Loin fillet	35.4	34.3	41.4	36.0		
Knuckle	40.5	33.0	42.2	39.7		
Rump	40.3	32.4	43.7	26.4		
Topside	45.0	32.5	35.2	40.4		
Mean	40.3	33.1	41.1	35.6	NS	P<0.01

(n=20)
Level of Significance P <0.05
NS: Not Significant (P>0.05)
PUFA: Poly-unsaturated fatty acids

Nutritional Composition of Kangaroo Meet

by Shane Beilken and Ron Tume
RIRDC Publication No. 08/142

This research examined commercially representative samples of meat from the red kangaroo (*Macropus rufus*) and the grey kangaroo (*Macropus giganteus*) species collected from two geographical locations – Wertaloona Station, South Australia and Blackall, Queensland.

These samples were analysed using standard procedures, and the industry was provided with information regarding specific lipid nutrients in their products. In addition to fat content, information was sought on cholesterol contents, fatty acid profiles, omega-3 and CLA contents.

This data can be used by people when they are preparing information for Nutritional Information Panels on Product labels and by wholesalers and retailers of kangaroo meat.

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