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11 July 2022

s 9(2)(a)

By email: s 9(2)(a)
Ref: H202207785

Tēnā koe s 9(2)(a)

Response to your request for official information

Thank you for your request under the Official Information Act 1982 (the Act) to the Ministry of Health (the Ministry) on 11 June 2022. You emailed your request in two parts. You requested:

> *"Part 1: I would like to make an information request the main documents pertaining to the process, beginning in 2013, for developing the Eating and Activity Guidelines 2015. Namely, I would like the discussion documents (the main summary document created at the end of the process) for each of these processes:*
> *"Work on the update began 2013, including:*
> *· Technical Advisory Group (TAG) review and discussion of evidence bases*
> *· Eating and Activity Statements drafted (in conjunction with TAG)*
> *· limited stakeholder consultation and focus group testing with the public on draft statements*
> *· draft Eating and Activity Guidelines document*
> *· TAG review*
> *· internal Ministry of Health review*
> *· external review: health practitioner/non-government organisation review, government agency review, food industry review*
> *· limited stakeholder consultation."*
> *From: https://www.health.govt.nz/our-work/eating-and-activity-guidelines/current-guidelines/process-developing-eating-and-activity-guidelines*
>
> *Part 2:*
> *Please provide all information (emails, texts, meeting minutes, reports, memos or any other official correspondence) relating to the process involved during and after the final stakeholder consultation involved in the process for developing, and release of, the Eating and Activity Guidelines.*
> *To clarify, I want all official information involved in the process during the final consultation, what steps were taken by the Ministry of Health following the consultation, including any discussion by the Ministry of Health in relation to the stakeholder submissions. To clarify, please provide all what points raised by stakeholders that were*

accepted by the ministry and subsequently changed in the guidelines before their release in 2015.
From the Ministry of Health website: "Work on the update began 2013, including:
Technical Advisory Group (TAG) review and discussion of evidence bases
Eating and Activity Statements drafted (in conjunction with TAG)
limited stakeholder consultation and focus group testing with the public on draft statements
draft Eating and Activity Guidelines document
TAG review
internal Ministry of Health review
external review: health practitioner/non-government organisation review, government agency review, food industry review
limited stakeholder consultation.
In 2015, the Eating and Activity Guidelines for New Zealand Adults document was published."

On 22 June 2022, you were contacted by the Ministry asking you to refine your request as the information requested would require substantial collation and research within the Ministry and may have been refused under section 18(f) of the Act. On the same day, you agreed to refine your request to:

"The review documents from the 2013 TAG and industry/stakeholder meetings (if they exist) and if there was a discussion document detailing what happened in the meetings, and what feedback the Ministry took from industry and put into the draft and final eating and activity guide document.
If the Ministry has any information about the previous review as well, you would like that documentation.
If the Ministry doesn't hold any discussion documents etc, can the Ministry please provide a narrative response, detailing what the process was and how the Ministry took on the feedback".

The Ministry has identified 14 documents within scope of your refined request. All documents are itemised in Appendix 1 and copies of the documents are enclosed. Where information is withheld, this is outlined in the Appendix and noted in the document itself. Where information is withheld under section 9 of the Act, I have considered the countervailing public interest in release in making this decision and consider that it does not outweigh the need to withhold at this time.

Additionally, the Ministry have published the 'Eating and Activity Guidelines for New Zealand Adults' on our website. Please refer to the following link: www.health.govt.nz/publication/eating-and-activity-guidelines-new-zealand-adults

I trust this information fulfils your request. Under section 28(3) of the Act, you have the right to ask the Ombudsman to review any decisions made under this request. The Ombudsman may be contacted by email at: info@ombudsman.parliament.nz or by calling 0800 802 602.

Please note that this response, with your personal details removed, may be published on the Ministry website at: www.health.govt.nz/about-ministry/information-releases/responses-official-information-act-requests.

Nāku iti noa, nā

Graham Cameron
Acting Director
Public Health Agency

Appendix 1: List of documents for release

#	Date	Document details	Decision on release
1	25 November 2005	The New Zealand Medical Journal, Vol 118, No 1226 – Decreased red meat fat consumption in New Zealand – 1995-2002	Released in full.
2	November 2012	Education Cooking Tool for Pacific Communities – Beef + Lamb New Zealand Inc.	Released in full.
3	May 2013	Massey University study – A Report to Beef + Lamb New Zealand Limited - The Concentration of Selected Nutrients in New Zealand Beef and Lamb Cuts and Offal Items	Released in full.
4	10 September 2013	'Proceedings of the International Meat Secretariat's Symposium on Protein Requirements for optimal health throughout all life stages'	Released in full.
5	11 November 2013	Minutes of the First Meeting of the Technical Advisory Group for the Eating and Activity Guidelines – November 2013	Released in full.
6	10 March 2014	Letter from New Zealand Meat Processors Association - Feedback on the draft Eating and Activity Guidelines Statements for New Zealand Adults	Released with some information withheld under section 9(2)(a) of the Act, to protect the privacy of natural persons.
7	21 March 2014	Draft Eating and Activity Guidelines Statements 2014	Released in full.
8	28 March 2014	Email – The Ministry inviting organisations to provide feedback on the draft guideline statements	Released in full.
9	17 July 2014	Draft Eating and Activity Guidelines as at 17 July 2014	Released in full.

#	Date	Document details	Decision on release
10	24 July 2014	Draft Eating and Activity Statements as at 24 July 2014	Released in full.
11	February 2015	'The Role of Red Meat in a Health New Zealand Diet' by Amanda Johnson	Released in full.
12	11 March 2015	Letter from Beef + Lamb New Zealand – Feedback on the draft Eating and Activity Guidelines Statements for New Zealand Adults	Released in full.
13	13 March 2015	Letter from New Zealand Food & Grocery Council - Feedback on the draft Eating and Activity Guidelines Statements for New Zealand Adults	Released in full.
14	2015	Submission from Grains & Legumes Nutrition Council – Eating and Activity Guidelines Statements for New Zealand Adults	Released with some information withheld under section 9(2)(a).

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Decreased red meat fat consumption in New Zealand: 1995–2002

Murray Laugesen

Abstract

Aim To review New Zealand red meat and meat fat supply trends before and after the introduction of the Quality Mark standard.

Methods Review of trends in: per capita meat fat supply estimates from the Food and Agriculture Organization (FAO); carcase and meat cut composition reports of knife dissection and chemical analyses; the fate of fat trim; and a Lincoln College study of home-cooked and trimmed beef.

Intervention From September 1997, the red meat industry's Quality Mark required trimming of beef and lamb cuts to no more than 5 mm external fat.

Results (1) Trimming of fat from red meat before sale (supported by virtually all butchers) decreased the fat and saturated fat content of a red meat carcase by 30% (beef, -27%; lamb, -30%; tallow unchanged); by -8% in the total food supply; and by -17% across all meat. In 2002, fat comprised 7.4% of trimmed beef cuts, and 11.2% of all beef sold: cuts, mince, or sausages. In 2002, fat comprised 15.3% of lamb cuts; and 15.5% with mince included. (2) From 1995 to 2002, total saturated fat availability per capita in the food supply decreased by 19% (from 65 g to 53 g per day), mostly due to 7 g less saturated fat daily from red meat. (3) When combining effects (1) and (2), saturated fat per capita decreased: -27% in total food supply; -65% in red meat excluding tallow; -48% in red meat including tallow. In 1995 (without trimming), red meat contributed 25% of saturated fat in the total food supply whereas in 2002, red meat contributed 19% before (and 13% after) trimming. (4) Home trimming may remove an additional 27% of fat from beef steaks.

Conclusion Centralised meat processing, and Quality Mark labelling since 1997, ensured fat was trimmed from beef and lamb cuts, and reduced saturated fat in red meats by 30%. In 2002, mince and sausages accounted for nearly half of beef fat sold as red meat.

This study updates meat and meat fat supply trends during 1995–2002, and adjusts for trimming of fat from red meat. It updates Laugesen and Swinburn's previous paper on meat fat in the food supply:[1]

- *Laugesen and Swinburn's previous paper found high per capita supply of meat fat*—In 1995, New Zealand had the highest per capita supply of butter and of meat fats among 24 OECD countries.[1] In 1995, red meat (beef and sheepmeat) contributed one-quarter of the total saturated fat in the food supply.[1]
- *Food and Agricultural Organization (FAO) data assume a standard fat percentage per carcase*—FAO food supply data, based on trade and production data, allow comparison of country food supplies internationally and down through time. Food supply statistics are about meat for sale, but may not account for pre-

sale trimming of fat. FAO estimations are expressed in terms of the primary product (unprocessed meat). Since FAO set the original carcase-fat content percentages in 1948, animal breeding, processing, and meat cooking practices have changed considerably.

- *Food composition data are available for cuts but not for carcases*—The FAO definition of beef is based on bone-in weight,[3] so that edible beef is 17% less than the beef supply stated in the food balance.[4] No carcase analysis of sheep meat since 1978[4], and of beef since 1986[12] was obtainable.
- *Changes at retail and in the national diet*—Nutrition surveys (based on 24-hour recall) indicate that total fat as a percentage of energy in the food supply reduced from over 40% in 1977;[5] to 37.5% in 1989;[6] and to 34.9% in 1997.[7] Data for the 1997 survey were collected between December 1996 and November 1997,[7] largely before the red meat industry took action to trim fat and label with the Quality Mark standard in September 1997.

The New Zealand Ministry of Health estimated approximately 4700 deaths in 1997 (17% of all deaths) were attributable to higher than optimal total blood cholesterol—a measure driven largely by dietary saturated fat.[8] Of these deaths, 87% were due to ischaemic heart disease and 13% due to stroke.[8] In 2000, ischaemic heart disease still accounted for 22%, and stroke for 10%, of all deaths.[9]

Between 1995 and 2000, however, the age-standardised mortality rate for vascular disease (mainly ischaemic heart disease and stroke) at age 35–69 years decreased remarkably, by nearly one-third for men and one-fifth for women.[9] Smoking prevalence at age 35 and over in 1995–2000 decreased from 23.3% to 21.3%[10]—which could not explain such a mortality reduction in both sexes. Meat fat trends merited further study.

The heart-health status of lean red meat—A recent review found that lean red meat was low in saturated fat and (if consumed in a diet low in saturated fats) was associated with reductions in LDL-cholesterol in both healthy and hypercholesterolemic subjects.[11] Certainly New Zealanders remain high consumers of red meat (115 g per capita per day in 2002[2]), and leanness of the red meat supply is of public health importance.

Because of these many factors, an updated assessment of red meat fat consumption was overdue. This study focused on meat fat derived from red meat (beef, and lamb), which contributes half of the meat fat in the food supply.

Methods and data sources

Red meat and meat fat definitions—Red meat here includes bovine or sheep meat. Fat from red meat, however, also includes the separable fats—fats (rendered to tallow) removed initially, and the fat discarded later by the butcher.

Food balance data—Data for 1995, 2000, and 2002 for New Zealand were updated from the 2004 versions of the food balance sheets.[2] These balance sheets depend on agricultural surveys for estimation of beef and lamb production, surveys which were conducted annually until 1996, then published on the Ministry of Agriculture website for 1999 and 2002. Data for the balance sheets were collated by Statistics New Zealand and provided directly to FAO until 1996 (after which FAO collected its own data from publications and official websites).

Carcase fat content data—As in Laugesen and Swinburn's previous paper,[1] fat estimations were based on FAO data on carcase composition. The most recent large dissection study of beef carcases

was in 1981–5.[12] To estimate the fat content of meat cuts as sold, the chemical fatcontent in 2002 of each cut, as trimmed to 5 mm fat maximum,[13] was multiplied by the weight of each saleable cut itemised in the price per kg for sale records of dressed carcases from a supermarket (J Dawber, Foodstuffs South Island Ltd, Personal Communication, December 2005) and from 'The Mad Butcher,' a popular low-cost independent franchise butchers' chain.[14] (These were mostly commercially sensitive data sources.) Beef carcases were described as P grade in 1981, 180 kg beef in 1985, P grade carcase in 1992-4, 206 kg carcase in 1999, and P grade carcase in 2002. Lamb carcases included a 23 kg hogget circa 1985 and 18 kg carcases in 1992 and 2002.

Fat trimming trend—Information relating to meat industry activities was gained from administrators, processors, and retailers. To study the effects of meat trimming and processing apart from farm and breeding effects, the fat content of the meat for sale from a 1992 beef carcase (23% fat in the edible carcase) was compared with the same grade and weight of carcase in 2002 (26% fat in the edible carcase).

Trend in saturated fat in total diet—The estimated fat content of fat-trimmed versus untrimmed beef and sheepmeat, derived as above, were entered into the Health New Zealand Ltd international food and nutrition database (HNZifn),[1] a spreadsheet that enabled estimation of the effect of trimming meat to various fat content percentages, on saturated fat supply, while holding meat supply data unchanged.

HNZifn contains over 70 FAO food categories,[2] uses British food composition tables,[4] and over 110 nutritional descriptors to estimate food and nutrition supply per capita. Fat content per 100 g of edible portion was listed as: 22.0 g for beef, 27.5 g for sheepmeat, and 93 g for animal fat (beef fat). Saturated fat content was listed as 6.75 g, 14.72 g, and 41.8 g respectively.

Fat loss in cooking and eating—To establish how much meat fat New Zealand consumers actually ate within the home, we reviewed a Lincoln University study of 191 pairs (one fatty, one already trimmed) of beef steaks for home cooking. Participants were asked to pan fry their steaks, collect all the fat trimmed, and note any fat added during cooking. They also collected any fat trimmed after cooking—i.e. plate waste. Fat was estimated by imaging, which correlated well with chemical measurements.[15]

The intervention—The Quality Mark (Table 2) was introduced by the Beef and Lamb Marketing Bureau and the red meat industry in September 1997 for beef and lamb. Abbatoirs supplied primary cuts to retail butchers who then trimmed the cuts for retail sale to no more than 5 mm of external fat (equivalent to 90% lean and 10% fat by chemical analysis). Consumers supported this move. Intermuscular fat may be removed but intramuscular fat is retained for taste reasons.

In 2004, the two main suppliers to the New Zealand market sold 97% of their beef and lamb cuts under the Quality Mark (H Bayliss, Land Meat New Zealand Ltd and D McClenaghan, Auckland Meat Processors; personal communication; December 5, 2004). The Mad Butcher chain also used Quality Mark. The few rural home-kill butchers were not part of this scheme. In 2000–2004, over 90% of all beef and lamb cuts (especially steaks and chops) were probably sold under Quality Mark, or dressed to an equivalent fat trim. Quality Mark does not include processed meats such as luncheon meat, nor mutton, cow, or bull meat.

Table 1. Changes in the fat content of red meat products consumed since 1997

Pre-1997	% Fat*	Since 1997	% Fat*
Beef, carcase 1981-5[12]	23.3	Beef carcase, trimmed, 2002	7.1
Lamb, carcase, UK 1978[4]	30.5	Lamb carcase, trimmed, 2002	15.5
Sausages 1995 (one major supplier)	25–30	Food Standards Code 2002	<25
		Two supermarkets, 2004	3–23
Mince, UK, 1978[3]	16.2	Quality Mark mince 1997	<10
Sirloin roast lean and fat[3]	21.1	Cooked beef steaks, as eaten,	4–8
Topside roast lean and fat[3]	12.0	trimmed at home; grilled. 2003.[14]	

*As percentage of the edible carcase or product. Assumes no trimming of fat prior to sale before 1997.

Results

Changes in the fattiness of retailed meat

Saleable beef as a percentage of the carcase weight, declined from 67% in the 1981–5 survey[12] to 63% in the 2002 carcase. No trend in the fat trimmed off was discernable from the few cutting records obtainable. Fat as a percentage of the meat sold (including cuts, mince and sausages) remained steady across the cutting records studied—at 6.8% in 1992, 7.1% in 1999, 7.1% in 2002—although the grade and breed were not stated.

Two typical heifer half carcases (of 100 kg within the same grade) ten years apart, processed by the same organisation using the same cuts were butcher dissected. The 2002 carcase yielded 63.2 kg (7.6 kg less) saleable meat, comprising 19 kg (7.3 kg more) mince, 1.6 kg (4.0 kg less) for sausages, with 13.0 kg (1.7 kg more) fat left over, and 2.5 kg more bone and waste.

Meat sold as chuck steak, for example, reduced from 6.23 kg to 4.45 kg, thus indicating greater trimming of fat. The 1.7 kg net reduction in fat retained for sale (as meat cuts, mince, or sausages) in the 2002 half-carcase was equivalent to 9.4% of the total carcase fat (trimmable or not) in 1992.

Meat cuts

In 2002, chemical fat content per 100g edible portion in beef cuts (trimmed to a 5 mm fat margin) varied from 2% fat (topside) to 11% (sirloin), thus averaging around 6% fat.[13] Lamb cuts varied from 7% fat (lamb shoulder lean) to 28% fat (lamb shoulder chop trimmed to 5 mm fat).[13]

Mince

Mince, whether made from butchers' meat trimmings or from mutton, must contain less than 10% fat to qualify for the Heart Foundation's 'Pick the Tick' program or a Quality Mark. Most mince sold in the shops inspected made no such claims, and tested at 20% fat.[13]

Sausages

The Food Standards Code, introduced at the end of 2002[16] required sausages to contain no more than 33% fat. A major sausage supplier said their sausages were 25%-30% fat in 1995, whereas voluntary labelling listed fat content between 12% and 18% fat. Fat content labelling is voluntary, but should be accurate. Some brands did not state any fat content. Other brands were labelled at 3.4% and 23% fat, commonly 16% fat. Heart Foundation's 'Pick the Tick' required less than 10% fat content, but even without the tick, some brands were labelled as 11% fat.

Processed meat

The Quality Mark scheme excludes processed meats such as sausages and luncheon meat. The Code requires that meat products be true to their name, so that a steak and kidney pie must state that it contains no less than 25% steak and kidney, although there is no fat maximum. Processed meat must contain no less than 30% meat.

Offal

FAO estimated offal supply per capita in 2002 at 14.0g including 0.4 g fat.[2] Kidneys contain 3% fat, but processors now package liver and kidney fat-free to retailers.

The fate of meat fat

Fat sold in meatcuts, mince, or sausages—Of a 100 kg side of dressed beef carcase in 2002, 24 kg was inedible bone, 13.0 kg fat was discarded, and 63.1 kg was saleable meat containing 7.1 kg fat comprising:

- 3.1 kg fat left in (or on) 42.5 kg of trimmed meat cuts (7% fat);
- An estimated 0.2 kg fat in 1.6 kg sausages (12.5% fat);
- 3.7 kg fat in 19 kg of mince (20% fat).

Fat formed 7.4% of the weight of the meat cuts, and 11.2% of the 63.1 kg of meat sold. In this carcase, more fat went into mince and sausages that was sold in meat cuts.

Raw animal fat— According to FAO food balance sheets, under half of the raw knife-separable animal fats retained for domestic supply in 2002 entered the food supply, providing 14.6 g of fat per capita per day,[2] mostly from beef. The amount of beef fat returned to the food supply (apart from fat in sausages and mince) amounted to 27% by weight of the weight of beef sold as cuts, sausages or mince. Tallow from sternal, kidney, channel, or omental fat deposits (which are easier to render into edible tallow) is used for making cooking margarine, dripping (used in frying oils), and baked goods. Inedible tallow is used for soap. Sheep fat has a characteristic odour limiting its inclusion with other animal fats for food.

Fat trim was either sold to tallow or by-product companies. Small independent butchers were restricted by Food Standards Code[16] as to the permitted fat content in sausages, burgers, and processed meats.

Meat fat supply trends

As Table 2 shows, from 1995 to 2002, total fat per capita entering the food supply from meat and meat products in total declined 16% (from 76.1 g a day in 1995 to 64.3 g in 2002), whereas fats from red meat declined 27% (from 59.0g in 1995 to 42.9g in 2002). In contrast, fats of white meat origin (pork, bacon, ham, poultry) increased, from 13 g to 19 g. These changes reflected changes in the meat supply, without allowing for any change in the fattiness of each class of meat.

Carcase composition trends

Lamb and mutton

From 1997 onwards, meat cuts were sold with less fat attached. From 1948, FAO estimated the bone-in carcase to be 22.8% fat; which at 83% edibility[4] would equate to 27.5% fat. This increased to 30.5% fat for a dressed bone-out UK carcase in 1978.[4]

In the 2002 lamb carcase of 18 kg, and based on chemical analysis of the cuts, half (50%) of the fat was trimmed off and half sold as meat (including mince and sausages). Total fat content of the edible carcase was 26.7% and (of the portions sold

in 2002) fat was estimated at 15.5%. According to the data, the fattiness of the sheepmeat carcase has changed little in 25 years, but 42% of sheepfat is now discarded.

Beef

In 1948, FAO estimated that an average (untrimmed) dressed beef carcase contained 18% fat. Based on 83% edibility,[4] this would equate to 22% of the edible dressed carcase. In 1978, British tables found that fat comprised 24.3% of the edible dressed carcase weight. In 1981–5, for a P grade heifer, knife-separable fat was 17%, and non-separable fat 10% of the lean (by visual estimate).[12]

In the 1999 butcher-trimmed beef carcase[14] edibility was 82% of the dressed carcase. Meat cuts with fat trimmed, mince, and sausages comprised 72% of the dressed carcase and bone was 16%. Total fat was 20% of the dressed carcase (12.5% discarded, plus 7.5% sold on, or in the meat cuts, or in mince and sausages). Fat content of a beef carcase was only 2 percentage points less than half a century before.[1]

Of the trimmed and discarded fat that comprised 12.5% of the carcase weight, less than half would have reappeared as edible tallow,[2] whereas 72% of the dressed carcase was sold as meat. If meat cuts, mince, and sausages were all included, estimated fat content of the edible dressed beef carcase (as prepared for sale at retail in 2002) was 11.2%. For 2002, FAO estimated a daily per capita supply of 59.3 g beef (of which 3.9 g was fat) and 15.4 g of raw beef fat (mostly tallow).[2]

Trends in fat and saturated fat of the food supply (Tables 2 and 3)

With respect to meat fat, after combining food composition and FAO food supply data for 2002 in the Health New Zealand database[1] without allowing for trimming of meatfat, per capita daily supply was estimated at 13.0g beef fat, 14.6 g separable fat, 15.3 g lamb or mutton fat, 9.7 g pig fat, 11.1g poultry fat, and 0.6 g game fat—a total of 64.3 g meat fat.[2] (Table 2).

After trimming of fat in 2002, 11.2% of the meat from a dressed (bone-in) beef carcase, and 15.5% of the meat from a lamb carcase (trimmed, cut and presented for sale at retail) was fat.[14] For beef, the 11.2% value allowed for fat sold as mince or sausages, which accounted for 46% of the beef fat sold.

Based on the 11.2% fat content of beef and the 15.5% fat content of lamb after trimming as estimated above, and not counting separable fats, we estimated that in 2002 trimming of fat nearly halved the fat sold as red meat: from 28.3 g of fat per capita per day untrimmed, to 15.2 g fat per day trimmed (Table 2); and from 12.2 g of saturated fat per day untrimmed to 6.6 g fat per day trimmed (Table 3).

Saturated fat consumption decreased by 12 g between 1995 and 2002 (from 65.3g to 53.2g; 19%); most of this decrease was due to decreased red meat supply causing a 7 g decrease in saturated fat. (Table 3)

Table 2. Meat fat supply per capita in New Zealand in 1995–2002, adjusting for trimming of red meat cuts

Variable	Untrimmed			After Trimming
	1995	2000	2002	2002
Red meat fats				
Beef fat	23.8	15.7	13.0	6.6
Separated animal fat	13.0	14.4	14.6	14.6
Mutton fat	22.2	14.4	15.3	8.6
White meat fats				
Pig meat	7.9	9.0	9.7	9.7*
Poultry	8.3	9.6	11.1	11.1*
Other meat fats				
Game, offal	0.9	0.6	0.6	0.6
Total meat fats	76.1	63.9	64.3	51.2
Red meat fat fraction	*0.78*	*0.69*	*0.66*	*0.58*

*Unadjusted.
Source: Health New Zealand food and nutrition database, based on FAO meat supply data, and FAO percentage fat estimates for the carcase, after allowing for inedible fractions. Raw animal fat (tallow) is estimated as 93% fat, and assumed to be all from beef.

Between 1995 and 2002, combining the change to trimming of red meat fat with a decreased red meat supply (Table 3), saturated fat sold as beef, mince, or sausages declined 72%, and sold as lamb, declined 61%. In the total food supply overall, saturated fat reduced 27% after allowing for both the reduced supply of red meat and the increased leanness of red meat cuts sold (Table 3).

Ulbricht and Southgate's[17] atherogenicity index in the 2000 and 2002 food supply, based on the balance of fats in the total diet, was unchanged by trimming, but the thrombogenicity index,[17] was 3% to 4% lower.

Changes in the amount of trimming of fat at home after purchase

In 1990 (and again in 1997) approximately two-thirds of consumers said they trimmed fat from their meat[6 7] though to an unknown extent. In a 2003 Lincoln University study, 191 consumers were each asked to cook one already-trimmed and one untrimmed steak; participants knife-trimmed the fat before or after cooking. An average lean steak lost 70% of its fat in cooking, and a fatty steak lost about 60%, mostly due to home trimming. After frying or grilling, average fat content was 9.5g of fat per 100g of porterhouse steak, but this varied according to the fattiness of the steak. A fatty steak (24–39% fat) resulted in 13.0 g fat per 100 g as eaten whereas a lean steak (14%–23% fat) resulted in 5.5g of fat per 100g steak as eaten.[18]

Table 3. Saturated fat in the New Zealand food supply (in 1995, 2000, 2002) with and without allowance for trimming of beef and lamb; grams per capita per day

Grams of saturated fat per capita per day		No trimming of red meat fat			Red meat fat trimmed	With allowance for sales trends and trimming of fat from red meat
Year		1995	2000	2002	2002	1995-2002 change %
Total in dairy products		**25.1**	**18.3**	**19.2**		***-23***
	In butterfat	12.9	6.7	8.3		
	In milkfat, cream	7.7	7.8	6.9		
	In cheese	4.5	3.8	4.0		
Total in meat		**31.8**	**26.0**	**27.1**	**21.6**	***-33***
	In beef	7.3	4.8	4.0	2.0	***-72***
	In sheep meat	11.9	7.7	8.2	4.6	***-61***
	In separated fats	6.0	5.9	6.5	6.5	***8***
	In pig meat	3.4	3.8	4.1		
	In poultry	3.0	3.5	4.0	*	
	In game	0.2	0.3	0.3		
Non-meat, non dairy		**8.4**	**8.0**	**7.0**		***-17***
	Oils	2.9	1.9	2.8		
	Eggs	1.1	1.3	1.0		
	Cereals	1.1	0.8	1.1		
	Fruit	0.2	0.2	0.2		
	Vegetables	0.2	0.2	0.2		
	Seafood	0.1	0.1	0.1		
	Other	2.8	3.5	1.6		
Total		**65.3**	**52.3**	**53.2**	**47.7**	**-27**
Red meat	Beef, lamb and separated fats	**25.2**	**18.4**	**18.7**	**13.1**	***-48***

*No allowance made for trimming of white meat or game.
Note: Totals and percentages are based on two decimal places.

Discussion

Principal findings

The fattiness of the beef or lamb carcase appears to have changed little over half a century, but in 2002, 30% of the total fat from a red meat carcase was discarded before sale. Less meat in the food supply and reductions in the fattiness of red meat available for sale, combined to reduce meat fat from red meat (excluding tallow) in the food supply by 65% between 1995 and 2002. Including tallow, the reduction was 48%.

Per capita supply of beef and sheep meat decreased by 36% between 1995 and 2002. Assuming no change in the fattiness of red meat, then the supply of fat and saturated fat from red meat also decreased in this proportion.

If, however, we also adjust for the trend to knife-trimming of fat from meat by processing butchers, then meat fat and saturated meat fat from red meat decreased by a further 29%. The Heart Foundation had urged trimming of meat fat since its first Food Festival campaign in 1987. In the 1990s two-thirds of consumers said they trimmed fat from meat.[6 7] From 1997, the industry's Quality Mark, (requiring central processors and supermarket chains to trim to 5 mm fat) ensured that leaner cuts became the norm for virtually everyone buying meat as steaks or chops.

The Lincoln College consumers study highlights the importance of pre-sale trimming, and the advantages of an industry-wide change to make this happen, rather than relying only on health education of consumers. Although 87% of consumers were sufficiently concerned to trim meat fat at home, those cooking pre-trimmed steaks ate much less fat than those eating untrimmed steaks (5.5 g versus 13.0 g per 100 g edible beef).

We estimated the approximate *additional* effect of home trimming of beef to be a 26% reduction in fat, (from 7.4% average fat for meat cuts estimated for the 2002 side of beef to 5.5% achieved in this home cooking study), as the 'lean' steaks in the home cooking study were fattier than the 2002 side of beef.

The fat content of most mince and sausages is higher than in most meat cuts. The main factors now affecting meat fat consumption are the ratio of mince and sausages to meat cuts, and the fat content of mince and sausages—for which fat labelling is voluntary.

How the findings compared with other sources

For 2002, FAO estimated 59.3g of beef, and 55.7g of sheepmeat per person per day in the food supply, besides 15.4g of separated fat (mainly tallow). This study estimated 29.4g of fat per person per day after trimming: 6.6g in beef, 8.6 g fat in sheepmeat, and raw fat 14.2g. FAO estimated fats from red meats totalling 33.8g per person per day: 3.9g in beef, 14.5g in sheepmeat, the rest being raw fat.[2] For 2002, the FAO-compiled data were consistent with the trimming of fat from beef but not from sheepmeat.

Strengths and weaknesses of the study

New Zealand-derived food composition data tables[13] described most cuts of meat. For a few cuts of unknown composition we conservatively assumed 10% fat content after trimming. Few cutting records of carcases with which to assess trimming trends were obtainable, making it difficult to distinguish time trends from individual carcase variation.

In 2002, an estimated 5.5 g of saturated fat (Table 3) and 13.1 g of total fat per capita per day (Table 2) were trimmed off total meat due to trimming of red meat. If white meats were also trimmed, then the 19% reduction in saturated fat in the total diet due to red meat (Table 3) is an underestimate. If the coverage of the Quality Mark was only 80%, then the reduction in fat is correspondingly reduced; however the mark has made trimming of fat the norm.

The annual FAO food balances, begun in 1961, were collated by Statistics New Zealand up until 1996. It is unclear if FAO statistics reflect all the changes in meat processing. For example, the fat composition data of trimmed cuts

for this study require purchase[10] and may not have been electronically available to the FAO.

The way forward

Red meat cuts as sold have undoubtedly become leaner in recent years. The meat industry monitors the end product, but there is as yet no statistical system to report back this achievement to the consumer. The Quality Mark scheme applies to almost all red meat, and merits formal on-going monitoring, with the results published annually based on methods such as:

- Random checks of the fat content of mince and sausages; and
- Monitoring of the ratio of sold weight of mince and sausages to total meat cuts, using sentinel stores or other means.

The actual data and formulae used by FAO in calculating meat and meat fat balances for New Zealand should be monitored by and transparent to New Zealand producers and health groups, so that the data and can be interpreted correctly by all concerned.

Further improvements are occurring. In 2004, one supermarket chain in 2004 introduced central processing and distribution of retail cuts ready for sale, enabling tighter control of fat content. In 2005, closer trimming of fat on all red meat cuts was under consideration.

In summary, the Quality Mark applies to virtually all red meat sold and further improvements are possible. Trimming of red meat before sale has decreased the fattiness of red meat (cuts, mince, sausages, plus separable fat) by 30%. From 1995 to 2002, coupled with a decreased red meat supply saturated fat per capita from red meat decreased 65%.

What this paper adds

The fat composition of the beef and lamb carcase has remained much the same for half a century, but red meat cuts as sold are now 30% leaner, following on from the introduction of a Quality Mark standard and industry-wide pre-sale trimming of red meat cuts in 1997.

In 2002, after trimming, a dressed beef carcase (cuts, mince, and sausages as sold) averaged 11% fat, and a lamb carcase 15%.

Home trimming of meat fat after purchase may have further decreased saturated fat consumption.

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Document 2

Category: Review

Theme 3: Crossing the borders

EDUCATIONAL COOKING TOOL FOR PACIFIC COMMUNITIES

Fiona Greig, Fiona Carruthers

Beef + Lamb New Zealand Inc.

With high rates of obesity and overweight amongst many Pacific populations, health workers are continually looking for ways to reduce the burden of these diseases, including improved eating habits. Having been identified as a higher fat food within the diet of some Pacific people, it has been suggested the regular consumption of sheep meat flaps influences health outcomes. The evidence for this, however, remains anecdotal due to a lack of nutritional survey data amongst these communities.

Despite this, regular activity in this area, involving the New Zealand meat industry, began in response to a request from the Ministry of Health some years ago. The meat industry worked with nutrition colleagues in both New Zealand and across the Pacific to undertake a comprehensive needs assessment. As a result, the industry produced an educational poster describing pictorially how the fat content of sheep meat flaps can be reduced during preparation and cooking. At the request of Pacific Island nutritionists, the education series was expanded to include canned corned beef and, following an approach from the Heart Foundation, povi/pulu masima as well.

Since production, 8000 posters have been distributed to health professionals and key influencing groups working in Pacific communities in both New Zealand and across the Pacific, and are used in a variety of settings. Two of the posters have been translated into French for use in specific French-speaking communities. After eight years of circulation, the posters are now under review to ensure the current messages and cooking methods are still relevant to the target audience. Consultation with user groups is underway, both through face-to-face meetings and via an online survey disseminated to key health and nutrition groups in Pacific communities; the findings of which will be presented.

Source of funding: Beef + Lamb New Zealand Inc.

Document 3

MASSEY UNIVERSITY

INSTITUTE OF FOOD,
NUTRITION AND HUMAN HEALTH

The Concentration of Selected Nutrients in New Zealand Beef and Lamb Cuts and Offal Items

A Report to:

Beef + Lamb New Zealand Limited
Wellington
NEW ZEALAND

Second Edition (Revised): May 2013

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NEW ZEALAND

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Table of Contents

B-1. Summary (Beef Section)

1. The nutrient content of the raw and cooked lean tissue from 23 items including beef cuts (17) and offal items (6) are presented. The items to be analysed were chosen by members of the Meat Industry Association of New Zealand, and supplied as frozen samples from a range of meat plants located throughout New Zealand.
2. Analyses were based primarily on the lean tissue after bone and fat (subcutaneous and intermuscular) had been removed by boning knife. This was done to avoid having variation in the concentrations of nutrients between items being dominated by variation in the amount of dissectible fat present. Some analyses were also carried out on the dissected fat so that the composition of cuts with varying levels of fat can be estimated.
3. The levels of loss as purge are reported along with cooking losses. Cooking losses enabled the estimation of true percentage retention values for individual nutrients in the lean.
4. Eight to ten samples of each item were obtained for analysis, but the lean tissues from all samples were combined (separately for raw and cooked material) into a single composite sample for analysis. Thus, no measures of variation between samples of the same item were obtained for concentrations of nutrients, except in the case of intramuscular fat of the striploin lean, in which case a more than two-fold range was shown for the ten samples.
5. Nutrients measured included those obtained from a basic proximate analysis (protein, water, lipid & ash) that enabled the calculation of energy content per unit weight, cholesterol, 10 vitamins, 11 minerals such as iron and zinc, and 40 fatty acids within the intramuscular fat together with several totals and ratios for various groups of fatty acids. In addition, estimates of the density of lean meat and fat are provided so that nutrient concentrations per unit weight can be converted to concentrations per unit volume.
6. For selected nutrients, results are presented as bar charts as well as in a tabular format.
7. Because of the amount of data presented in the report, no attempt is made in this summary to pick out the main points. It is noted, however, that there is no suggestion that the composition of New Zealand beef has changed appreciably over the last 20 years, which is the time since previous analyses of this sort were published.
8. The information contained herein will be of value and interest to several groups of people including meat marketers (domestic as well as export markets), nutritionists, dietitians, the medical profession, and, probably most importantly, the beef-consuming public.

B-2. Introduction (Beef Section)

This section of the report provides the results obtained from an exercise where the nutrient content of the lean parts of 23 beef cuts and offal items was measured both before and after cooking. Items to be analysed were selected by members of the New Zealand meat industry through the Meat Industry Association, with the various items being supplied from different meat plants. The logistics of having the samples delivered to Massey University for dissection was managed by personnel employed by Beef and Lamb New Zealand (previously Meat & Wool New Zealand). Generally 10 samples of each item were provided with samples being large enough so that the dissected lean (muscle) of each sample when combined in a minced composite sample provided at least 3 kg of cooked and 3 kg of uncooked mince.

For most items 10 samples were processed, and then the lean tissue from all 10 samples was combined during the mincing procedure, so that only two samples per item (one cooked and one raw) were made available for freeze-drying. The one exception to this procedure was for the striploin cut, in which case sub-samples of the muscle tissue for each of the 10 samples were kept separate in order to obtain some indication of the variability in intramuscular fat levels. The composition of dissected subcutaneous and intermuscular fat from raw and cooked samples separately was also assessed for a number of nutrients to enable the estimation of the composition of items containing varying proportions of dissectible fat.

B-3. Material and Methods (Beef Section)

a) ***Samples Analysed:*** The 23 items analysed are listed in Table B1 along with their code number from "*The New Zealand Meat Specifications Guide"* (published by Meat & Wool New Zealand, Wellington). Table B1 also contains an outline of the cooking methods used for each item. Cooking methods used were those recommended by personnel at Beef + Lamb New Zealand Inc (www.beeflambnz.co.nz).

b) ***Procedures up to Freeze-Drying:*** The overall procedure up to the freeze-drying step is shown as a flow diagram in Figure B1.

Points to note about the samples processed up to this point are as follows:

1. Samples came from several different meat companies and from meat plants located in different regions of New Zealand.
2. Samples of cuts were from P2 steer carcasses (fat depths over the eye muscle between ribs 12 and 13 of 3 to 10 mm) weighing between 270 and 320 kg. For offal items it was not possible to specify the class or weight of the corresponding carcass.
3. Samples were received in frozen, vacuum-packs over the period from mid-January to mid-July of 2010.
4. Most samples came as 10 packs of approximately 1 kg, but some came in fewer but larger packs that had to be sub-divided after partial thawing.
5. Every attempt was made to have equivalent sub-samples cooked and left uncooked, but this was difficult for some items such as the "ribs prepared" where each 1 kg sample included only one rib.
6. For dissection the "waste" items that were included with the bone for weighing purposes included items such as cartilage, gristle, large blood vessels, blood clots, bruised tissue, valves and tubes with some offal items, and skin for the tongue.
7. Samples for analysis of subcutaneous and intermuscular fat came from striploins (1640) and chuck-eye rolls (2430), respectively. Dissection was carried out by boning knife and the fat inevitably included small remnants of muscle, blood vessels, and exudate from muscle. Separation of fat was particularly difficult with cooked samples.

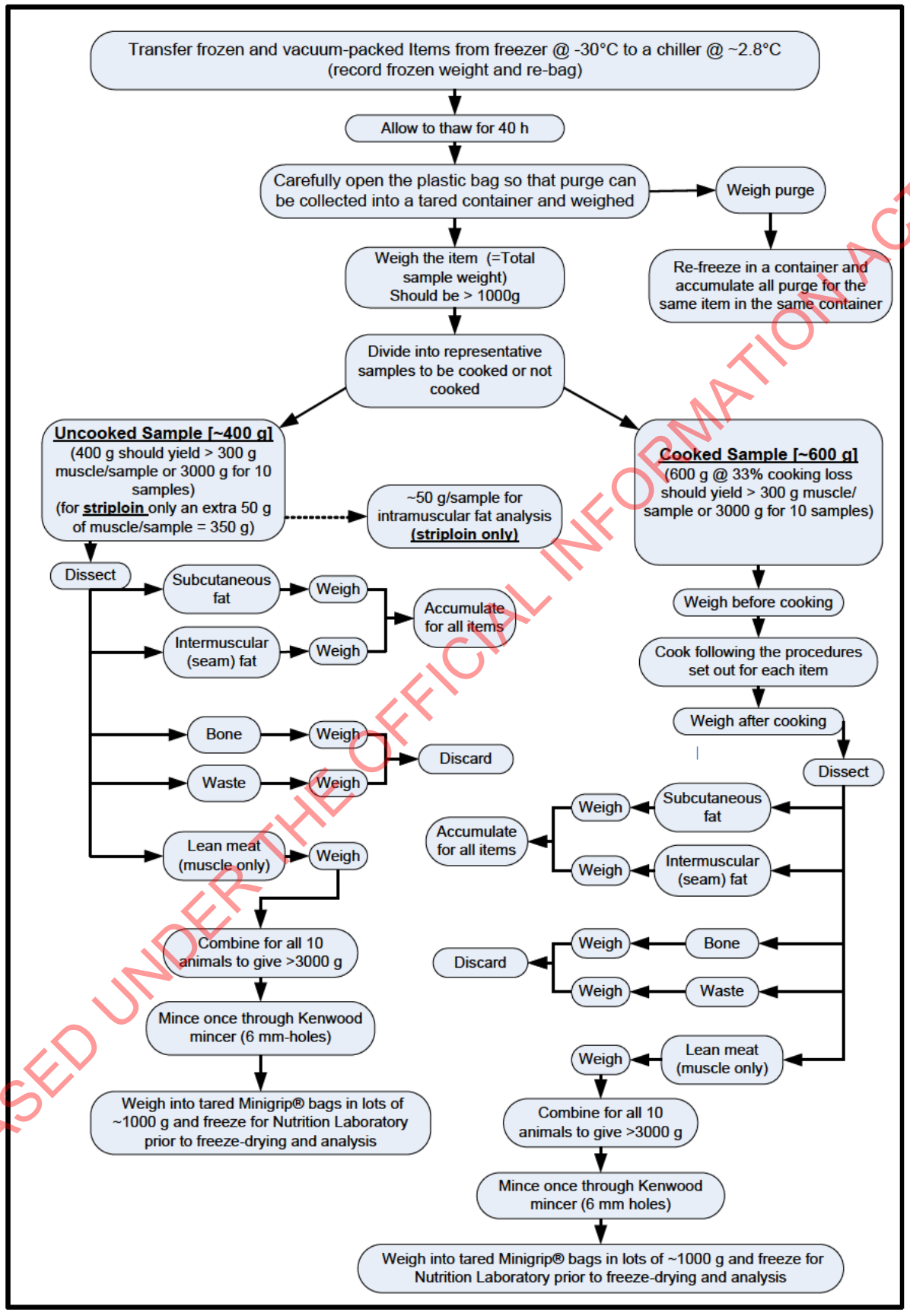
Table B1: A list of the 23 beef cuts and beef offal items processed, together with a description of the cooking procedures used. Equivalent names for the domestic market are given in Appendix 3.

NZ Export Description	*Meat Specs Guide Code*	*Cooking procedures*
Inside; cap-off	1224 [p18]	**Braise:** • Cut into pieces with sides of 20-25 mm; weigh. • Preheat a non-stick skillet to high heat. • Brown ~ 500 g of pieces on all sides for ~4 min. • Transfer to a ceramic or pyrex oven dish and add water at 800 mL/kg; record amount of water. • Cover with a tight-fitting lid and cook at 160°C (pre-heated) in an oven for 2 hours. • Remove liquid by draining through a colander. • Re-weigh after cooling at room temperature for ~20 min.
Knuckle	1410 [p20]	• Fast-fry (as for tenderloin below) except the steaks should be prepared as schnitzel or minute steaks with a thickness of about **15 mm.**
Eye round	1330 [p19]	**Slow roast:** • Trim to roast(s) of 500-700 g; weigh. • Pre-heat oven to 160°C. • Domestic oven on fan-bake. • Set up roast on a rack within a roasting pan. • Roast to an internal temperature of 70°C (about 25-30 min/500 g); record time of cooking. • Re-weigh cooked roast after cooling at room temperature for ~20 min.
Tenderloin side muscle off	1710 [p25]	**Fast fry:** • Prepare 25 mm thick steaks; weigh. • Pre-heat a good-quality non-stick skillet over moderate to high heat. • Cook to an internal temperature of 70°C (about 6 min/side); turn when half way to target temp. • record time of cooking. • Re-weigh after cooling at room temperature for ~20 min.
Cube roll/rib eye (ribs 6 to 12)	2240 [p28]	**Fast roast:** • As for slow roast (see Eye Round) except the oven should be at 200°C (about 15 min/500g).
Oyster Blade	2330 [p30]	• Braise as for Inside (2 hr).
Bolar blade (trim fat to 5 mm)	2320 [p30]	• Braise as for Inside (2 hr).
Manufacturing beef (95% CL)	2715 [p35]	**Mince:** • Mince twice through a ~6 mm die & mix. • Add water (800 mL/kg of mince) in 'boil-in-a-bag' bag, seal, and cook at 90 – 100°C in a steam-heated kettlefor 30 min. • Drain through a sieve for 5 min. • Re-weigh after cooling at room temperature for ~20 min.
Chuck Eye roll (ribs 1 to 5)	2430 [p31]	• Braise as for Inside (2 hr).
Flank steak	1820 [p26]	• Braise as for Inside, but for 2.5 hr.
Flat (trim fat to 5 mm)	1320 [p19]	• Braise as for Inside but for 3 hr.
Ribs prepared (ribs 6 to 12; bone in)	2211 [p27]	• Fast roast as for Cube roll.

Striploin (trim fat to 5 mm)	1640 [p24]	• Fast fry as for tenderloin.
Rump centre (fully skinned)	1555 [p22]	• Fast fry as for tenderloin.
Brisket Point End – deckle off (trim fat to 5 mm)	2520 [p32]	• Braise as for Inside but for 3 hr.
Navel end brisket (trim fat to 5 mm)	2540 [p32]	• Braise as for Inside but for 3 hr.
Hind Shin	1100 [p33]	• Braise as for Inside but for 3 hr.
Tongue Swiss cut	0112 [p38]	• Soak in 5 times their weight in cold water for 5 minutes; repeat twice (to remove blood, etc.). • Seal in a 'Boil-in-bag' bag with water at 800 mL/kg product. • Heat at 90 to 100°C in a steam-heated kettle for 2 hr. • Drain through a sieve, and re-weigh after cooling for ~20 min. • Peel, remove bones, fat and gristle.
Heart cap off	0121 [p39]	• Soak as above for tongues. • Cook as for tongues but for 1.5 hours. • Drain and weigh after cooling for ~20 min.
Liver	0130 [p39]	• Soak as above for tongues. • Prepare slices about 12-15 mm thick. • Pre-heat a non-stick skillet to high heat. • Fry to an internal temperature of 72°C with turning when temp is half way to the target. • Re-weigh after cooling for ~20 min.
Kidneys	0140 [p39]	• Halve and trim cores plus any tubes, valves and skin. • Soak as for tongues. • Cook as for tongues but for 1.5 hours. • Drain and weigh after cooling for ~20 min.
Sweetbread	0117 [p39]	• Soak as above for tongues. • Cook as for heart but for 30 min. • Drain and weigh after cooling for ~20 min.
Uncooked Tripe[a] (excluding honeycomb)	0173 [p41]	• Soak as above for tongues. • Cook as for heart but for 5 hours. • Drain and weigh after cooling for ~20 min.

[a] Tripe needs to be specified as being "Uncooked" because there is an option within item 0173 for tripe to be cooked.

Figure B1: A flow diagram summarizing the steps involved in processing the samples of beef cuts and offal items up to the stage when they were ready to be freeze-dried.



c) ***Laboratory Procedures:*** Laboratory procedures for individual nutrients along with measures of the sensitivity of the methods are provided in Appendix 1. Prior to analysis the lots of approximately 1000 g of minced lean tissue were freeze-dried (approximately 3.5 days with a maximum temperature of 20°C in a Cuddons 0610 model freeze dryer) and then ground to a fine powder (Magimix Automatic 5100 food processor) in order to provide an homogenous sample that could be sampled for all assays. Freeze-drying yields are given in Appendix 1. These freeze-dried samples were stored in sealed plastic bags at less than -20°C.

d) ***Data Analysis:*** Because the analysis of nutrients was carried out on a single composite for the cooked and uncooked samples of each item, it was not possible to determine whether there were statistically significant differences between items or to determine the level of variability between samples within an item for nutrients, except in the case of intramuscular fat of the striploin cut.

It would have been possible to have determined the statistical significance of differences in the dissected composition between cuts and/or offal items, but there was little point in carrying out such analyses in light of the nature of the items. The averages and standard deviations in Table B3 provide an indication of the extent to which samples within the different items differed in their averages and degree of variation.

Paired t-tests were used to determine the significance of differences in dissectible components of each item before and after cooking.

Percent true retention values for individual nutrients as estimates of the amount of a nutrient in the raw lean sample that was retained in the cooked lean sample expressed as percentages, were calculated using the following equation:

%Retention = [(CookedConc) x ((100 – CookingLoss%)/100) x 100]/[UncookedConc]

A percentage retention of 100 indicates that all the nutrient has been retained and will often be associated with a higher concentration of the nutrient in the cooked sample because of the loss of water during cooking. A percent retention of greater than 100 suggests that the nutrient has been transferred to the lean tissue from other tissues during cooking. These estimated percent retention values are, however, approximations as they are based on average cooking loss percentages, and the samples cooked were not identical to the uncooked samples. Also, the percent retention value refers to the lean tissue only, but the item was cooked before it had been dissected into its component parts. Therefore, any movement of a nutrient between the parts (muscle, fat & bone) during cooking will influence the value obtained.

Energy content was estimated from the content of protein and fat according to the following equation:

Energy(kJ/100 g) = [Protein(g/100g) x 16.7] + [Fat(g/100g) x 37.4]

The coefficients in this equation are those given by Livesey (2001; *British Journal of Nutrition, 85*: 271-287. "Review article: A perspective on food energy standards for nutrition labelling") for the calculation of metabolisable energy.

Energy in terms of kcal/100 g can be calculated by dividing the value in kJ/100 g by 4.184. Note that 1 kcal = 1 Calorie (with a capital "C").

B-4. Results (Beef Section)

a) ***Cooking and Dissection Results:*** Summaries of results from dissection and cooking for the 23 items processed are given in Tables B2, B3, B4, and B5. Points to note from the data in these tables include the following:

1. For all items there were either 9 or 10 samples processed. The mean weights for the different items did not vary widely, but there was considerable variation between samples within some items as illustrated by the standard deviations (Table B2).
2. The purge percentage represents the loss in weight due to fluid loss during the standard thawing treatment of 40 ±1 hours at 2.5 to 3.0°C. For the beef cuts the purge percent varied from a low of 0.19% for the navel-end brisket cut to a high of 7.2% for the inside (cap-off) (Table B2). It is not possible to be definite about the reasons for the differences in the purge percent, but they may have been due in part to the extent of fat cover and the extent to which the muscle had been cut across in preparing the samples of approximately 1 kg, as well as to any intrinsic differences in meat water-holding capacity, and variation in the ways in which the items were treated prior to arrival at Massey University.
3. The purge percentage for the offal items varied from a low value of 0.30% for the tongue to a high of 5.39 for the kidney (Table B2). These items vary widely in their structure and the nature of the tissues they contain, so it is not possible to suggest meaningful reasons for the differences shown, although the very low value for the tongue is likely to be at least partly due to the skin present.
4. The purge percentages for most items were characterised by having high standard deviations relative to the averages compared with a number of other characteristics such as the initial frozen weight.
5. Comparisons of cooking loss percentages between the different items need to be made with care because of the different cooking procedures used as outlined in Table B1. For the beef cuts, average cooking loss percentages ranged from a low of 11.91% for the manufacturing beef (as mince) to a high of 43.90% for the flat (Table B2). The lowest value for the non-minced cuts was for the ribs prepared at 25.42%. Cooking loss percentages for the offal items ranged from a low of 14.97% for liver samples to 53.42% for the kidney (Table B2).
6. The compositions of the cooked and uncooked items are shown in Table B3 as percentages of the total following dissection of each item into the components shown using a boning knife. Thus, the precision with which the components were separated was not as great as would have been possible with a scalpel and scissors, but doing it that way would have been much more time-consuming. When possible, the fat was separated into subcutaneous fat and intermuscular fat (Table B4), but the distinction between these two depots was often difficult to make (particularly in cooked samples), in which case all the fat was designated intermuscular. The best measure of overall fatness is the "Dissected fat %" value (Table B3).
7. Results for the dissectible composition of both raw and cooked samples indicated that there was considerable variation between samples within each item. Coefficients of variation (the SD as a % of the average) were generally least for the muscle portion for most items, largely because this portion usually made up the greatest percentage of the whole.
8. The characteristic of most interest in Table B5 is the difference in the percentage of the muscle or lean tissue in the raw samples relative to the cooked samples, but it can be seen that the values varied widely in both size and direction. The P values provide an indication of whether the differences are likely to be real or whether they probably arose by chance, with a lower P value indicating that the associated difference is more likely to be real. Differences are generally not considered to be significant if the P value is greater than 0.05, as was the case for most of the differences in Table B5.
9. Muscle or lean-tissue % made up a greater proportion of raw samples than cooked samples for bolar blade, kidneys, and navel-end brisket, but raw samples contained a smaller percentage of muscle or lean-tissue % for eye round, rump centre, tenderloin, and Swiss-cut tongue (Table B5). In some cases these differences were due to differences in the fat content and some to differences in bone and/or waste percentage.

10. Total fat % made up a greater proportion of raw samples than cooked samples (i.e. the difference in Table B5 is positive and the P value is less than 0.05) for eye round, ribs prepared, rump centre, and tenderloin, but raw samples contained a smaller percentage of fat for navel-end brisket.

Table B2: Results for beef cuts and beef offal items showing the number of lots for each item and the averages (±SD) for weight per lot, purge losses as a percentage of frozen weight, and cooking losses as a percentage of uncooked weight.

Cut or offal item	N[a]	Weight/lot[a] (g)	Purge (%)	Cooking Loss (%)
FOREQUARTER ITEMS:				
Bolar Blade	10	1032.3 ± 45.8	1.92 ± 0.87	38.19 ± 1.79
Brisket Navel End	10	1073 ± 20.4	0.19 ± 0.11	32.31 ± 1.44
Brisket Point End	9	1044.8 ± 49.3	1.86 ± 1.06	43.87 ± 1.66
Chuck Eye Roll	10	1047.2 ± 34.2	1.77 ± 0.72	38.76 ± 2.78
Cube Roll	10	1056.8 ± 25.7	3.03 ± 1.16	30.38 ± 2.61
Manufacturing Beef	10	1004.3 ± 6.4	2.61 ± 1.25	11.91 ± 7.27
Oyster Blade	10	1007.2 ± 0.34	0.72 ± 0.34	34.20 ± 1.48
Ribs Prepared	10	1208.2 ± 262.6	0.63 ± 0.56	25.42 ± 3.18
HINDQUARTER ITEMS				
Eye Round	10	1006.6 ± 10.8	3.41 ± 1.48	19.93 ± 2.66
Flank	10	1150.9 ± 127.0	0.62 ± 0.43	40.33 ± 2.28
Flat	10	1005.8 ± 7.2	2.55 ± 0.72	43.90 ± 1.67
Hind Shin	10	1021.1 ± 34.8	1.36 ± 0.51	35.78 ± 2.40
Inside	10	1085.6 ± 37.1	7.20 ± 1.51	41.58 ± 1.97
Knuckle	10	999.5 ± 77.2	4.12 ± 0.89	22.82 ± 3.73
Rump Centre	10	1000.6 ± 178.8	4.12 ± 0.98	30.28 ± 7.37
Striploin	10	1049.0 ± 29.6	3.97 ± 0.91	26.45 ± 3.41
Tenderloin	10	1022.7 ± 66.1	4.27 ± 0.61	33.05 ± 2.68
OFFAL ITEMS				
Heart	10	1053.1 ± 101.5	3.37 ± 1.36	43.65 ± 2.57
Kidney	10	990.0 ± 145.3	3.53 ± 1.18	53.42 ± 2.04
Liver	9	983.3 ± 158.6	5.39 ± 0.83	14.97 ± 3.94
Sweetbread	10	900.3 ± 4.3	0.50 ± 0.17	15.50 ± 4.30
Tongue	10	1289.8 ± 113.5	0.30 ± 0.16	31.21 ± 4.69
Tripe Uncooked	10	909.2 ± 76.6	0.43 ± 0.70	30.60 ± 8.68

[a] N = the number of lots to produce at least 3 kg of raw and 3 kg of cooked lean tissue.
For smaller items there were a number of individual items from different animals per lot.

Table B3: Results for beef cuts and beef offal items showing the averages (±SD) for muscle, fat, and bone as determined by dissection with a boning knife before or after cooking. For offal items, "muscle" refers to all lean tissue that would normally be consumed.

Cut or offal item	Dissected Muscle %		Dissected Fat %		Bone & Waste %	
	Raw	Cooked	Raw	Cooked	Raw	Cooked
FOREQUARTER ITEMS:						
Bolar Blade	92.4±3.5	86.0±6.2	5.5±3.5	8.1±6.7	2.1±3.3	6.0±3.9
Brisket Navel End	67.2±5.0	59.6±7.1	32.8±5.0	40.4±7.1	0	0
Brisket Point End	93.0±3.9	90.9±3.8	7.0±3.9	9.2±3.8	0	0
Chuck Eye Roll	90.5±6.2	91.0±4.1	8.8±6.1	8.4±3.7	0.7±0.7	0.6±0.8
Cube Roll	88.1±3.4	90.4±4.1	11.9±3.4	9.6±4.1	0	0
Manufacturing Beef	-	-	-	-	-	-
Oyster Blade	95.7±2.4	94.2±3.6	4.3±2.3	5.8±3.6	0.1±0.1	0
Ribs Prepared	75.3±11.1	73.9±12.1	17.1±6.6	10.3±4.2	7.7±5.6	15.8±10.0
HINDQUARTER ITEMS						
Eye Round	97.8±0.9	99.2±0.6	2.3±0.9	0.8±0.6	0	0
Flank	96.6±1.5	97.0±2.3	3.4±1.4	2.6±1.9	0.1±0.1	0.4±0.6
Flat	94.9±2.6	94.9±2.5	5.1±2.6	5.1±2.5	0	0
Hind Shin	92.7±3.9	92.4±5.2	6.3±3.3	5.7±3.9	1.0±1.1	1.9±1.6
Inside	97.7±1.9	98.5±1.3	1.7±1.0	1.3±1.1	0.6±1.1	0.2±0.4
Knuckle	93.0±3.9	95.0±1.7	6.2±3.1	4.7±1.6	0.8±0.9	0.4±0.2
Rump Centre	94.5±1.8	99.3±0.6	5.5±1.8	0.7±0.6	0	0
Striploin	80.7±6.3	83.5±5.1	19.3±6.3	16.5±5.1	0	0
Tenderloin	98.8±0.5	99.5±0.5	1.2±0.5	0.5±0.5	0	0
OFFAL ITEMS						
Heart	86.0±5.4	82.7±8.9	13.1±5.5	16.2±9.1	0.9±0.6	1.1±0.4
Kidney	89.5±2.8	80.0±4.8	0	0	10.5±2.8	20.0±4.8
Liver	97.2±2.1	98.1±2.3	0	0	2.8±2.1	1.9±2.3
Sweetbread	92.3±8.1	90.6±4.5	5.6±7.1	4.9±4.2	2.2±2.4	4.5±1.9
Tongue	78.63±2.4	89.0±2.7	3.2±2.1	2.5±1.9	18.1±2.9	8.5±3.6
Tripe Uncooked	89.0±7.4	91.4±5.6	11.0±7.4	8.6±5.6	0	0

Table B4: Results for beef cuts and offal items showing the averages (±SD) for the percentage of subcutaneous and intermuscular (seam) fat before or after cooking. When there was difficulty in distinguishing between subcutaneous and intermuscular fat it was designated intermuscular fat.

Cut or offal item	Subcutaneous Fat %		Intermuscular Fat %	
	Raw	Cooked	Raw	Cooked
FOREQUARTER ITEMS:				
Bolar Blade	4.0±3.0	0	1.5±1.7	8.1±6.7
Brisket Navel End	19.4±5.5	0	13.4±5.6	40.4±7.1
Brisket Point End	6.1±4.0	0	0.9±0.8	9.2±3.8
Chuck Eye Roll	0	0	8.8±6.1	8.4±3.7
Cube Roll	2.6±1.2	0.8±0.3	9.3±3.4	8.8±4.0
Manufacturing Beef	0	0	0	0
Oyster Blade	4.1±1.9	5.8±3.6	0.2±0.5	0
Ribs Prepared	0	0	17.1±6.6	10.3±4.2
HINDQUARTER ITEMS				
Eye Round	2.3±0.9	0.8±0.6	0	0
Flank	0	0	3.4±1.4	2.6±1.9
Flat	0	0	5.1±2.6	5.1±2.5
Hind Shin	3.5±1.8	3.7±2.9	2.8±1.7	2.1±1.3
Inside	0	0	1.7±1.0	1.3±1.1
Knuckle	0	0	6.2±3.1	4.7±1.6
Rump Centre	0	0	5.5±1.8	0.7±0.6
Striploin	17.4±5.9	15.8±5.0	1.8±1.3	0.7±0.9
Tenderloin	0	0	1.2±0.5	0.5±0.50
OFFAL ITEMS				
Heart	0	0	13.1±5.5	16.2±9.1
Kidney	0	0	0	0
Liver	0	0	0	0
Sweetbread	0	0	5.6±7.1	4.9±4.2
Tongue	0	0	3.2±2.1	2.5±1.9
Tripe Uncooked	0	0	11.0±7.4	8.6±5.6

Table B5: Differences in the percentage composition of raw and cooked samples for the 22 beef cut and offal items dissected (excluding manufacturing beef). The differences for muscle (or lean tissue for offal items), total fat, and bone and/or waste are expressed as the **raw value minus the cooked value**. Thus, negative values indicate that levels were higher in the cooked sample. The statistical significance of differences are given as P values from t-tests. Items are listed in this table in alphabetical order.

Item	N	Δ-Muscle %[a]		Δ-Total Fat %[a]		Δ-Bone and/or Waste%[a]	
		Mean ±SD	P	Mean ±SD	P	Mean ±SD	P
Beef Sweetbread	10	1.70 ±7.26	0.48	0.61 ±5.63	0.74	-4.46 ±3.01	0.04
Bolar Blade	10	6.36 ±5.88	0.008	-2.52 ±5.92	0.21	-3.84 ±6.05	0.08
Chuck Eye Roll	10	-0.54 ±7.87	0.83	0.48 ±7.68	0.85	0.06 ±0.97	0.85
Cube Roll	10	-2.23 ±4.13	0.12	2.23 ±4.14	0.12	-	-
Eye Round	10	-1.45 ±0.69	<0.0001	1.45 ±0.69	<0.0001	-	-
Flank Steak	10	-0.45 ±3.09	0.66	0.81 ±2.80	0.38	-0.36 ±0.64	0.11
Flat	10	0.04 ±4.83	0.98	-0.04 ±4.83	0.98	-	-
Heart Cap-off	10	3.36 ±6.06	0.11	-3.17 ±6.41	0.15	-0.19 ±0.54	0.29
Hind Shin	10	0.34 ±5.43	0.85	0.53 ±3.70	0.66	-0.86 ±1.94	0.19
Inside Cap-off	10	-0.79 ±1.26	0.09	0.37 ±0.57	0.07	0.42 ±1.18	0.29
Kidneys	10	9.49 ±2.02	<0.0001	-	-	-9.49 ±2.02	<0.0001
Knuckle	10	1.96 ±3.60	0.12	-1.52 ±2.80	0.12	0.44 ±0.92	0.17
Liver	9	-0.87 ±3.86	0.52	-	-	0.87 ±3.86	0.52
Navel-end Brisket	10	7.62 ±6.07	0.003	-7.62 ±6.07	0.003	-	-
Oyster Blade	10	1.47 ±2.89	0.14	-1.51 ±2.86	0.13	0.04 ±0.13	0.34
Point-end Brisket	9	2.17 ±5.85	0.30	-2.17 ±5.85	0.30	-	-
Ribs Prepared	10	1.35 ±18.39	0.82	6.74 ±8.37	0.03	-8.10 ±12.26	0.07
Rump Centre	10	-4.82 ±2.03	<0.0001	4.82 ±2.03	<0.0001	-	-
Striploin	10	-2.79 ±3.98	0.053	2.79 ±3.98	0.053	-	-
Tenderloin	10	-0.65 ±0.68	0.014	0.65 ±0.68	0.014	-	-
Tongue Swiss-cut	10	-10.40 ±4.02	<0.0001	0.79 ±3.40	0.48	9.92 ±6.01	0.0007
Uncooked Tripe	10	-2.43 ±7.73	0.35	2.43 ±7.73	0.35	-	-

[a] The differences for muscle%, fat% and bone and/or waste% are expressed as (Raw% - Cooked%).

b) ***Nutrient Composition by Nutrient:*** Tables B6 to B12 below give the nutrient composition of the 23 beef cuts and offal items arranged by each nutrient item, so that each table contains the information for all 23 items for several nutrients. This is followed in **Section c)** where Tables B13 to B18 give the same information arranged so that all the nutrients for a particular item (beef cut or beef offal item) are shown in the same table. The acronym "BDL" in these tables indicates that the nutrient concentration was below detectable limits.

Table B6: Composition of the cooked (Ckd) and raw lean portion of 23 beef cuts and offal items in terms of the percentages of water, protein, and fat, together with the estimated energy content and percentage true retention (%Ret) of each item.

	Water (%)			Energy kJ/100 g)			Protein (%)			Fat (%)		
Cut or offal item	**Ckd**	**Raw**	**%Ret**	**Ckd**	**Raw**	**%Ret**	**Ckd**	**Raw**	**%Ret**	**Ckd**	**Raw**	**%Ret**
FOREQUARTER ITEMS:												
Bolar Blade	60.5	73.1	**51.1**	805	537	**92.7**	33.5	22.1	**93.8**	6.6	4.5	**90.4**
Brisket Navel End	54.9	67.9	**54.7**	1102	806	**92.5**	29.3	19.7	**100.6**	16.4	12.8	**86.9**
Brisket Point End	58.6	73.7	**44.6**	840	522	**90.3**	34.5	20.9	**92.6**	7.1	4.6	**85.7**
Chuck Eye Roll	59.7	73.5	**49.7**	868	544	**97.7**	32.1	20.5	**96.0**	8.9	5.4	**100.6**
Cube Roll	56.8	69.4	**57.0**	997	649	**107.0**	30.1	19.8	**106.0**	13.2	8.5	**108.2**
Manufacturing Beef	73.1	73.8	**87.2**	526	492	**94.2**	24.2	21.2	**100.5**	3.3	3.7	**78.1**
Oyster Blade	62.4	71.7	**57.3**	815	647	**82.8**	29.9	21.8	**90.0**	8.5	7.6	**73.6**
Ribs Prepared	61.8	71.3	**64.6**	819	610	**100.2**	27.2	21.3	**95.3**	9.7	6.8	**107.1**
HINDQUARTER ITEMS:												
Eye Round	65.4	74.1	**61.8**	682	462	**103.5**	29.7	20.2	**103.2**	5.0	3.6	**104.3**
Flank	61.5	73.6	**49.9**	810	592	**81.6**	30.7	20.5	**89.4**	7.9	6.7	**70.9**
Flat	56.4	70.8	**47.5**	940	643	**87.2**	33.2	21.3	**93.1**	10.3	7.7	**80.0**
Hind Shin	64.4	74.6	**55.5**	695	475	**94.0**	31.2	21.5	**93.5**	4.6	3.1	**95.7**
Inside	57.8	72.4	**46.7**	851	533	**93.2**	34.5	22.2	**91.0**	7.3	4.4	**98.4**
Knuckle	64.7	72.3	**69.0**	743	567	**101.1**	27.5	21.9	**97.1**	7.6	5.4	**108.4**
Rump Centre	61.8	72.2	**59.6**	783	589	**92.7**	30.2	21.7	**96.8**	7.5	6.1	**86.2**
Striploin	59.6	70.4	**62.3**	903	611	**108.6**	28.5	20.9	**100.3**	11.4	7.0	**119.8**
Tenderloin	59.7	71.8	**55.7**	827	582	**95.2**	29.4	21.2	**92.8**	9.0	6.1	**98.9**
All-Cuts averages	**61.1**	**72.2**	**57.3**	**824**	**580**	**95.0**	**30.3**	**21.1**	**96.0**	**8.5**	**6.1**	**93.7**
OFFAL ITEMS:												
Heart	62.3	78.1	**44.9**	747	436	**96.4**	31.3	18.5	**95.2**	6.0	3.4	**99.4**
Kidney	66.4	80.5	**38.4**	653	361	**84.3**	27.3	15.7	**81.0**	5.3	2.6	**93.0**
Liver	66.4	70.4	**80.3**	564	494	**97.2**	23.3	20.5	**96.6**	4.7	4.1	**98.4**
Sweetbread	56.3	57.7	**82.4**	1324	1262	**88.6**	12.5	11.5	**92.0**	29.8	28.6	**88.0**
Tongue	57.0	65.2	**60.1**	1067	1011	**72.6**	18.3	17.8	**70.9**	20.3	19.1	**73.3**
Tripe Uncooked	77.7	82.2	**65.6**	429	322	**92.3**	19.0	14.9	**88.7**	3.0	2.0	**104.3**
Offals averages	**64.3**	**72.3**	**62.0**	**797**	**648**	**88.6**	**22.0**	**16.5**	**87.4**	**11.5**	**10.0**	**92.8**

Table B7: Composition of the cooked (Ckd) and raw lean portion of 23 beef cuts and offal items in terms of the ash (%), and the concentrations of vitamins B1, B2, and B3, together with the estimated percentage true retention (%Ret) of each item.

	Ash (%)			Vitamin B1 (mg/100 g) (Thiamine)			Vitamin B2 (mg/100 g) (Riboflavin)			Vitamin B3 (mg/100 g) (Niacin)		
Cut or offal item	**Ckd**	**Raw**	**%Ret**	**Ckd**	**Raw**	**%Ret**	**Ckd**	**Raw**	**%Ret**	**Ckd**	**Raw**	**%Ret**
FOREQUARTER ITEMS:												
Bolar Blade	1.15	0.98	72.2	0.037	0.048	47.4	0.14	0.11	80.2	2.2	3.1	43.9
Brisket Navel End	0.93	0.84	75.0	0.017	0.034	33.5	0.09	0.10	63.6	2.4	3.6	46.3
Brisket Point End	0.83	0.96	48.6	0.015	0.035	24.0	0.12	0.05	126.9	3.5	4.3	45.1
Chuck Eye Roll	0.78	0.95	50.3	0.028	0.051	33.5	0.14	0.12	72.8	2.0	2.9	43.3
Cube Roll	1.07	0.91	82.6	0.067	0.071	64.9	0.15	0.08	135.5	4.2	3.3	89.3
Manufacturing Beef	0.63	1.02	54.4	0.042	0.055	68.1	0.10	0.11	78.7	1.8	2.9	53.3
Oyster Blade	0.63	0.90	46.1	0.023	0.054	28.7	0.15	0.12	80.2	1.6	2.4	45.9
Ribs Prepared	1.12	0.94	88.3	0.026	0.030	65.7	0.12	0.09	97.4	5.1	4.3	87.5
HINDQUARTER ITEMS:												
Eye Round	1.15	1.02	79.3	0.041	0.037	78.9	0.11	0.07	112.8	4.0	3.5	79.9
Flank	0.67	0.96	41.6	0.021	0.032	39.2	0.09	0.08	62.6	3.5	4.7	43.7
Flat	1.06	0.92	68.9	0.024	0.045	31.8	0.19	0.14	81.8	2.3	3.3	41.1
Hind Shin	1.62	0.99	105.3	0.019	0.036	33.4	0.12	0.12	65.9	2.7	3.3	52.7
Inside	0.79	1.03	45.1	0.029	0.058	29.5	0.12	0.07	99.0	3.0	4.0	44.7
Knuckle	1.25	1.02	94.4	0.058	0.042	105.2	0.09	0.07	106.1	3.2	2.7	93.3
Rump Centre	1.38	0.97	99.1	0.081	0.066	85.1	0.20	0.12	117.8	3.9	2.7	100.2
Striploin	1.09	0.91	87.3	0.053	0.048	80.7	0.09	0.09	73.3	4.8	4.2	83.9
Tenderloin	1.66	1.05	106.3	0.058	0.054	71.9	0.21	0.12	118.4	5.0	4.1	82.6
All-Cuts averages	**1.05**	**0.96**	**73.2**	**0.038**	**0.047**	**54.2**	**0.13**	**0.10**	**92.5**	**3.3**	**3.5**	**63.3**
OFFAL ITEMS:												
Heart	1.04	1.02	57.5	0.237	0.252	53.0	0.98	0.68	81.3	3.4	4.4	42.7
Kidney	1.55	1.15	62.5	0.403	0.559	33.6	2.95	2.12	64.8	3.9	4.9	37.3
Liver	1.80	1.46	104.6	0.376	0.371	86.2	3.04	2.35	110.1	13.8	15.4	76.2
Sweetbread	1.91	2.36	68.4	0.077	0.087	74.8	0.11	0.12	79.0	1.6	2.0	67.6
Tongue	0.72	0.80	61.9	0.059	0.065	63.0	0.23	0.21	73.8	2.6	3.0	59.2
Tripe uncooked	0.89	1.10	56.5	0.022	0.051	30.0	0.10	0.19	37.3	2.6	7.9	22.9
Offals averages	**1.32**	**1.32**	**68.6**	**0.196**	**0.231**	**56.8**	**1.24**	**0.95**	**74.4**	**4.6**	**6.3**	**51.0**

Table B8: Composition of the cooked (Ckd) and raw lean portion of 23 beef cuts and offal items in terms of the concentrations of vitamins B5, B6, B12, and vitamin A, together with the estimated percentage true retention (%Ret) of each item.

	Vitamin B5 (mg/100 g) (Pantothenic acid)			Vitamin B6 (mg/100 g) (Pyridoxine)			Vitamin B12 (µg/100 g) (Cyanocobalamin)			Vitamin A (µg/100 g)		
Cut or offal item	**Ckd**	**Raw**	**%Ret**	**Ckd**	**Raw**	**%Ret**	**Ckd**	**Raw**	**%Ret**	**Ckd**	**Raw**	**%Ret**
FOREQUARTER ITEMS:												
Bolar Blade	0.4	0.5	45.1	0.191	0.331	35.6	1.7	1.8	56.7	13.5	6.2	133.5
Brisket Navel End	BDL	0.3	-	0.102	0.237	29.1	1.3	2.0	46.0	16.0	12.9	84.2
Brisket Point End	BDL	0.3	-	0.195	0.322	34.0	1.2	1.4	47.4	12.3	8.5	81.3
Chuck Eye Roll	BDL	0.3	-	0.147	0.187	48.0	2.0	2.3	53.5	12.2	8.5	87.4
Cube Roll	0.4	0.3	97.4	0.305	0.280	75.7	1.4	1.5	63.6	12.4	16.8	51.4
Manufacturing Beef	0.3	0.5	47.5	0.160	0.194	72.6	1.0	1.4	63.6	8.2	9.6	75.3
Oyster Blade	BDL	0.9	-	0.099	0.156	41.7	1.9	2.3	52.4	10.5	12.2	56.6
Ribs Prepared	0.4	0.3	99.0	0.266	0.255	77.7	1.1	1.2	73.0	8.8	7.8	84.8
HINDQUARTER ITEMS:												
Eye Round	0.4	0.3	93.3	0.337	0.329	71.8	1.3	1.1	77.0	7.2	7.1	71.8
Flank	0.1	0.1	55.4	0.120	0.205	35.0	1.4	1.6	53.7	11.3	7.8	86.4
Flat	0.2	0.3	28.0	0.171	0.276	37.1	1.9	2.9	38.7	14.8	10.9	81.1
Hind Shin	0.2	0.5	23.6	0.144	0.259	35.7	1.3	1.5	53.4	8.0	6.3	81.8
Inside	0.4	0.3	88.4	0.248	0.367	39.5	1.5	1.6	52.1	13.2	7.5	102.8
Knuckle	0.4	0.3	98.5	0.319	0.286	86.0	1.9	1.6	92.3	13.5	8.8	118.4
Rump Centre	0.8	0.6	93.3	0.276	0.276	69.6	2.2	2.1	71.8	11.6	7.2	112.8
Striploin	0.4	0.3	99.6	0.323	0.316	75.1	0.9	0.7	97.5	19.0	12.2	114.4
Tenderloin	0.8	0.6	95.5	0.230	0.267	57.9	2.0	1.8	73.9	12.6	9.2	92.0
All-Cuts averages	**0.4**	**0.4**	**74.2**	**0.214**	**0.267**	**54.2**	**1.5**	**1.7**	**62.7**	**12.1**	**9.4**	**89.2**
OFFAL ITEMS:												
Heart	1.2	1.8	38.8	0.122	0.160	43.2	6.7	10.8	35.1	14.1	10.3	77.2
Kidney	3.1	4.0	35.8	0.254	0.316	37.3	21.3	27.7	36.0	104.2	89.1	54.4
Liver	9.8	10.3	80.9	0.452	0.428	89.8	96.0	84.5	96.6	21013.7	28319.5	63.1
Sweetbread	0.5	0.6	70.4	0.041	0.041	85.4	1.5	2.1	60.4	18.7	19.4	81.5
Tongue	0.7	0.4	112.5	0.072	0.094	52.4	3.9	5.2	52.4	12.5	12.0	71.8
Tripe uncooked	0.2	0.7	21.1	0.013	0.035	24.8	2.3	7.1	22.3	5.9	6.1	66.4
Offals averages	**2.6**	**3.0**	**59.9**	**0.159**	**0.179**	**55.5**	**22.0**	**22.9**	**50.5**	**3528.2**	**4742.7**	**69.1**

Table B9: Composition of the cooked (Ckd) and raw lean portion of 23 beef cuts and offal items in terms of the concentrations of vitamins D3, 25-hydroxy D3, and E, and cholesterol, together with the estimated percentage true retention (%Ret) of each item.

	Vitamin D3 (µg/100 g)			25-OH Vit D3 (µg/100 g)			Vitamin E (mg/100 g)			Cholesterol (mg/100 g)		
Cut or offal item	**Ckd**	**Raw**	**%Ret**	**Ckd**	**Raw**	**%Ret**	**Ckd**	**Raw**	**%Ret**	**Ckd**	**Raw**	**%Ret**
FOREQUARTER ITEMS:												
Bolar Blade	0.21	0.13	101.7	0.153	0.111	85.2	0.76	0.40	118.9	91.3	55.5	101.7
Brisket Navel End	0.22	0.15	96.4	0.145	0.081	121.2	0.71	0.43	111.4	78.5	52.7	100.8
Brisket Point End	0.17	0.12	78.3	0.200	0.065	172.7	0.85	0.48	100.1	95.3	53.5	100.0
Chuck Eye Roll	0.16	0.15	67.0	0.222	0.220	61.8	0.90	0.63	87.5	98.0	60.5	99.2
Cube Roll	0.38	0.19	141.2	0.156	0.132	82.3	0.40	0.39	71.2	93.8	59.2	110.3
Manufacturing Beef	0.13	0.13	85.5	0.141	0.175	71.0	0.57	0.49	102.6	67.4	49.2	120.7
Oyster Blade	0.24	0.18	87.5	0.215	0.195	72.5	0.76	0.38	132.0	86.9	55.9	102.3
Ribs Prepared	0.31	0.18	127.7	0.200	0.146	102.2	0.93	0.74	94.8	68.8	56.5	90.8
HINDQUARTER ITEMS:												
Eye Round	0.13	0.09	104.6	0.103	0.076	95.0	0.60	0.46	90.7	66.6	47.4	98.5
Flank	0.28	0.14	120.4	0.179	0.140	76.3	0.95	0.34	166.9	77.9	48.9	95.1
Flat	BDL	BDL	-	0.192	0.116	98.8	1.16	0.52	133.6	93.9	55.3	101.3
Hind Shin	0.18	BDL	-	0.191	0.164	74.8	0.74	0.43	110.2	88.9	55.6	102.7
Inside	0.25	0.28	52.1	0.177	0.126	82.1	0.42	0.20	122.7	91.2	55.2	96.5
Knuckle	0.10	0.08	105.8	0.161	0.127	97.8	0.38	0.53	56.1	76.1	56.2	104.5
Rump Centre	0.17	0.09	133.7	0.113	0.097	81.2	0.56	0.32	124.5	78.1	54.9	99.2
Striploin	0.33	0.19	126.5	0.156	0.134	85.6	0.53	0.35	112.2	70.2	53.9	95.8
Tenderloin	0.20	0.10	131.0	0.166	0.124	89.6	0.81	0.60	90.9	80.8	58.4	92.6
All-cuts averages	**0.22**	**0.15**	**104.4**	**0.169**	**0.131**	**91.2**	**0.71**	**0.45**	**107.4**	**82.6**	**54.6**	**100.7**
OFFAL ITEMS:												
Heart	0.17	0.15	62.4	0.357	0.270	74.5	2.09	1.22	96.3	200.7	123.7	91.4
Kidney	0.83	0.15	255.4	0.284	0.321	41.2	1.53	0.82	87.1	1002.3	404.2	115.5
Liver	0.11	0.03	287.7	0.149	0.174	72.8	1.28	1.84	59.3	242.5	254.1	81.1
Sweetbread	0.56	0.62	76.3	0.119	0.100	100.6	0.79	0.69	97.3	248.7	216.7	97.0
Tongue	0.34	0.35	67.8	0.241	0.256	64.8	0.95	0.95	68.7	104.9	80.5	89.6
Tripe uncooked	0.26	0.20	91.6	0.085	0.282	20.9	0.51	0.45	77.6	198.9	117.4	117.6
Offals averages	**0.38**	**0.25**	**140.2**	**0.206**	**0.234**	**62.5**	**1.19**	**1.00**	**81.1**	**333.0**	**199.4**	**98.7**

Table B10: Composition of the cooked (Ckd) and raw lean portion of 23 beef cuts and offal items in terms of the concentrations of calcium, copper, iodine, and iron, together with the estimated percentage true retention (%Ret) of each item.

	Calcium (mg/100 g)			Copper (mg/100 g)			Iodine (µg/100 g)			Iron (mg/100 g)		
Cut or offal item	**Ckd**	**Raw**	**%Ret**	**Ckd**	**Raw**	**%Ret**	**Ckd**	**Raw**	**%Ret**	**Ckd**	**Raw**	**%Ret**
FOREQUARTER ITEMS:												
Bolar Blade	5.50	3.55	**95.7**	0.13	0.15	**54.5**	0.9	0.8	**70.8**	2.7	2.1	**81.1**
Brisket Navel End	6.71	4.78	**95.0**	0.07	0.05	**95.7**	2.0	3.5	**37.9**	1.8	1.4	**88.9**
Brisket Point End	6.05	3.75	**90.6**	0.11	0.10	**62.6**	0.9	1.9	**26.4**	2.8	2.1	**75.9**
Chuck Eye Roll	5.85	4.49	**79.8**	0.10	0.08	**80.3**	1.2	0.7	**113.5**	2.7	2.0	**81.5**
Cube Roll	4.56	3.45	**92.1**	0.07	0.06	**87.1**	1.3	BDL	**-**	2.4	2.1	**79.4**
Manufacturing Beef	6.19	5.75	**95.0**	0.11	0.07	**128.6**	1.4	0.6	**189.9**	1.8	2.0	**80.1**
Oyster Blade	4.71	3.77	**82.2**	0.09	0.06	**98.7**	0.6	0.8	**50.0**	2.8	2.0	**93.6**
Ribs Prepared	17.65	15.20	**86.6**	0.06	0.05	**92.8**	2.4	1.1	**168.5**	2.2	1.8	**90.4**
HINDQUARTER ITEMS:												
Eye Round	4.19	3.44	**85.4**	0.06	0.05	**93.3**	1.6	BDL	**-**	1.9	1.4	**95.3**
Flank	5.06	3.66	**82.7**	0.07	0.05	**86.5**	1.2	1.3	**54.1**	2.4	1.6	**91.7**
Flat	5.73	4.93	**65.2**	0.19	0.12	**88.8**	2.9	0.8	**203.4**	3.2	1.9	**95.3**
Hind Shin	6.48	3.96	**105.0**	0.11	0.07	**107.0**	0.8	0.5	**93.7**	2.7	2.0	**85.3**
Inside	4.52	3.61	**73.2**	0.14	0.08	**107.3**	2.0	0.5	**243.9**	3.9	2.3	**99.1**
Knuckle	4.81	3.57	**103.9**	0.09	0.07	**104.1**	2.4	BDL	**-**	2.3	1.8	**96.2**
Rump Centre	4.62	3.57	**90.2**	0.15	0.11	**95.0**	0.7	0.8	**63.3**	3.0	2.3	**89.7**
Striploin	6.16	4.49	**100.9**	0.08	0.05	**105.1**	0.6	0.5	**93.4**	2.0	1.6	**89.3**
Tenderloin	4.27	3.51	**81.4**	0.18	0.10	**116.7**	0.9	2.0	**29.6**	3.0	2.2	**91.3**
All-cuts averages	**6.06**	**4.67**	**88.5**	**0.11**	**0.08**	**94.4**	**1.4**	**1.1**	**102.7**	**2.6**	**1.9**	**88.5**
OFFAL ITEMS:												
Heart	5.58	4.06	**77.4**	0.65	0.37	**98.0**	2.0	1.5	**75.3**	6.8	4.4	**87.7**
Kidney	13.88	9.22	**70.1**	0.56	0.41	**64.1**	6.7	6.0	**52.2**	5.7	3.8	**69.3**
Liver	4.20	3.80	**94.0**	5.73	5.30	**91.9**	4.1	4.3	**81.6**	7.2	8.4	**72.2**
Sweetbread	4.10	3.80	**94.0**	5.10	5.10	**84.5**	2.0	3.2	**52.8**	1.1	1.2	**82.3**
Tongue	5.20	4.40	**81.3**	0.16	0.12	**93.4**	1.5	1.5	**71.8**	2.5	1.8	**95.8**
Tripe uncooked	157.63	112.21	**97.5**	0.11	0.09	**78.0**	2.5	4.3	**40.8**	3.7	4.4	**58.1**
Offals averages	**31.76**	**22.92**	**85.2**	**2.05**	**1.90**	**85.0**	**3.1**	**3.4**	**62.4**	**4.5**	**4.0**	**77.6**

Table B11: Composition of the cooked (Ckd) and raw lean portion of 23 beef cuts and offal items in terms of the concentrations of magnesium, manganese, phosphorus, and potassium, together with the estimated percentage true retention (%Ret) of each item.

	Magnesium (mg/100 g)			Manganese (µg/100 g)			Phosphorus (mg/100 g)			Potassium (mg/100 g)		
Cut or offal item	**Ckd**	**Raw**	**%Ret**	**Ckd**	**Raw**	**%Ret**	**Ckd**	**Raw**	**%Ret**	**Ckd**	**Raw**	**%Ret**
FOREQUARTER ITEMS:												
Bolar Blade	19.4	22.5	**53.2**	12.0	13.4	**55.2**	165	190	**53.5**	181	325	**34.3**
Brisket Navel End	14.4	16.9	**57.7**	BDL	BDL	-	113	148	**51.5**	142	277	**34.6**
Brisket Point End	19.6	21.4	**51.5**	12.6	10.7	**66.1**	167	189	**49.7**	178	321	**31.1**
Chuck Eye Roll	19.1	20.3	**57.7**	10.4	9.1	**69.5**	157	180	**53.3**	189	315	**36.7**
Cube Roll	23.4	19.5	**83.3**	BDL	9.4	-	209	174	**83.4**	361	319	**78.6**
Manufacturing Beef	16.0	20.9	**67.4**	7.5	8.0	**82.3**	129	182	**62.3**	193	340	**49.9**
Oyster Blade	16.7	18.1	**60.5**	10.7	8.1	**87.5**	144	158	**60.0**	151	297	**33.6**
Ribs Prepared	22.4	20.4	**81.9**	7.8	5.9	**99.0**	204	184	**82.6**	363	337	**80.4**
HINDQUARTER ITEMS:												
Eye Round	24.4	21.7	**78.7**	BDL	BDL	-	222	192	**81.0**	374	352	**74.4**
Flank	18.5	19.8	**55.7**	11.0	6.0	**109.4**	141	175	**48.0**	192	331	**34.6**
Flat	17.6	19.9	**49.6**	15.9	8.3	**107.0**	159	175	**51.0**	172	291	**33.2**
Hind Shin	19.5	20.8	**60.2**	11.9	9.1	**84.2**	155	178	**55.9**	217	326	**42.7**
Inside	20.1	22.4	**52.6**	21.3	8.5	**147.3**	178	198	**52.5**	182	338	**31.4**
Knuckle	25.9	21.7	**92.3**	7.9	6.7	**90.3**	232	189	**94.8**	405	340	**92.0**
Rump Centre	28.7	21.7	**92.3**	11.7	9.6	**84.8**	254	191	**92.5**	427	343	**86.9**
Striploin	24.1	19.7	**89.9**	BDL	6.1	-	217	177	**89.9**	364	309	**86.5**
Tenderloin	30.6	24.1	**84.9**	15.2	12.1	**84.1**	259	204	**84.9**	427	362	**78.8**
All-cuts averages	**21.2**	**20.7**	**68.8**	**12.0**	**8.7**	**89.7**	**183**	**182**	**67.5**	**266**	**325**	**55.3**
OFFAL ITEMS:												
Heart	26.3	21.9	**67.5**	41.5	33.9	**68.8**	265	209	**71.3**	184	275	**37.8**
Kidney	18.1	14.7	**57.1**	154.8	108.7	**66.3**	338	234	**67.2**	144	225	**29.9**
Liver	21.0	19.3	**92.5**	328.0	299.0	**93.3**	397	362	**93.3**	336	327	**87.4**
Sweetbread	16.2	15.3	**89.5**	12.0	12.0	**84.5**	356	331	**90.9**	258	318	**68.6**
Tongue	17.1	16.3	**72.2**	13.1	13.4	**67.1**	157	150	**72.0**	189	252	**51.6**
Tripe uncooked	24.4	19.1	**88.6**	6066.0	4055.0	**103.8**	168	159	**73.3**	102	217	**32.7**
Offal averages	**20.5**	**17.8**	**77.9**	**1103.0**	**754.0**	**80.6**	**280**	**241**	**78.0**	**202**	**269**	**51.3**

Table B12: Composition of the cooked (Ckd) and raw lean portion of 23 beef cuts and offal items in terms of the concentrations of selenium, sodium, and zinc, together with the estimated percentage true retention (%Ret) of each item.

	Selenium (µg/100 g)			Sodium (mg/100 g)			Zinc (mg/100 g)		
Cut or offal item	**Ckd**	**Raw**	**%Ret**	**Ckd**	**Raw**	**%Ret**	**Ckd**	**Raw**	**%Ret**
FOREQUARTER ITEMS:									
Bolar Blade	2.4	1.4	**106.0**	33	55	**36.8**	6.4	3.6	**108.5**
Brisket Navel End	3.6	2.6	**94.4**	39	66	**40.2**	5.8	3.6	**107.0**
Brisket Point End	5.3	2.7	**111.9**	30	51	**33.1**	5.2	2.7	**109.1**
Chuck Eye Roll	2.1	1.3	**94.6**	38	56	**41.4**	7.8	4.8	**98.8**
Cube Roll	6.6	4.7	**97.4**	52	45	**79.8**	5.0	3.7	**94.9**
Manufacturing Beef	1.1	1.1	**95.0**	32	55	**51.8**	5.0	4.3	**103.2**
Oyster Blade	2.0	2.0	**65.3**	25	59	**27.9**	5.3	4.6	**75.0**
Ribs Prepared	3.5	2.9	**89.1**	58	54	**80.6**	4.9	4.0	**92.4**
HINDQUARTER ITEMS:									
Eye Round	1.8	1.1	**116.6**	43	40	**75.9**	3.9	2.8	**99.5**
Flank	5.5	3.5	**93.1**	28	47	**36.3**	6.9	4.3	**95.1**
Flat	2.2	1.5	**82.5**	30	50	**33.7**	4.5	5.4	**46.8**
Hind Shin	2.0	2.0	**64.2**	44	63	**44.8**	6.2	3.9	**102.5**
Inside	3.0	1.4	**123.7**	22	40	**32.5**	5.5	2.9	**108.7**
Knuckle	1.8	1.4	**98.5**	49	42	**90.5**	4.7	3.5	**102.4**
Rump Centre	1.9	1.5	**93.3**	55	49	**78.3**	4.1	3.5	**82.3**
Striploin	4.0	3.0	**98.1**	55	47	**85.4**	3.4	2.8	**90.8**
Tenderloin	5.7	4.3	**89.1**	45	39	**76.0**	3.3	2.3	**95.5**
All-cuts averages	**3.2**	**2.3**	**94.9**	**40**	**50**	**55.6**	**5.2**	**3.7**	**94.9**
OFFAL ITEMS:									
Heart	17.2	8.7	**111.4**	59	86	**38.9**	2.8	1.5	**103.9**
Kidney	105.2	103.3	**47.4**	123	175	**32.7**	2.6	1.5	**79.0**
Liver	16.2	16.5	**83.4**	55	53	**88.2**	3.4	3.0	**96.4**
Sweetbread	11.0	9.0	**103.3**	52	64	**68.7**	1.2	1.0	**101.4**
Tongue	3.9	2.5	**108.2**	57	73	**53.7**	4.2	2.7	**107.0**
Tripe uncooked	4.3	3.1	**94.5**	40	81	**34.6**	2.4	1.7	**96.4**
Offals averages	**26.3**	**23.9**	**91.4**	**64**	**89**	**52.8**	**2.8**	**1.9**	**97.4**

c) ***Nutrient Composition by Beef Cut or Offal Item:***

Table B13: Nutrient content of the lean portion of raw and cooked (Ckd) beef cuts including bolar blade, brisket navel-end and point-end, and chuck-eye roll.

	Bolar Blade		Brisket Navel End		Brisket Point End		Chuck Eye Roll	
Nutrient item	**Ckd**	**Raw**	**Ckd**	**Raw**	**Ckd**	**Raw**	**Ckd**	**Raw**
Water (%)	60.5	73.1	54.9	67.9	58.6	73.7	59.7	73.5
Energy (kJ/100 g)	805	537	1102	806	840	522	868	544
Protein (%)	33.5	22.1	29.3	19.7	34.5	20.9	32.1	20.5
Fat (%)	6.6	4.5	16.4	12.8	7.1	4.6	8.9	5.4
Ash (%)	1.15	0.98	0.93	0.84	0.83	0.96	0.78	0.95
Vitamin B1 (mg/100 g) (Thiamine)	0.037	0.048	0.017	0.034	0.015	0.035	0.028	0.051
Vitamin B2 (mg/100 g) (Riboflavin)	0.14	0.11	0.09	0.10	0.12	0.05	0.14	0.12
Vitamin B3 (mg/100 g) (Niacin)	2.2	3.1	2.4	3.6	3.5	4.3	2.0	2.9
Vitamin B5 (mg/100 g) (Pantothenic acid)	0.4	0.5	BDL	0.3	BDL	0.3	BDL	0.3
Vitamin B6 (mg/100 g) (Pyridoxine)	0.191	0.331	0.102	0.237	0.195	0.322	0.147	0.187
Vitamin B12 (µg/100 g) (Cyanocobalamin)	1.7	1.8	1.3	2.0	1.2	1.4	2.0	2.3
Vitamin A (µg/100 g)	13.5	6.2	16.0	12.9	12.3	8.5	12.2	8.5
Vitamin D3 (µg/100 g)	0.21	0.13	0.22	0.15	0.17	0.12	0.16	0.15
25-OH Vitamin D3 (µg/100g)	0.153	0.111	0.145	0.081	0.200	0.065	0.222	0.220
Vitamin E (mg/100 g)	0.76	0.40	0.71	0.43	0.85	0.48	0.90	0.63
Cholesterol (mg/100 g)	91.3	55.5	78.5	52.7	95.3	53.5	98.0	60.5
Calcium (mg/100 g)	5.50	3.55	6.71	4.78	6.05	3.75	5.85	4.49
Copper (mg/100 g)	0.13	0.15	0.07	0.05	0.11	0.10	0.10	0.08
Iodine (µg/100 g)	0.9	0.8	2.0	3.5	0.9	1.9	1.2	0.7
Iron (mg/100 g)	2.70	2.06	1.84	1.40	2.78	2.06	2.71	2.04
Magnesium (mg/100 g)	19.4	22.5	14.4	16.9	19.6	21.4	19.1	20.3
Manganese (µg/100 g)	12.0	13.4	BDL	BDL	12.6	10.7	10.4	9.1
Phosphorus (mg/100 g)	165	190	113	148	167	189	157	180
Potassium (mg/100 g)	181	325	142	277	178	321	189	315
Selenium (µg/100 g)	2.4	1.4	3.6	2.6	5.3	2.7	2.1	1.3
Sodium (mg/100 g)	33	55	39	66	30	51	38	56
Zinc (mg/100 g)	6.4	3.6	5.8	3.6	5.2	2.7	7.8	4.8

Table B14: Nutrient content of the lean portion of raw and cooked (Ckd) beef cuts including cube roll, manufacturing beef, oyster blade, and ribs prepared.

	Cube Roll		Manufacturing Beef		Oyster Blade		Ribs Prepared	
Nutrient item	**Ckd**	**Raw**	**Ckd**	**Raw**	**Ckd**	**Raw**	**Ckd**	**Raw**
Water (%)	56.8	69.4	73.1	73.8	62.4	71.7	61.8	71.3
Energy (kJ/100 g)	997	649	526	492	815	647	819	610
Protein (%)	30.1	19.8	24.2	21.2	29.9	21.8	27.2	21.3
Fat (%)	13.2	8.5	3.3	3.7	8.5	7.6	9.7	6.8
Ash (%)	1.07	0.91	0.63	1.02	0.63	0.90	1.12	0.94
Vitamin B1 (mg/100 g) (Thiamine)	0.067	0.071	0.042	0.055	0.023	0.054	0.026	0.030
Vitamin B2 (mg/100 g) (Riboflavin)	0.15	0.08	0.10	0.11	0.15	0.12	0.12	0.09
Vitamin B3 (mg/100 g) (Niacin)	4.2	3.3	1.8	2.9	1.6	2.4	5.1	4.3
Vitamin B5 (mg/100 g) (Pantothenic acid)	0.4	0.3	0.3	0.5	BDL	0.9	0.4	0.3
Vitamin B6 (mg/100 g) (Pyridoxine)	0.305	0.280	0.160	0.194	0.099	0.156	0.266	0.255
Vitamin B12 (µg/100 g) (Cyanocobalamin)	1.4	1.5	1.0	1.4	1.9	2.3	1.1	1.2
Vitamin A (µg/100 g)	12.4	16.8	8.2	9.6	10.5	12.2	8.8	7.8
Vitamin D3 (µg/100 g)	0.38	0.19	0.13	0.13	0.24	0.18	0.31	0.18
25-OH Vitamin D3 (µg/100g)	0.156	0.132	0.141	0.175	0.215	0.195	0.200	0.146
Vitamin E (mg/100 g)	0.40	0.39	0.57	0.49	0.76	0.38	0.93	0.74
Cholesterol (mg/100 g)	93.8	59.2	67.4	49.2	86.9	55.9	68.8	56.5
Calcium (mg/100 g)	4.56	3.45	6.19	5.75	4.71	3.77	17.65	15.20
Copper (mg/100 g)	0.07	0.06	0.11	0.07	0.09	0.06	0.06	0.05
Iodine (µg/100 g)	1.3	BDL	1.4	0.6	0.6	0.8	2.4	1.1
Iron (mg/100 g)	2.4	2.1	1.8	2.0	2.8	2.0	2.2	1.8
Magnesium (mg/100 g)	23.4	19.5	16.0	20.9	16.7	18.1	22.4	20.4
Manganese (µg/100 g)	BDL	9.4	7.5	8.0	10.7	8.1	7.8	5.9
Phosphorus (mg/100 g)	209	174	129	182	144	158	204	184
Potassium (mg/100 g)	361	319	193	340	151	297	363	337
Selenium (µg/100 g)	6.6	4.7	1.1	1.1	2.0	2.0	3.5	2.9
Sodium (mg/100 g)	52	45	32	55	25	59	58	54
Zinc (mg/100 g)	5.0	3.7	5.0	4.3	5.3	4.6	4.9	4.0

Table B15: Nutrient content of the lean portion of raw and cooked (Ckd) beef cuts including eye round, flank flat and hind shin.

	Eye Round		Flank		Flat		Hind Shin	
Nutrient item	**Ckd**	**Raw**	**Ckd**	**Raw**	**Ckd**	**Raw**	**Ckd**	**Raw**
Water (%)	65.4	74.1	61.5	73.6	56.4	70.8	64.4	74.6
Energy (kJ/100 g)	682	462	810	592	940	643	695	475
Protein (%)	29.7	20.2	30.7	20.5	33.2	21.3	31.2	21.5
Fat (%)	5.0	3.4	7.9	6.7	10.3	7.7	4.6	3.1
Ash (%)	1.15	1.02	0.67	0.96	1.06	0.92	1.62	0.99
Vitamin B1 (mg/100 g) (Thiamine)	0.041	0.037	0.021	0.032	0.024	0.045	0.019	0.036
Vitamin B2 (mg/100 g) (Riboflavin)	0.11	0.07	0.09	0.08	0.19	0.14	0.12	0.12
Vitamin B3 (mg/100 g) (Niacin)	4.0	3.5	3.5	4.7	2.3	3.3	2.7	3.3
Vitamin B5 (mg/100 g) (Pantothenic acid)	0.4	0.3	0.1	0.1	0.2	0.3	0.2	0.5
Vitamin B6 (mg/100 g) (Pyridoxine)	0.337	0.329	0.120	0.205	0.171	0.276	0.144	0.259
Vitamin B12 (µg/100 g) (Cyanocobalamin)	1.3	1.1	1.4	1.6	1.9	2.9	1.3	1.5
Vitamin A (µg/100 g)	7.2	7.1	11.3	7.8	14.8	10.9	8.0	6.3
Vitamin D3 (µg/100 g)	0.13	0.09	0.28	0.14	BDL	BDL	0.18	BDL
25-OH Vitamin D3 (µg/100g)	0.103	0.076	0.179	0.140	0.192	0.116	0.191	0.164
Vitamin E (mg/100 g)	0.60	0.46	0.95	0.34	1.16	0.52	0.74	0.43
Cholesterol (mg/100 g)	66.6	47.4	77.9	48.9	93.9	55.3	88.9	55.6
Calcium (mg/100 g)	4.19	3.44	5.06	3.66	5.73	4.93	6.48	3.96
Copper (mg/100 g)	0.06	0.05	0.07	0.05	0.19	0.12	0.11	0.07
Iodine (µg/100 g)	1.6	BDL	1.2	1.3	2.9	0.8	0.8	0.5
Iron (mg/100 g)	1.9	1.4	2.4	1.6	3.2	1.9	2.7	2.0
Magnesium (mg/100 g)	24.4	21.7	18.5	19.8	17.6	19.9	19.5	20.8
Manganese (µg/100 g)	BDL	BDL	11.0	6.0	15.9	8.3	11.9	9.1
Phosphorus (mg/100 g)	222	192	141	175	159	175	155	178
Potassium (mg/100 g)	374	352	192	331	172	291	217	326
Selenium (µg/100 g)	1.8	1.1	5.5	3.5	2.2	1.5	2.0	2.0
Sodium (mg/100 g)	43	40	28	47	30	50	44	63
Zinc (mg/100 g)	3.9	2.8	6.9	4.3	4.5	5.4	6.2	3.9

Table B16: Nutrient content of the lean portion of raw and cooked (Ckd) beef cuts including inside, knuckle, rump centre, and striploin.

	Inside		Knuckle		Rump Centre		Striploin	
Nutrient item	**Ckd**	**Raw**	**Ckd**	**Raw**	**Ckd**	**Raw**	**Ckd**	**Raw**
Water (%)	57.8	72.4	64.7	72.3	61.8	72.2	59.6	70.4
Energy (kJ/100 g)	851	533	743	567	783	589	903	611
Protein (%)	34.5	22.2	27.5	21.9	30.2	21.7	28.5	20.9
Fat (%)	7.3	4.4	7.6	5.4	7.5	6.1	11.4	7.0
Ash (%)	0.79	1.03	1.25	1.02	1.38	0.97	1.09	0.91
Vitamin B1 (mg/100 g) (Thiamine)	0.029	0.058	0.058	0.042	0.081	0.066	0.053	0.048
Vitamin B2 (mg/100 g) (Riboflavin)	0.12	0.07	0.09	0.07	0.20	0.12	0.09	0.09
Vitamin B3 (mg/100 g) (Niacin)	3.0	4.0	3.2	2.7	3.9	2.7	4.8	4.2
Vitamin B5 (mg/100 g) (Pantothenic acid)	0.4	0.3	0.4	0.3	0.8	0.6	0.4	0.3
Vitamin B6 (mg/100 g) (Pyridoxine)	0.248	0.367	0.319	0.286	0.276	0.276	0.323	0.316
Vitamin B12 (µg/100 g) (Cyanocobalamin)	1.5	1.6	1.9	1.6	2.2	2.1	0.9	0.7
Vitamin A (µg/100 g)	13	8	13	9	12	7	19	12
Vitamin D3 (µg/100 g)	0.25	0.28	0.10	0.08	0.17	0.09	0.33	0.19
25-OH Vitamin D3 (µg/100g)	0.177	0.126	0.161	0.127	0.113	0.097	0.156	0.134
Vitamin E (mg/100 g)	0.42	0.20	0.38	0.53	0.56	0.32	0.53	0.35
Cholesterol (mg/100 g)	91.2	55.2	76.1	56.2	78.1	54.9	70.2	53.9
Calcium (mg/100 g)	4.52	3.61	4.81	3.57	4.62	3.57	6.16	4.49
Copper (mg/100 g)	0.14	0.08	0.09	0.07	0.15	0.11	0.08	0.05
Iodine (µg/100 g)	2.0	0.5	2.4	BDL	0.7	0.8	0.6	0.5
Iron (mg/100 g)	3.85	2.27	2.25	1.81	2.96	2.30	1.96	1.61
Magnesium (mg/100 g)	20.1	22.4	25.9	21.7	28.7	21.7	24.1	19.7
Manganese (µg/100 g)	21.3	8.5	7.9	6.7	11.7	9.6	BDL	6.1
Phosphorus (mg/100 g)	178	198	232	189	254	191	217	177
Potassium (mg/100 g)	182	338	405	340	427	343	364	309
Selenium (µg/100 g)	3.0	1.4	1.8	1.4	1.9	1.5	4.0	3.0
Sodium (mg/100 g)	22	40	49	42	55	49	55	47
Zinc (mg/100 g)	5.5	2.9	4.7	3.5	4.1	3.5	3.4	2.8

Table B17: Nutrient content of the lean portion of raw and cooked (Ckd) beef tenderloin and beef offal items heart, kidney, and liver.

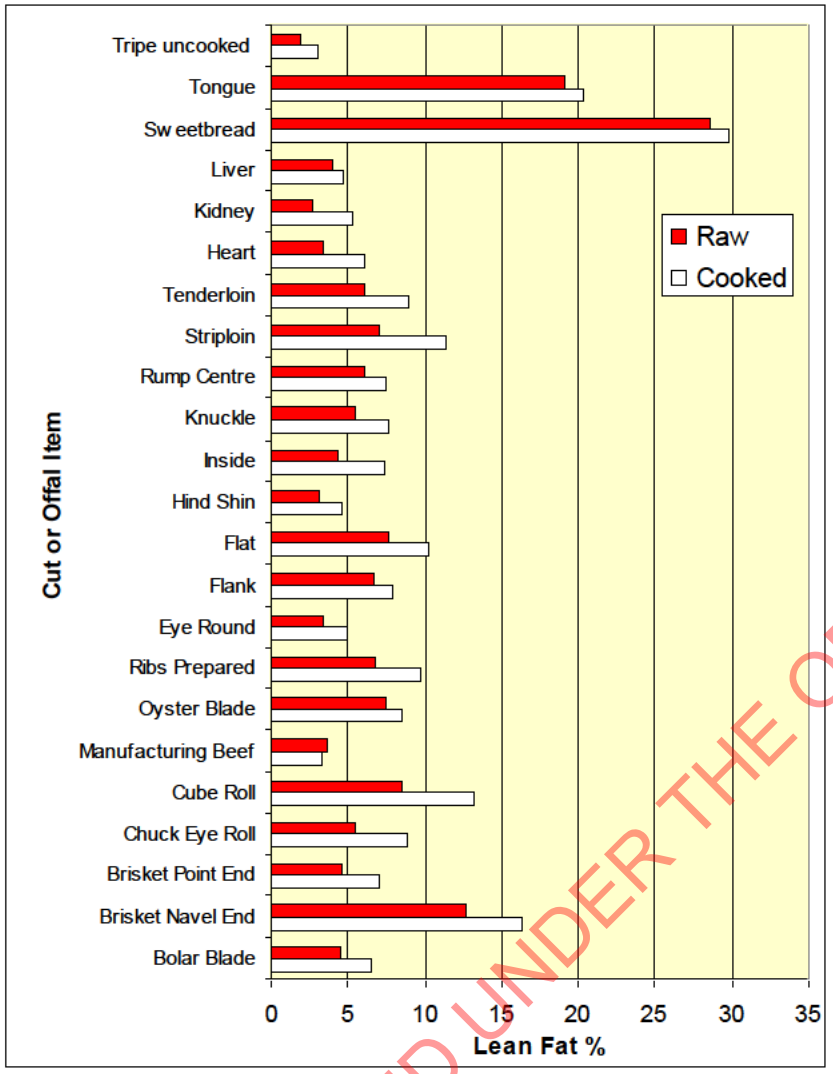
	Tenderloin		Heart		Kidney		Liver	
Nutrient item	**Ckd**	**Raw**	**Ckd**	**Raw**	**Ckd**	**Raw**	**Ckd**	**Raw**
Water (%)	59.7	71.8	62.3	78.1	66.4	80.5	66.4	70.4
Energy (kJ/100 g)	827	582	747	436	653	361	564	494
Protein (%)	29.4	21.2	31.3	18.5	27.3	15.7	23.3	20.5
Fat (%)	9.0	6.1	6.0	3.4	5.3	2.6	4.7	4.1
Ash (%)	1.66	1.05	1.04	1.02	1.55	1.15	1.80	1.46
Vitamin B1 (mg/100 g) (Thiamine)	0.058	0.054	0.237	0.252	0.403	0.559	0.376	0.371
Vitamin B2 (mg/100 g) (Riboflavin)	0.21	0.12	0.98	0.68	2.95	2.12	3.04	2.35
Vitamin B3 (mg/100 g) (Niacin)	5.0	4.1	3.4	4.4	3.9	4.9	13.8	15.4
Vitamin B5 (mg/100 g) (Pantothenic acid)	0.8	0.6	1.2	1.8	3.1	4.0	9.8	10.3
Vitamin B6 (mg/100 g) (Pyridoxine)	0.230	0.267	0.122	0.160	0.254	0.316	0.452	0.428
Vitamin B12 (µg/100 g) (Cyanocobalamin)	2.0	1.8	6.7	10.8	21.3	27.7	96.0	84.5
Vitamin A (µg/100 g)	12.6	9.2	14.1	10.3	104.2	89.1	21014	28319
Vitamin D3 (µg/100 g)	0.20	0.10	0.17	0.15	0.83	0.15	0.11	0.03
25-OH Vitamin D3 (µg/100g)	0.166	0.124	0.357	0.270	0.284	0.321	0.149	0.174
Vitamin E (mg/100 g)	0.81	0.60	2.09	1.22	1.53	0.82	1.28	1.84
Cholesterol (mg/100 g)	80.8	58.4	200.7	123.7	1002	404.2	242.5	254.1
Calcium (mg/100 g)	4.27	3.51	5.58	4.06	13.88	9.22	4.20	3.80
Copper (mg/100 g)	0.18	0.10	0.65	0.37	0.56	0.41	5.73	5.30
Iodine (µg/100 g)	0.9	2.0	2.0	1.5	6.7	6.0	4.1	4.3
Iron (mg/100 g)	3.01	2.21	6.81	4.38	5.70	3.83	7.17	8.44
Magnesium (mg/100 g)	30.6	24.1	26.3	21.9	18.1	14.7	21.0	19.3
Manganese (µg/100 g)	15.2	12.1	41.5	33.9	154.8	108.7	328.0	299.0
Phosphorus (mg/100 g)	259	204	265	209	338	234	397	362
Potassium (mg/100 g)	427	362	184	275	144	225	336	327
Selenium (µg/100 g)	5.7	4.3	17.2	8.7	105.2	103.3	16.2	16.5
Sodium (mg/100 g)	45	39	59	86	123	175	55	53
Zinc (mg/100 g)	3.3	2.3	2.8	1.5	2.6	1.5	3.4	3.0

Table B18: Nutrient content of the lean portion of raw and cooked (Ckd) beef offal items including sweetbread, tongue, and tripe uncooked.

	Sweetbread		Tongue		Tripe uncooked	
Nutrient item	**Ckd**	**Raw**	**Ckd**	**Raw**	**Ckd**	**Raw**
Water (%)	56.3	57.7	57.0	65.2	77.7	82.2
Energy (kJ/100 g)	1324	1262	1067	1011	429	322
Protein (%)	12.5	11.5	18.3	17.8	19.0	14.9
Fat (%)	29.8	28.6	20.3	19.1	3.0	2.0
Ash (%)	1.91	2.36	0.72	0.80	0.89	1.10
Vitamin B1 (mg/100 g) (Thiamine)	0.077	0.087	0.059	0.065	0.022	0.051
Vitamin B2 (mg/100 g) (Riboflavin)	0.11	0.12	0.23	0.21	0.10	0.19
Vitamin B3 (mg/100 g) (Niacin)	1.6	2.0	2.6	3.0	2.6	7.9
Vitamin B5 (mg/100 g) (Pantothenic acid)	0.5	0.6	0.7	0.4	0.2	0.7
Vitamin B6 (mg/100 g) (Pyridoxine)	0.041	0.041	0.072	0.094	0.013	0.035
Vitamin B12 (µg/100 g) (Cyanocobalamin)	1.5	2.1	3.9	5.2	2.3	7.1
Vitamin A (µg/100 g)	18.7	19.4	12.5	12.0	5.9	6.1
Vitamin D3 (µg/100 g)	0.56	0.62	0.34	0.35	0.26	0.20
25-OH Vitamin D3 (µg/100g)	0.119	0.100	0.241	0.256	0.085	0.282
Vitamin E (mg/100 g)	0.79	0.69	0.95	0.95	0.51	0.45
Cholesterol (mg/100 g)	248.7	216.7	104.9	80.5	198.9	117.4
Calcium (mg/100 g)	4.10	3.80	5.20	4.40	157.63	112.21
Copper (mg/100 g)	5.10	5.10	0.16	0.12	0.11	0.09
Iodine (µg/100 g)	2.0	3.2	1.5	1.5	2.5	4.3
Iron (mg/100 g)	1.12	1.15	2.52	1.81	3.72	4.44
Magnesium (mg/100 g)	16.2	15.3	17.1	16.3	24.4	19.1
Manganese (µg/100 g)	12.0	12.0	13.1	13.4	6066.0	4055.0
Phosphorus (mg/100 g)	356	331	157	150	168	159
Potassium (mg/100 g)	258	318	189	252	102	217
Selenium (µg/100 g)	11.0	9.0	3.9	2.5	4.3	3.1
Sodium (mg/100 g)	52	64	57	73	40	81
Zinc (mg/100 g)	1.2	1.0	4.2	2.7	2.4	1.7

Figures B2, B3, B4, and B5 on the following four pages show selected examples of the data from Sections b) and c) as bar graphs. No error bars can be shown with these bars because the values are for a single composite sample in each case.

Figure B2: Levels of fat and cholesterol in the lean portions of 23 beef cut and offal items



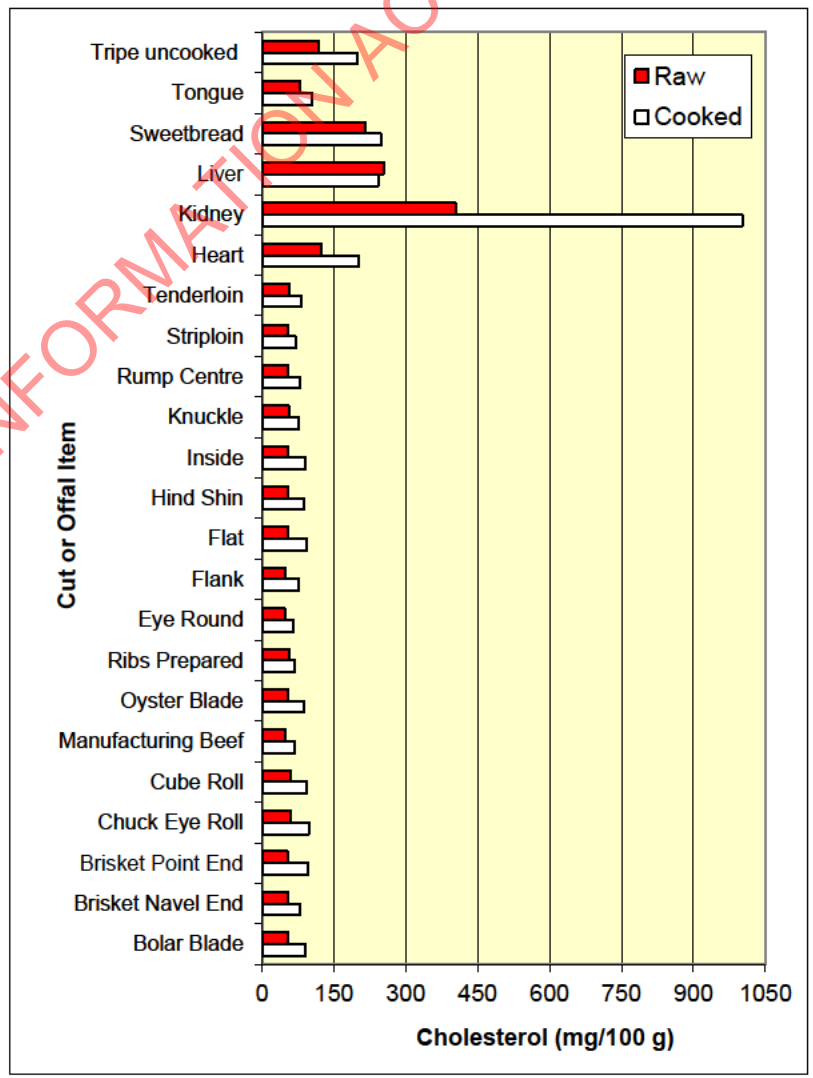
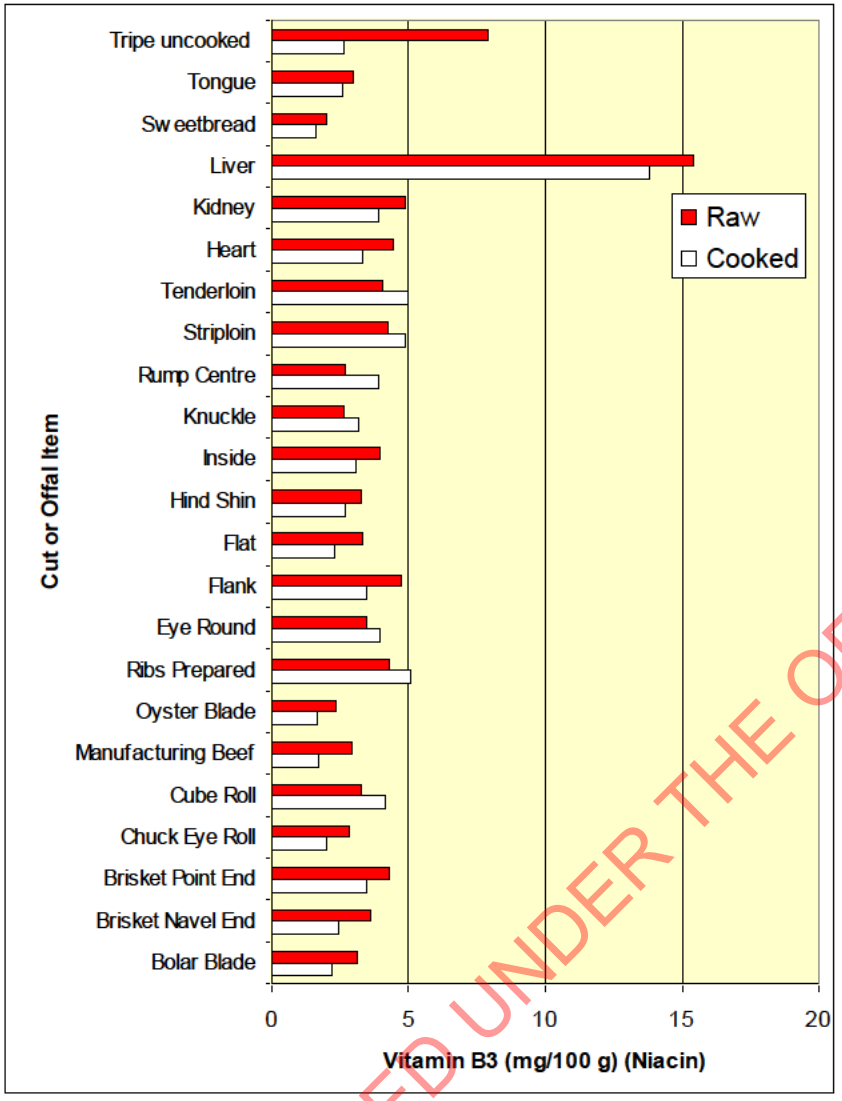


Figure B3: Levels of vitamin B3 (Niacin) and vitamin E in the lean portion of 23 beef cut and offal items.



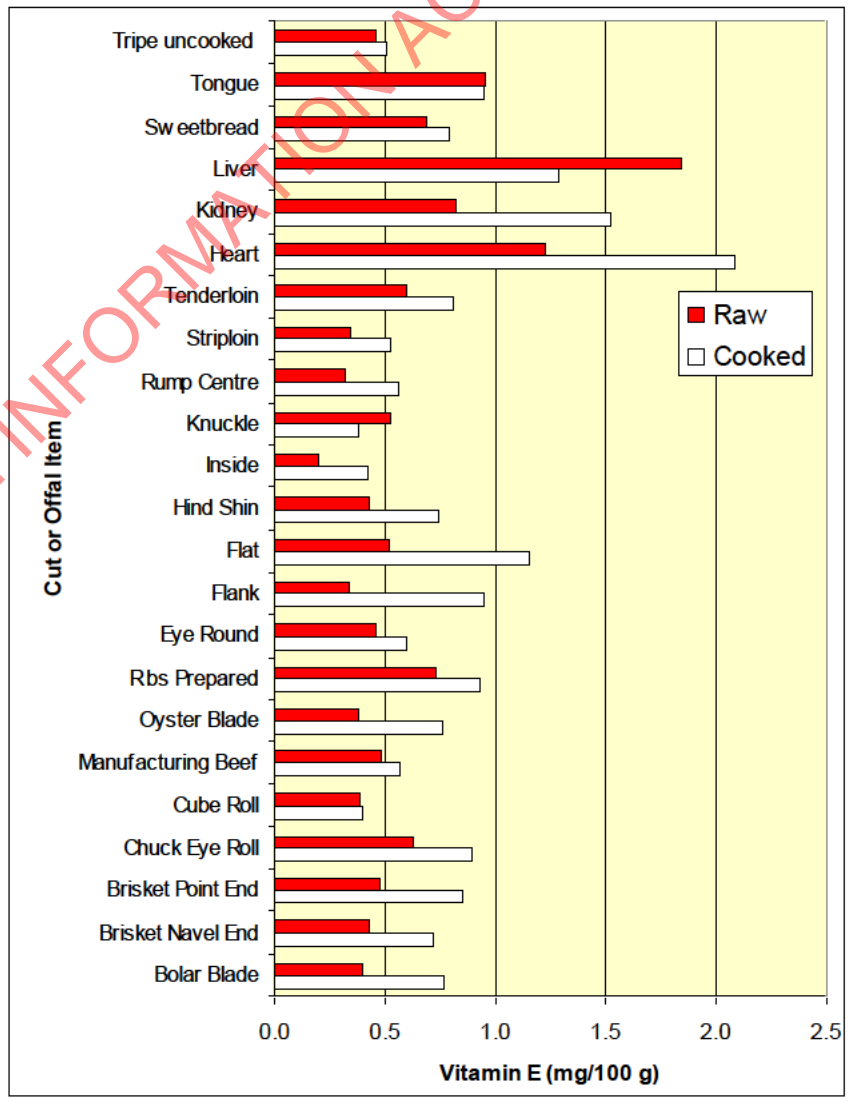
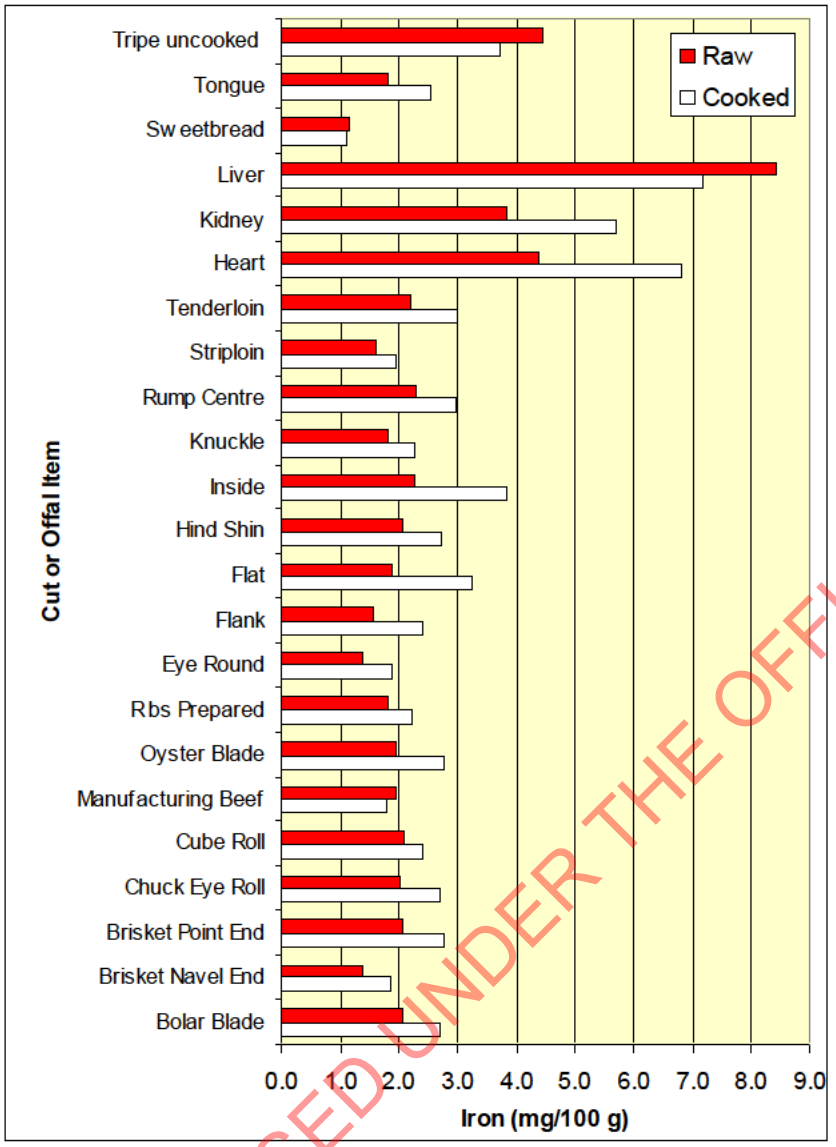


Figure B4: Levels of iron and zinc in the lean portion of 23 beef cut and offal items.



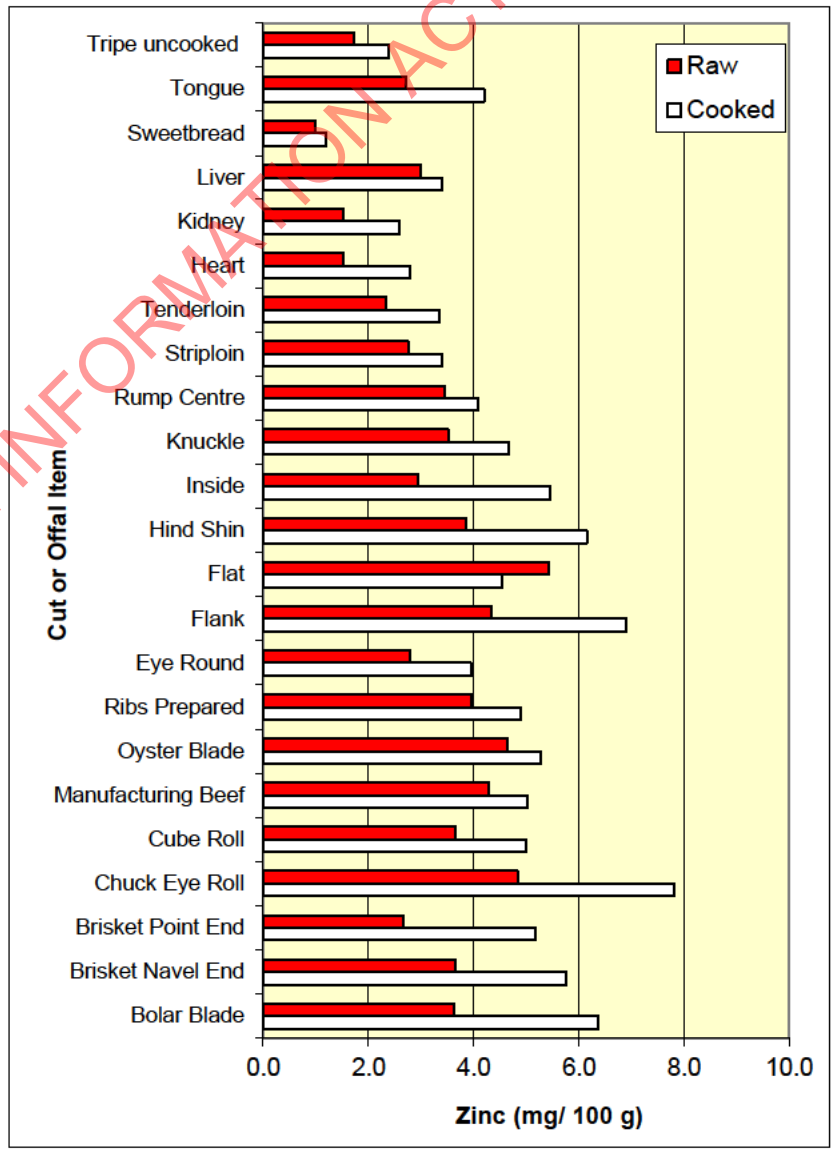
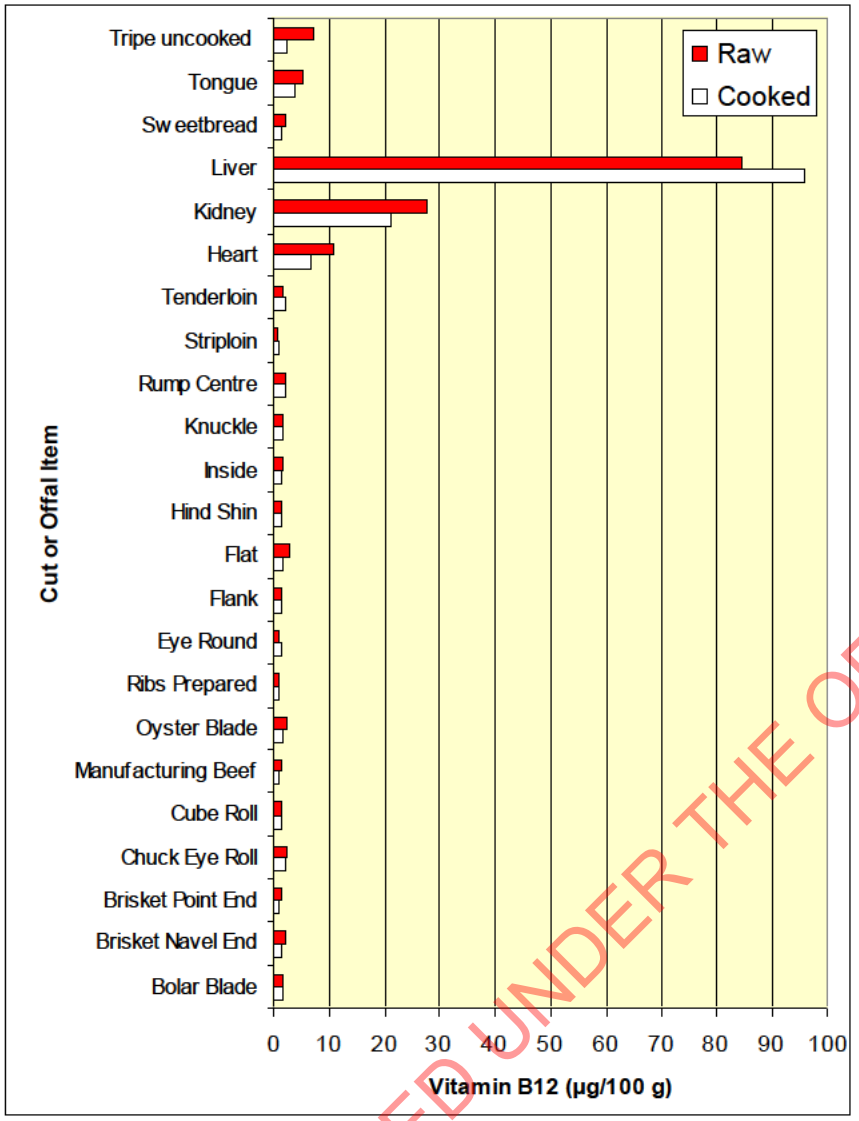
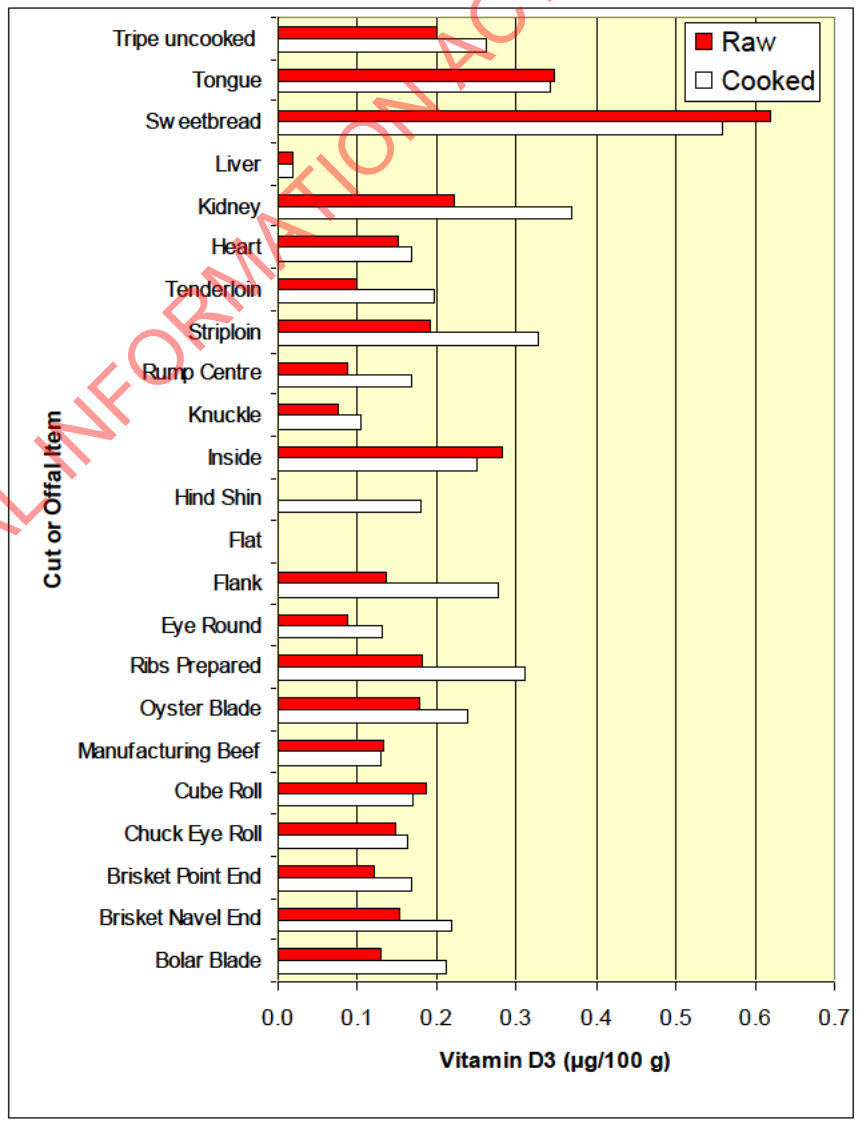


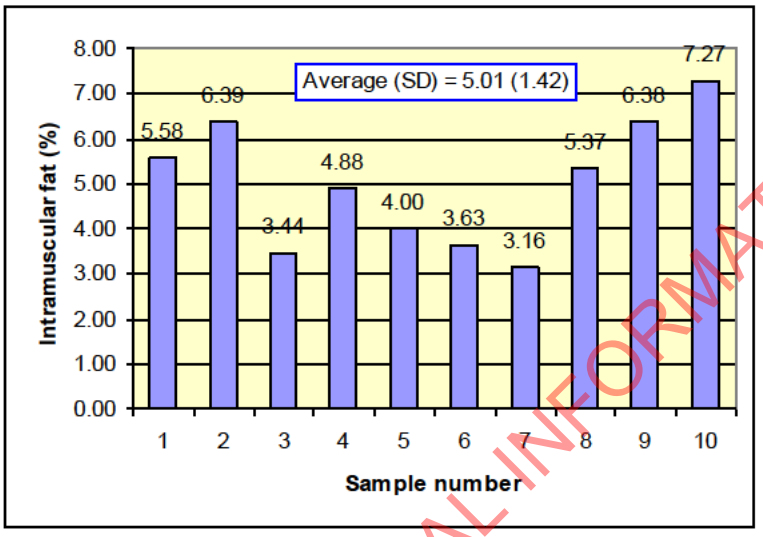
Figure B5: Levels of vitamin B12 and vitamin D3 in the lean portion of 23 beef cut and offal items.





d) ***Variability Within Beef Striploin Intramuscular Fat:*** All the results presented in Tables B6 to B18 and in Figures B2 to B5 are those obtained on composite samples as explained in Figure B1, so that no measures are given of how the composition varied between the 8 to 10 individual samples that contributed to the composite samples analysed. In order to provide an indication of the sort of variation that might be expected, internal samples of the longissimus muscle from each of the 10 striploin samples were analysed for fat content only. The results shown in Figure B6 indicate quite a wide variation with a coefficient of variation of 28.3%.

Figure B6: Variation in the intramuscular fat concentrations in 10 samples from within the longissimus muscle of 10 beef striploin cuts.



This variation between animals in intramuscular fat within one muscle provides some indication of the likely variation within other muscles and also of the possible variation in concentrations of nutrients other than fat. Fat is likely to be one of the more variable components within meat, but the more than two-fold range in intramuscular fat% shown in Figure B6 will influence the concentration of other nutrients in muscle if the concentration of a nutrient is appreciably higher in muscle than in intramuscular fat (i.e. the fat will have a diluting effect).

The mean level of intramuscular fat of 5.01% shown in Figure B6 is lower than the value for striploin raw lean tissue of 7.00% shown in Table B6 because the former value refers to an internal muscle sample that would not include any of the small remnants of subcutaneous fat or intermuscular fat that would remain on the surface of the muscles following dissection with a knife and designated here as lean muscle tissue.

e) ***Fatty-Acid Composition of Beef Intramuscular Fat:*** Table B19, which extends over the following five pages, gives the fatty acid composition of the lean portion of 23 raw or cooked beef cuts and beef offal items expressed as a percentage of the sum of all fatty acids. The amount of any fatty acid relative to product weight can be calculated from the percentages given and the total FAs (g/100 g) given at the bottom of each column in Table B19. The separate part at the bottom of each column in Table B19 and also Tables B20 and B21 give characteristics that combine a number of the fatty acids in various ways. Explanations of some of the abbreviations used in Table B19, B20 and B21 are as follows:

SFA	Saturated fatty acids
MUFA	Monounsaturated fatty acids
PUFA	Polyunsaturated fatty acids
P/S	Ratio of PUFA to SFA
n-6/n-3	Ratio of n-3 to n-6 polyunsaturated fatty acids (= omega-3 to omega 6 PUFA)
LCN3FA	Long-chain n-3 fatty acids (C20:3n3 + EPA + DPA + DHA)
Total FAs (g/100 g)	The sum of weights of all fatty acids relative to raw or cooked (Ckd) weight.
EPA, DPA, & DHA	Eicosapentaenoic acid, docosapentaenoic acid, & docosahexaenoic acid

Table B19: Fatty acid composition of the cooked (Ckd) and raw lean portions of beef cuts and offal items expressed as a percentage of total fatty acids (ND = not detectable).

Fatty acid (% of total fatty acids except for Total FAs and the ratios)	Bolar Blade		Brisket NE		Brisket PE		Chuck Eye Roll		Cube Roll	
	Ckd	Raw	Ckd	Raw	Ckd	Raw	Ckd	Raw	Ckd	Raw
C8:0 Caprylic	ND	ND	ND	ND	ND	ND	0.01	ND	ND	ND
C10:0 Capric	0.07	0.05	0.05	0.07	0.08	0.06	0.04	0.06	0.08	0.07
C11:0 Undecanoic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C12:0 Lauric	0.05	0.06	0.14	0.07	0.06	0.07	0.05	0.05	0.06	0.06
C13:0 Tridecanoic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C14:0 Myristic	1.99	2.02	3.02	3.03	2.46	2.34	2.15	2.09	3.02	2.88
C14:1n5 c9 Myristoleic	0.73	0.72	1.36	1.39	1.09	0.91	0.57	0.57	0.66	0.59
C15:1n5 c10 Pentadecenoic	0.08	0.09	ND	ND	0.08	0.08	0.05	0.06	0.03	0.02
C16:0 Palmitic	23.80	23.67	25.03	25.86	23.62	23.32	24.12	23.62	26.47	26.36
C16:1n7 t9 Palmitelaidic	0.40	0.39	0.47	0.42	0.40	0.44	0.45	0.44	0.49	0.50
C16:1n7 c9 Palmitoleic	4.04	4.05	5.46	5.56	5.44	5.13	3.29	3.36	3.07	2.88
C17:0 Margaric	1.31	1.33	1.49	1.37	1.37	1.35	1.52	1.49	1.51	1.64
C17:1n7 c10 Heptadecenoic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C18:0 Stearic	13.44	13.73	12.46	11.82	11.39	11.79	16.60	16.22	19.28	21.16
C18:1n9 t9 Elaidic	0.25	0.23	0.26	0.29	0.24	0.25	0.29	0.28	0.29	0.28
C18:1n7 t11 Vaccenic	0.84	0.83	1.44	1.62	1.10	1.08	1.07	1.07	1.93	2.15
C18:1n9 c9 Oleic	43.49	43.36	42.85	42.38	42.16	44.23	41.91	42.59	37.39	36.10
C18:1n7 c11 Vaccenic	1.35	1.28	1.46	1.48	1.65	1.60	1.16	1.14	0.75	0.68
C18:2n6 t Linolelaidic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C18:2n6 c Linoleic	2.40	2.33	1.25	1.28	2.47	2.02	1.99	2.04	1.14	1.10
C20:0 Arachidic	0.09	0.07	0.06	0.09	0.09	0.09	0.12	0.11	0.13	0.14
C18:3n6 c Gamma linolenic	0.05	0.06	ND	ND	0.08	0.06	0.04	0.06	0.04	0.06
C20:1n9 c11 Eicosenoic	0.17	0.18	0.17	0.20	0.27	0.27	0.20	0.19	0.12	0.12
C18:3n3 c Alpha linolenic	1.31	1.35	0.76	0.74	1.29	1.11	1.16	1.20	0.94	0.94
CLA C18:2-c9,t11	0.56	0.55	0.89	1.14	0.83	0.76	0.54	0.60	0.69	0.43
CLA C18:2-t10,c12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C21:0 Heneicosanoic	0.32	0.41	0.55	0.59	0.65	0.60	0.38	0.38	0.49	0.51
C20:2n6 c Eicosadienoic	0.09	0.06	ND	ND	0.06	0.05	0.05	0.06	0.04	0.03
C22:0 Behenic	0.06	0.04	ND	ND	0.05	0.03	0.03	0.03	0.04	0.05
C20:3n6 c Eicosatrienoic	0.28	0.25	0.11	0.08	0.27	0.21	0.20	0.21	0.11	0.10
C22:1n9 c13 Erucic	0.03	ND	ND	ND	ND	ND	ND	ND	ND	ND
C20:3n3 c Eicosatrienoic	0.05	0.06	ND	ND	0.05	0.05	0.03	0.05	0.04	0.04
C20:4n6 c Arachidonic	0.91	0.93	0.22	0.15	1.01	0.75	0.62	0.67	0.30	0.28
C23:0 Tricosanoic	0.04	0.03	ND	ND	0.04	0.03	0.03	0.03	0.03	0.03
C22:2n6 c Docosadienoic	0.21	0.19	0.11	0.09	0.19	0.16	0.16	0.16	0.11	0.11
C20:5n3 c EPA	0.62	0.62	0.12	0.10	0.55	0.40	0.43	0.43	0.22	0.20
C24:0 Lignoceric	0.04	0.04	ND	ND	0.04	0.03	0.04	0.03	0.03	0.02
C24:1n9 c15 Nervonic	ND	0.04	ND	ND	0.05	0.05	ND	ND	0.05	0.04
C22:5n3 c DPA	0.79	0.89	0.27	0.18	0.81	0.66	0.60	0.65	0.41	0.39
C22:6n3 c DHA	0.13	0.10	ND	ND	0.06	0.04	0.08	0.06	0.03	0.03
SFA	41.21	41.45	42.79	42.91	39.84	39.71	45.1	44.12	51.16	52.92
MUFA	51.38	51.17	53.47	53.34	52.48	54.01	48.98	49.69	44.78	43.37
PUFA	7.41	7.38	3.74	3.75	7.68	6.28	5.92	6.19	4.07	3.71
P/S ratio	0.18	0.18	0.09	0.09	0.19	0.16	0.13	0.14	0.08	0.07
n-6/n-3 ratio	1.36	1.27	1.47	1.56	1.48	1.43	1.33	1.33	1.06	1.05
LCN3FA	1.59	1.67	0.39	0.28	1.47	1.16	1.14	1.19	0.70	0.66
Total FAs (g/100 g)	4.60	3.28	13.11	10.28	5.67	4.22	6.48	4.02	8.93	7.04

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Fatty acid (% of total fatty acids except for Total FAs and the ratios)	Manufacturing Beef		Oyster Blade		Ribs Prepared		Eye Round		Flank	
	Ckd	Raw	Ckd	Raw	Ckd	Raw	Ckd	Raw	Ckd	Raw
C8:0 Caprylic	ND	ND	ND	0.16	ND	ND	ND	ND	ND	ND
C10:0 Capric	0.03	0.02	0.07	0.07	0.10	0.07	0.07	0.03	0.07	0.06
C11:0 Undecanoic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C12:0 Lauric	0.03	0.04	0.07	0.08	0.07	0.07	0.04	0.05	0.07	0.07
C13:0 Tridecanoic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C14:0 Myristic	2.27	2.54	2.49	2.53	2.78	2.69	2.26	2.10	2.90	2.97
C14:1n5 c9 Myristoleic	0.35	0.37	0.67	0.61	0.51	0.59	0.80	0.87	0.65	0.73
C15:1n5 c10 Pentadecenoic	0.18	0.08	0.05	ND	0.04	0.05	0.17	0.14	0.06	0.05
C16:0 Palmitic	22.21	23.36	24.70	25.02	27.31	26.85	25.99	25.48	27.29	28.32
C16:1n7 t9 Palmitelaidic	0.60	0.62	0.47	ND	0.55	0.55	0.48	0.50	0.45	0.45
C16:1n7 c9 Palmitoleic	2.25	2.26	3.28	3.66	2.83	3.20	4.08	4.14	3.48	3.47
C17:0 Margaric	1.80	1.91	1.66	1.61	1.87	1.78	1.54	1.39	1.57	1.62
C17:1n7 c10 Heptadecenoic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C18:0 Stearic	23.16	24.80	17.09	17.45	20.09	17.90	13.06	12.41	16.50	16.50
C18:1n9 t9 Elaidic	0.38	0.43	0.27	0.23	0.24	0.25	0.25	0.24	0.27	0.27
C18:1n7 t11 Vaccenic	2.40	2.62	1.11	1.20	1.88	1.68	1.64	1.36	1.26	1.38
C18:1n9 c9 Oleic	31.41	31.80	40.76	41.22	36.55	38.61	39.99	39.38	38.73	38.53
C18:1n7 c11 Vaccenic	1.04	0.86	1.01	1.07	0.76	0.91	1.23	1.26	0.93	0.84
C18:2n6 t Linolelaidic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C18:2n6 c Linoleic	3.97	2.69	1.82	1.65	1.14	1.23	2.29	2.93	1.67	1.29
C20:0 Arachidic	0.18	0.21	0.11	0.10	0.16	0.13	0.10	0.08	0.13	0.14
C18:3n6 c Gamma linolenic	0.04	0.05	0.05	ND	0.05	0.04	0.07	0.09	0.05	0.04
C20:1n9 c11 Eicosenoic	0.16	0.13	0.17	0.11	0.13	0.15	0.15	0.16	0.16	0.14
C18:3n3 c Alpha linolenic	2.69	1.96	1.17	1.07	0.73	0.79	1.35	1.64	0.98	0.81
CLA C18:2-c9,t11	0.69	0.61	0.52	0.63	0.44	0.52	0.80	0.95	0.34	0.43
CLA C18:2-t10,c12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C21:0 Heneicosanoic	0.58	0.53	0.39	ND	0.46	0.50	0.74	0.73	0.38	0.43
C20:2n6 c Eicosadienoic	0.07	0.06	0.05	ND	0.04	0.05	0.05	0.05	0.04	0.05
C22:0 Behenic	0.11	0.06	0.04	ND	0.07	0.04	0.15	0.14	0.06	0.06
C20:3n6 c Eicosatrienoic	0.25	0.12	0.20	0.16	0.13	0.15	0.26	0.39	0.21	0.16
C22:1n9 c13 Erucic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C20:3n3 c Eicosatrienoic	0.06	0.08	0.06	ND	0.03	0.03	0.05	0.05	0.03	0.03
C20:4n6 c Arachidonic	1.04	0.60	0.55	0.40	0.30	0.36	0.80	1.26	0.59	0.37
C23:0 Tricosanoic	0.08	0.05	0.04	ND	0.03	0.04	0.04	0.05	0.03	0.02
C22:2n6 c Docosadienoic	0.22	0.15	0.16	ND	0.12	0.13	0.25	0.32	0.19	0.15
C20:5n3 c EPA	0.76	0.42	0.33	0.29	0.16	0.21	0.50	0.80	0.30	0.20
C24:0 Lignoceric	0.08	0.05	0.03	ND	0.03	0.03	0.03	ND	0.04	0.03
C24:1n9 c15 Nervonic	0.03	ND	0.01	ND	0.05	0.05	ND	ND	0.07	0.04
C22:5n3 c DPA	0.83	0.47	0.55	0.44	0.28	0.33	0.71	0.92	0.44	0.34
C22:6n3 c DHA	0.05	0.05	0.06	0.23	0.02	0.04	0.06	0.06	0.05	0.03

SFA	50.55	53.57	46.69	47.02	52.98	50.09	44.02	42.47	49.04	50.21
MUFA	38.78	39.17	47.8	48.1	43.56	46.04	48.79	48.06	46.06	45.9
PUFA	10.67	7.27	5.51	4.88	3.46	3.87	7.19	9.47	4.90	3.88
P/S ratio	0.21	0.14	0.12	0.10	0.07	0.08	0.16	0.22	0.10	0.08
n-6/n-3 ratio	1.27	1.23	1.29	1.09	1.45	1.40	1.39	1.45	1.53	1.47
LCN3FA	1.70	1.03	1.00	0.96	0.56	0.60	1.32	1.84	0.83	0.59
Total FAs (g/100 g)	2.31	3.11	6.32	5.51	6.83	4.95	3.75	2.10	5.88	4.62

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Fatty acid (% of total fatty acids except for Total FAs and the ratios)	Flat		Hind Shin		Inside		Knuckle		Rump Centre	
	Ckd	Raw	Ckd	Raw	Ckd	Raw	Ckd	Raw	Ckd	Raw
C8:0 Caprylic	ND	ND	ND	0.17	ND	ND	0.01	ND	ND	ND
C10:0 Capric	0.05	0.05	0.06	0.04	0.07	0.06	0.05	0.06	0.04	0.04
C11:0 Undecanoic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C12:0 Lauric	0.06	0.07	0.05	0.05	0.06	0.06	0.05	0.07	0.04	0.05
C13:0 Tridecanoic	ND	ND	ND	ND	ND	0.05	ND	ND	ND	ND
C14:0 Myristic	2.44	2.47	1.92	1.94	2.38	2.26	2.26	2.49	2.08	1.96
C14:1n5 c9 Myristoleic	0.96	0.96	0.65	0.67	0.68	0.52	0.51	0.64	0.43	0.40
C15:1n5 c10 Pentadecenoic	0.05	0.04	0.11	ND	0.09	0.12	0.08	0.09	0.09	0.07
C16:0 Palmitic	24.55	24.47	22.29	22.59	26.30	26.29	26.63	26.52	25.45	24.68
C16:1n7 t9 Palmitelaidic	0.48	0.46	0.46	ND	0.45	0.48	0.50	0.50	0.51	0.54
C16:1n7 c9 Palmitoleic	4.77	4.71	3.84	4.42	3.57	3.23	3.10	3.28	2.72	2.65
C17:0 Margaric	1.50	1.56	1.40	1.27	1.56	1.71	1.67	1.68	1.73	1.89
C17:1n7 c10 Heptadecenoic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C18:0 Stearic	13.00	12.96	13.47	12.42	14.01	15.40	14.92	14.96	16.53	16.92
C18:1n9 t9 Elaidic	0.29	0.26	0.25	0.14	0.29	0.29	0.28	0.28	0.28	0.27
C18:1n7 t11 Vaccenic	1.57	1.70	0.86	0.81	1.56	1.69	1.77	1.90	1.96	2.22
C18:1n9 c9 Oleic	40.80	42.31	43.35	47.04	39.53	38.83	39.39	38.90	39.06	39.34
C18:1n7 c11 Vaccenic	1.34	1.30	1.48	1.69	1.12	1.09	1.09	1.03	1.09	1.10
C18:2n6 t Linolelaidic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C18:2n6 c Linoleic	2.22	1.76	2.73	2.17	2.50	2.45	2.13	1.99	2.52	2.48
C20:0 Arachidic	0.11	0.10	0.09	0.07	0.10	0.12	0.12	0.12	0.13	0.13
C18:3n6 c Gamma linolenic	0.05	0.05	0.07	ND	0.07	0.08	0.05	0.06	0.09	0.07
C20:1n9 c11 Eicosenoic	0.17	0.18	0.20	0.18	0.15	0.17	0.15	0.15	0.18	0.17
C18:3n3 c Alpha linolenic	1.34	1.15	1.56	1.29	1.45	1.41	1.34	1.35	1.45	1.46
CLA C18:2-c9,t11	1.07	0.83	0.58	0.71	0.72	0.60	0.99	0.91	0.72	0.72
CLA C18:2-t10,c12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C21:0 Heneicosanoic	0.70	0.81	0.47	ND	0.62	0.59	0.57	0.75	0.55	0.62
C20:2n6 c Eicosadienoic	0.07	0.05	0.04	ND	0.05	0.07	0.05	0.05	0.08	0.10
C22:0 Behenic	0.08	0.03	0.02	ND	0.03	0.07	0.05	0.06	0.05	0.05
C20:3n6 c Eicosatrienoic	0.24	0.17	0.33	0.24	0.27	0.25	0.23	0.22	0.22	0.21
C22:1n9 c13 Erucic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C20:3n3 c Eicosatrienoic	0.06	0.05	0.08	0.04	0.05	0.05	0.05	0.05	0.06	0.04
C20:4n6 c Arachidonic	0.70	0.47	1.16	0.74	0.78	0.71	0.63	0.57	0.66	0.58
C23:0 Tricosanoic	0.05	0.03	0.04	0.09	0.04	0.04	0.03	0.04	0.02	0.03
C22:2n6 c Docosadienoic	0.21	0.18	0.26	ND	0.21	0.21	0.20	0.21	0.20	0.18
C20:5n3 c EPA	0.43	0.30	0.88	0.48	0.55	0.47	0.44	0.42	0.44	0.37
C24:0 Lignoceric	0.04	0.03	0.08	ND	0.03	0.04	0.03	0.04	0.03	0.04
C24:1n9 c15 Nervonic	0.05	0.05	0.04	ND	0.04	ND	ND	0.02	ND	0.04
C22:5n3 c DPA	0.50	0.37	1.04	0.67	0.59	0.52	0.55	0.54	0.53	0.48
C22:6n3 c DHA	0.06	0.05	0.15	0.09	0.07	0.07	0.06	0.05	0.06	0.06
SFA	42.58	42.59	39.89	38.63	45.19	46.7	46.4	46.78	46.65	46.43
MUFA	50.47	51.98	51.23	54.95	47.49	46.41	46.87	46.79	46.32	46.81
PUFA	6.95	5.44	8.88	6.42	7.31	6.89	6.73	6.42	7.03	6.76
P/S ratio	0.16	0.13	0.22	0.17	0.16	0.15	0.15	0.14	0.15	0.15
n-6/n-3 ratio	1.46	1.40	1.24	1.23	1.43	1.49	1.35	1.29	1.48	1.49
LCN3FA	1.05	0.76	2.15	1.27	1.26	1.11	1.10	1.06	1.09	0.96
Total FAs (g/100 g)	7.45	6.05	3.48	2.29	5.54	3.32	5.02	4.09	5.66	4.37

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Fatty acid (% of total fatty acids except for Total FAs and the ratios)	Striploin		Tenderloin		Heart		Kidney		Liver	
	Ckd	Raw	Ckd	Raw	Ckd	Raw	Ckd	Raw	Ckd	Raw
C8:0 Caprylic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C10:0 Capric	0.07	0.05	0.07	0.06	0.01	0.03	0.03	0.06	0.06	ND
C11:0 Undecanoic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C12:0 Lauric	0.06	0.06	0.07	0.07	0.02	0.04	ND	ND	ND	ND
C13:0 Tridecanoic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C14:0 Myristic	3.01	3.01	2.41	2.30	1.24	0.95	0.41	0.44	0.69	0.67
C14:1n5 c9 Myristoleic	1.20	1.00	0.24	0.27	0.09	0.07	0.04	0.12	0.11	0.12
C15:1n5 c10 Pentadecenoic	0.03	0.04	0.05	0.06	0.28	0.37	0.35	0.31	0.11	0.11
C16:0 Palmitic	25.45	25.76	25.74	25.16	17.32	16.23	17.88	18.21	14.17	13.19
C16:1n7 t9 Palmitelaidic	0.46	0.45	0.54	0.56	0.69	0.66	0.83	0.92	0.68	0.61
C16:1n7 c9 Palmitoleic	4.71	4.36	1.94	1.86	1.30	1.42	0.81	0.84	1.33	1.24
C17:0 Margaric	1.38	1.41	1.97	2.01	1.87	1.71	1.46	1.54	1.94	1.74
C17:1n7 c10 Heptadecenoic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C18:0 Stearic	13.32	14.14	23.57	24.72	25.43	23.76	15.73	16.34	32.45	29.98
C18:1n9 t9 Elaidic	0.19	0.23	0.32	0.29	0.30	0.24	0.14	0.17	0.20	0.17
C18:1n7 t11 Vaccenic	1.61	1.57	1.77	1.85	2.17	1.86	0.84	0.99	2.33	2.23
C18:1n9 c9 Oleic	42.53	41.47	34.30	33.69	19.70	20.63	15.28	15.79	13.31	12.62
C18:1n7 c11 Vaccenic	1.13	1.09	0.66	0.62	1.34	1.42	2.02	1.99	0.87	0.86
C18:2n6 t Linolelaidic	ND	ND	ND	ND	ND	ND	ND	0.11	ND	ND
C18:2n6 c Linoleic	0.99	1.18	1.82	1.81	12.37	12.68	12.30	11.95	5.01	5.46
C20:0 Arachidic	0.10	0.09	0.16	0.17	0.24	0.21	0.54	0.53	0.13	0.12
C18:3n6 c Gamma linolenic	0.03	0.04	0.07	0.06	0.14	0.19	0.19	0.15	0.37	0.38
C20:1n9 c11 Eicosenoic	0.21	0.18	0.13	0.13	0.15	0.15	0.37	0.33	0.09	0.11
C18:3n3 c Alpha linolenic	0.82	0.97	1.42	1.32	2.91	3.09	2.62	2.58	1.81	2.06
CLA C18:2-c9,t11	0.83	0.78	0.38	0.38	0.48	0.38	0.39	0.43	0.50	0.70
CLA C18:2-t10,c12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C21:0 Heneicosanoic	0.67	0.62	0.36	0.36	0.38	0.36	0.47	0.45	0.54	0.56
C20:2n6 c Eicosadienoic	0.04	0.04	0.06	0.12	0.14	0.14	0.27	0.26	0.24	0.28
C22:0 Behenic	0.02	0.02	0.04	0.11	0.18	0.17	1.29	1.22	0.24	0.30
C20:3n6 c Eicosatrienoic	0.09	0.12	0.14	0.15	1.20	1.31	1.88	1.79	3.37	3.83
C22:1n9 c13 Erucic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C20:3n3 c Eicosatrienoic	0.04	0.04	0.04	0.05	0.10	0.07	0.61	0.60	0.10	0.10
C20:4n6 c Arachidonic	0.28	0.37	0.55	0.59	4.82	5.58	11.98	10.81	6.47	7.43
C23:0 Tricosanoic	0.02	0.02	0.04	0.04	0.23	0.22	0.30	0.27	0.60	0.53
C22:2n6 c Docosadienoic	0.13	0.15	0.16	0.16	0.62	0.70	0.59	0.59	2.21	2.62
C20:5n3 c EPA	0.22	0.29	0.41	0.43	2.59	3.23	4.95	4.92	3.67	4.39
C24:0 Lignoceric	0.02	0.02	0.02	0.03	0.18	0.17	0.68	0.67	0.41	0.35
C24:1n9 c15 Nervonic	0.04	0.04	0.03	0.05	0.09	0.10	0.39	0.42	0.11	0.09
C22:5n3 c DPA	0.27	0.33	0.46	0.47	1.28	1.62	3.35	3.24	4.66	5.64
C22:6n3 c DHA	0.03	0.04	0.06	0.09	0.16	0.22	1.00	0.95	1.24	1.53

SFA	44.12	45.21	54.44	55.03	47.10	43.86	38.80	39.74	51.20	47.43
MUFA	52.13	50.43	39.99	39.36	26.11	26.92	21.06	21.88	19.16	18.15
PUFA	3.754	4.36	5.56	5.62	26.79	29.22	40.13	38.37	29.64	34.41
P/S ratio	0.09	0.10	0.10	0.10	0.57	0.67	1.03	0.97	0.58	0.73
n-6/n-3 ratio	1.13	1.13	1.17	1.22	2.74	2.50	2.17	2.09	1.54	1.46
LCN3FA	0.55	0.71	0.97	1.04	4.12	5.14	9.91	9.71	9.66	11.66
Total FAs (g/100 g)	9.02	5.58	6.65	4.48	3.92	1.98	3.07	1.57	2.78	2.56

Document 3

Fatty acid (% of total fatty acids except for Total FAs and the ratios)	Sweetbread		Tongue		Tripe Uncooked	
	Ckd	Raw	Ckd	Raw	Ckd	Raw
C8:0 Caprylic	ND	ND	ND	ND	0.39	ND
C10:0 Capric	0.07	0.06	0.04	0.08	ND	0.04
C11:0 Undecanoic	ND	ND	ND	ND	ND	ND
C12:0 Lauric	0.21	0.26	0.10	0.08	0.05	0.06
C13:0 Tridecanoic	ND	ND	ND	ND	ND	ND
C14:0 Myristic	3.52	3.51	3.19	3.22	2.43	2.47
C14:1n5 c9 Myristoleic	0.31	0.38	0.58	0.58	0.36	0.38
C15:1n5 c10 Pentadecenoic	ND	ND	0.06	ND	ND	0.10
C16:0 Palmitic	27.97	28.08	23.90	24.52	22.58	22.61
C16:1n7 t9 Palmitelaidic	0.54	0.55	0.59	0.64	ND	0.82
C16:1n7 c9 Palmitoleic	1.81	1.95	3.03	3.16	3.11	1.95
C17:0 Margaric	1.92	1.89	2.15	2.26	2.80	2.80
C17:1n7 c10 Heptadecenoic	ND	ND	ND	ND	ND	ND
C18:0 Stearic	25.55	24.39	19.20	18.93	22.52	22.63
C18:1n9 t9 Elaidic	0.35	0.36	0.33	0.36	0.30	0.52
C18:1n7 t11 Vaccenic	1.90	1.92	1.57	1.53	3.57	3.75
C18:1n9 c9 Oleic	31.43	32.19	38.32	37.91	31.07	30.26
C18:1n7 c11 Vaccenic	0.86	0.83	1.34	1.32	1.07	0.99
C18:2n6 t Linolelaidic	ND	ND	ND	ND	ND	ND
C18:2n6 c Linoleic	1.07	1.08	2.07	2.01	2.78	2.90
C20:0 Arachidic	0.18	0.19	0.11	0.12	0.26	0.32
C18:3n6 c Gamma linolenic	ND	ND	ND	ND	ND	0.04
C20:1n9 c11 Eicosenoic	0.13	0.15	0.18	0.20	0.18	0.17
C18:3n3 c Alpha linolenic	0.65	0.60	1.02	0.99	0.98	1.09
CLA C18:2-c9,t11	0.47	0.62	0.69	0.80	1.06	0.54
CLA C18:2-t10,c12	ND	ND	ND	ND	ND	ND
C21:0 Heneicosanoic	0.25	0.23	0.35	0.39	0.19	0.72
C20:2n6 c Eicosadienoic	0.06	0.07	0.01	ND	ND	0.11
C22:0 Behenic	ND	ND	ND	ND	ND	0.25
C20:3n6 c Eicosatrienoic	0.07	0.09	0.13	0.11	0.57	0.46
C22:1n9 c13 Erucic	ND	ND	ND	ND	0.13	ND
C20:3n3 c Eicosatrienoic	0.04	ND	0.03	ND	ND	0.11
C20:4n6 c Arachidonic	0.23	0.21	0.32	0.23	1.36	1.40
C23:0 Tricosanoic	ND	ND	ND	ND	0.18	0.12
C22:2n6 c Docosadienoic	0.08	0.09	0.11	0.14	ND	0.23
C20:5n3 c EPA	0.10	0.09	0.17	0.12	0.64	0.61
C24:0 Lignoceric	ND	ND	ND	ND	ND	0.19
C24:1n9 c15 Nervonic	ND	ND	ND	ND	ND	0.07
C22:5n3 c DPA	0.25	0.23	0.40	0.31	1.23	1.15
C22:6n3 c DHA	ND	ND	0.02	ND	0.20	0.14
SFA	59.66	58.6	49.04	49.59	51.40	52.22
MUFA	37.33	38.33	45.99	45.72	39.79	39.01
PUFA	3.01	3.07	4.97	4.70	8.81	8.78
P/S ratio	0.05	0.05	0.10	0.09	0.17	0.17
n-6/n-3 ratio	1.46	1.67	1.61	1.75	1.54	1.65
LCN3FA	0.38	0.32	0.62	0.43	2.07	2.01
Total FAs (g/100 g)	20.99	21.06	14.41	13.59	1.81	2.20

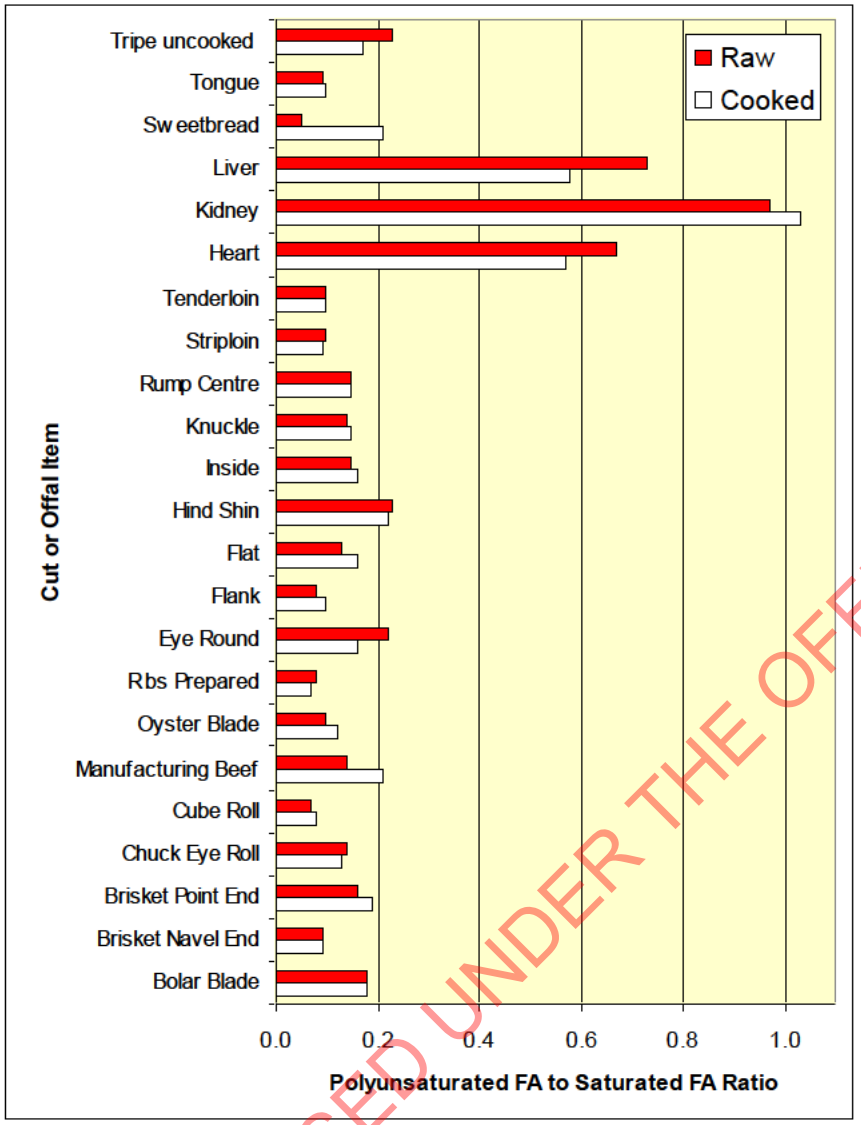
Table B20: A summary of fatty-acid characteristics for each cooked cut and offal item of beef expressed as g/100 g of the lean tissue (except in the case of the ratios of P/S and n-6/n-3) rather than as a percentage of total fatty acids as shown in Table B19.

	SFA	MUFA	Trans MUFA	PUFA	P/S	n-6 PUFA	n-3 PUFA	n-6/ n-3	LCn3FA	Total FA
	COOKED ITEMS (lean part only)									
FOREQUARTER ITEMS:										
Bolar Blade	1.90	2.37	0.07	0.341	0.180	0.182	0.134	1.359	0.073	4.60
Brisket Navel End	5.60	7.00	0.28	0.509	0.091	0.221	0.151	1.466	0.051	13.11
Brisket Point End	2.26	2.97	0.10	0.435	0.193	0.232	0.157	1.477	0.083	5.67
Chuck Eye Roll	2.92	3.17	0.12	0.383	0.131	0.199	0.149	1.331	0.074	6.48
Cube Roll	4.57	4.00	0.24	0.363	0.079	0.155	0.146	1.059	0.062	8.93
Manufacturing Beef	1.17	0.90	0.08	0.247	0.211	0.129	0.102	1.271	0.039	2.31
Oyster Blade	2.95	3.02	0.12	0.348	0.118	0.178	0.138	1.294	0.063	6.32
Ribs Prepared	3.62	2.97	0.18	0.236	0.065	0.122	0.084	1.446	0.034	6.83
HINDQUARTER ITEMS:										
Eye Round	1.65	1.83	0.09	0.270	0.163	0.140	0.100	1.391	0.050	3.75
Flank	2.89	2.71	0.12	0.289	0.100	0.162	0.106	1.529	0.049	5.88
Flat	3.17	3.76	0.17	0.518	0.163	0.260	0.178	1.459	0.078	7.45
Hind Shin	1.39	1.78	0.05	0.309	0.223	0.160	0.129	1.235	0.075	3.48
Inside	2.50	2.63	0.13	0.405	0.162	0.215	0.150	1.430	0.070	5.54
Knuckle	2.33	2.35	0.13	0.338	0.145	0.165	0.123	1.348	0.055	5.02
Rump Centre	2.64	2.62	0.16	0.398	0.151	0.213	0.144	1.480	0.062	5.66
Striploin	3.98	4.70	0.20	0.339	0.085	0.140	0.124	1.133	0.050	9.02
Tenderloin	3.62	2.66	0.18	0.370	0.102	0.186	0.159	1.174	0.065	6.65
All-cuts averages	**2.89**	**3.03**	**0.14**	**0.359**	**0.139**	**0.180**	**0.134**	**1.346**	**0.061**	**6.28**
OFFAL ITEMS:										
Heart	1.85	1.02	0.12	1.052	0.569	0.757	0.276	2.744	0.162	3.92
Kidney	1.20	0.64	0.06	1.239	1.034	0.840	0.387	2.174	0.306	3.07
Liver	1.42	0.53	0.09	0.824	0.579	0.491	0.319	1.540	0.269	2.78
Sweetbread	12.53	7.84	0.59	0.631	0.050	0.317	0.217	1.460	0.080	20.99
Tongue	7.07	6.63	0.36	0.716	0.101	0.381	0.236	1.610	0.089	14.41
Tripe Uncooked	0.93	0.72	0.07	0.159	0.171	0.085	0.055	1.544	0.037	1.81
Offal averages	**4.17**	**2.90**	**0.21**	**0.770**	**0.418**	**0.479**	**0.248**	**1.845**	**0.157**	**7.83**

Table B21: A summary of fatty-acid characteristics for each uncooked (raw) cut and offal item of beef expressed as g/100 g of the lean tissue (except in the case of the ratios of P/S and n-6/n-3) rather than as a percentage of total fatty acids as shown in Table B19.

	SFA	MUFA	Trans MUFA	PUFA	P/S	n-6 PUFA	n-3 PUFA	n-6/ n-3	LCn3FA	Total FA
	UNCOOKED (RAW) ITEMS (lean part only)									
FOREQUARTER ITEMS:										
Bolar Blade	1.36	1.68	0.05	0.242	0.178	0.125	0.099	1.266	0.055	3.28
Brisket Navel End	4.41	5.48	0.24	0.385	0.087	0.164	0.105	1.562	0.028	10.28
Brisket Point End	1.68	2.28	0.07	0.265	0.158	0.137	0.096	1.433	0.049	4.22
Chuck Eye Roll	1.77	2.00	0.07	0.249	0.140	0.128	0.096	1.334	0.048	4.02
Cube Roll	3.73	3.05	0.21	0.261	0.070	0.119	0.112	1.054	0.047	7.04
Manufacturing Beef	1.67	1.22	0.11	0.226	0.136	0.114	0.093	1.226	0.032	3.11
Oyster Blade	2.59	2.65	0.08	0.269	0.104	0.122	0.112	1.093	0.053	5.51
Ribs Prepared	2.48	2.28	0.12	0.192	0.077	0.097	0.069	1.400	0.030	4.95
HINDQUARTER ITEMS:										
Eye Round	0.89	1.01	0.04	0.199	0.223	0.106	0.073	1.453	0.039	2.10
Flank	2.32	2.12	0.10	0.179	0.077	0.095	0.064	1.472	0.027	4.62
Flat	2.58	3.14	0.15	0.329	0.128	0.163	0.116	1.403	0.046	6.05
Hind Shin	0.88	1.26	0.02	0.147	0.166	0.072	0.059	1.227	0.029	2.29
Inside	1.55	1.54	0.08	0.229	0.147	0.125	0.084	1.493	0.037	3.32
Knuckle	1.91	1.91	0.11	0.262	0.137	0.127	0.099	1.286	0.043	4.09
Rump Centre	2.03	2.04	0.13	0.295	0.146	0.158	0.106	1.494	0.042	4.37
Striploin	2.52	2.81	0.13	0.243	0.096	0.106	0.093	1.134	0.040	5.58
Tenderloin	2.46	1.76	0.12	0.251	0.102	0.129	0.106	1.223	0.047	4.48
All-cuts averages	**2.17**	**2.25**	**0.11**	**0.248**	**0.128**	**0.123**	**0.093**	**1.327**	**0.041**	**4.66**
OFFAL ITEMS:										
Heart	0.87	0.53	0.05	0.579	0.666	0.408	0.163	2.502	0.102	1.98
Kidney	0.63	0.34	0.03	0.606	0.966	0.405	0.194	2.087	0.154	1.57
Liver	1.21	0.46	0.08	0.880	0.726	0.511	0.351	1.457	0.298	2.56
Sweetbread	12.34	8.07	0.59	0.647	0.052	0.323	0.194	1.669	0.067	21.06
Tongue	6.74	6.21	0.34	0.638	0.095	0.337	0.192	1.754	0.058	13.59
Tripe Uncooked	1.15	0.86	0.11	0.193	0.168	0.113	0.068	1.654	0.044	2.20
Offal averages	**3.82**	**2.75**	**0.20**	**0.591**	**0.445**	**0.350**	**0.194**	**1.854**	**0.121**	**7.16**

Figure B7: The P/S ratio and the percentage of MUFA in the fatty acids of the cooked and raw lean portion of 23 beef cuts and offal items.



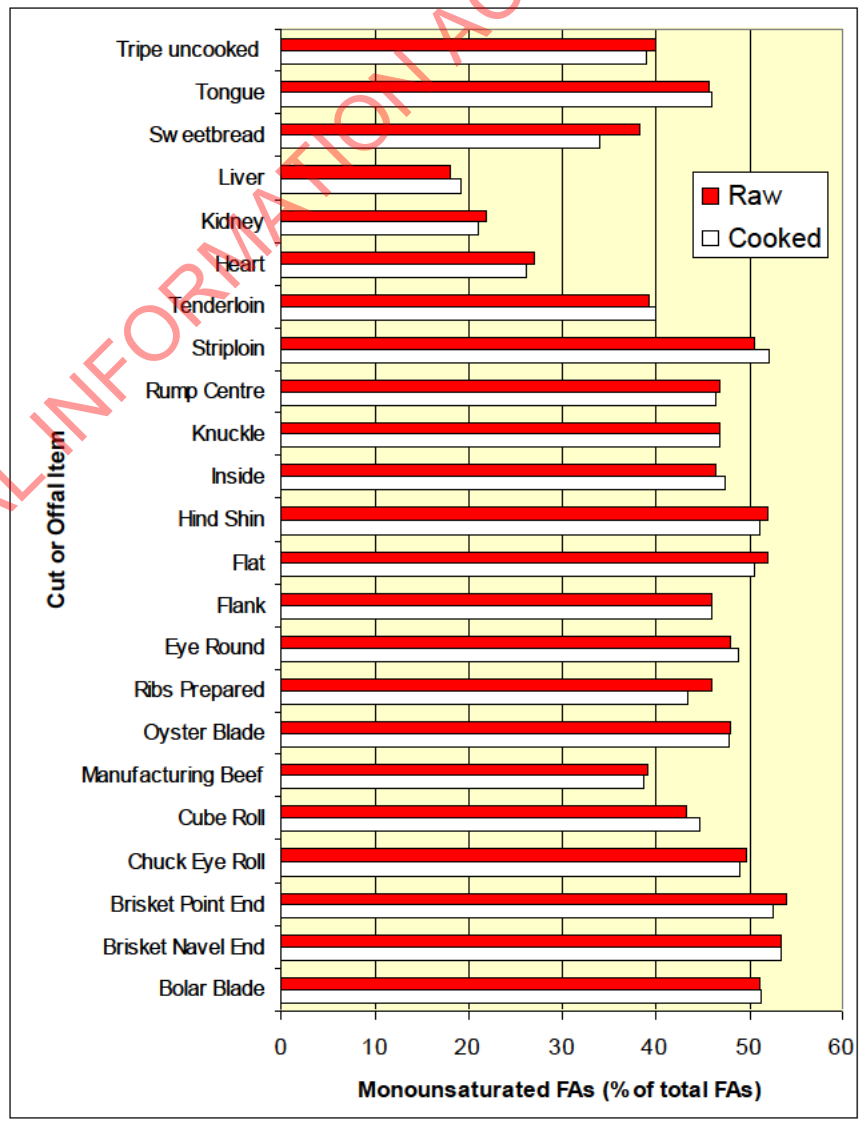
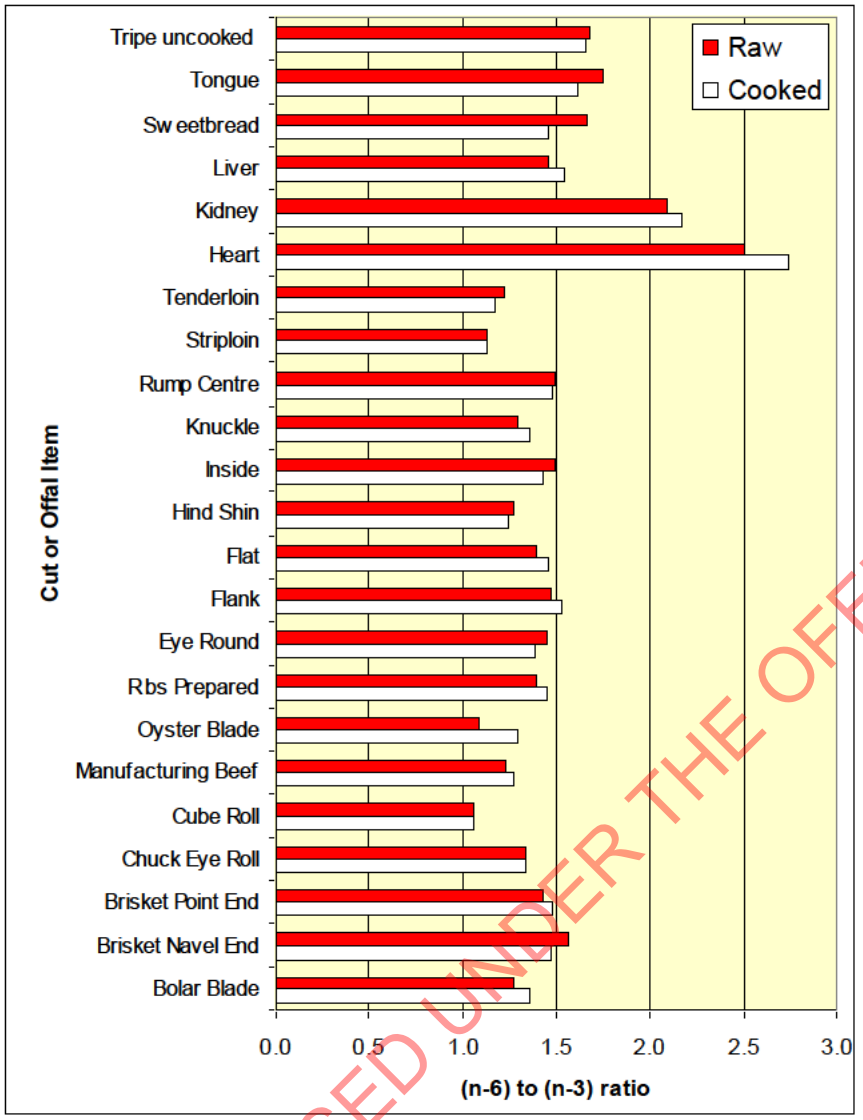
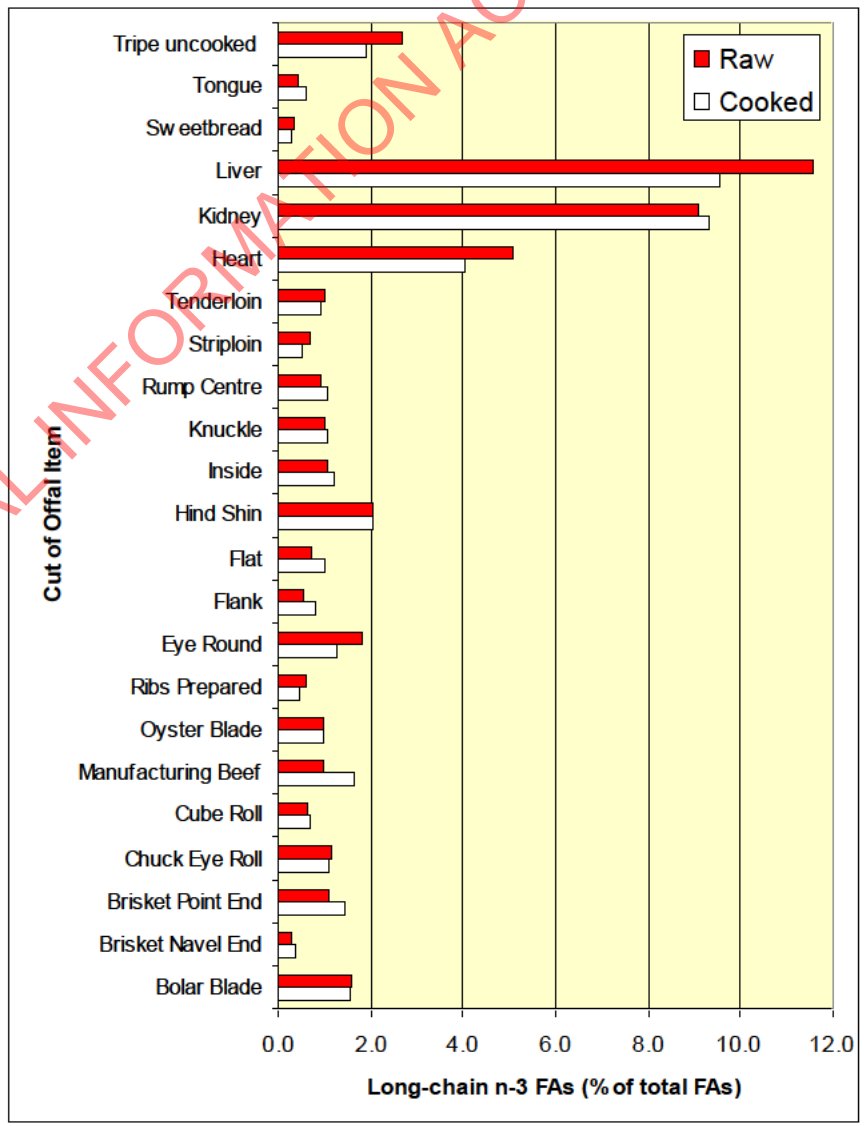


Figure B8: The (n-6) to (n-3) ratio and levels of the long chain n-3 fatty acids in the cooked and raw lean portion of 23 beef cuts and offal items.





f) ***Composition of Beef Fat Tissue Samples***: Concentrations of nutrients in dissected subcutaneous and intermuscular fat tissue from selected raw and cooked cuts are shown in Tables B22 (proximate composition and cholesterol) B23 (vitamins), B24 (minerals, and B25 (fatty acids).

Table B22: Beef fat (subcutaneous and intermuscular) composition in terms of energy, proximate composition and cholesterol for both cooked (Ckd) and raw samples.

	Subcutaneous Fat[a]		Intermuscular Fat[b]	
	Ckd	Raw	Ckd	Raw
Water (%)	15.4	19.9	31.2	29.0
Energy (kJ/100 g)	3037	2849	2272	2502
Energy (kcal/100 g)	725.8	680.9	543.0	597.9
Protein (%)	6.5	8.5	7.9	7.0
Fat (%)	78.3	72.4	57.2	63.8
Ash (%)	0.3	0.1	0.3	0.2
Cholesterol (mg/100 g)	63.0	64.2	87.1	104.1

[a] Subcutaneous fat from the beef striploin cuts (1640)
[b] Intermuscular (seam) fat from beef chuck-eye roll cuts (2430)

Table B23: Beef fat (subcutaneous and intermuscular) composition in terms of the concentration of vitamins for both cooked (Ckd) and raw samples (BDL = below detectable limit).

	Subcutaneous Fat[a]		Intermuscular Fat[b]	
	Ckd	Raw	Ckd	Raw
Vitamin B1 (mg/100 g) (Thiamine)	0.063	0.132	0.046	0.059
Vitamin B2 (mg/100 g) (Riboflavin)	0.034	0.027	0.056	0.032
Vitamin B3 (mg/100 g) (Niacin)	1.27	0.74	1.07	1.05
Vitamin B5 (mg/100 g) (Pantothenic acid)	BDL	BDL	0.2	0.1
Vitamin B6 (mg/100 g) (Pyridoxine)	0.057	0.052	0.084	0.063
Vitamin B12 (µg/100 g) (Cyanocobalamin)	0.3	0.2	0.4	0.2
Vitamin A (µg/100 g)	65.4	60.8	38.4	32.7
Vitamin D3 (µg/100 g)	0.32	0.28	0.38	0.31
25-OH Vitamin D3 (µg/100 g)	0.89	1.25	1.25	1.91
Vitamin E (mg/100 g)	1.46	1.43	1.46	1.11

[a & b] as for Table B22

Table B24: Beef fat (subcutaneous and intermuscular) composition in terms the concentration of minerals for both cooked (Ckd) and raw samples.

	Subcutaneous Fat[a]		Intermuscular Fat[b]	
	Ckd	Raw	Ckd	Raw
Calcium (mg/100 g)	16.7	20.1	16.0	11.1
Copper (mg/100 g)	0.02	0.01	0.03	0.02
Iodine (µg/100 g)	2.0	3.1	1.2	1.8
Iron (mg/100 g)	0.47	0.38	1.18	0.76
Magnesium (mg/100 g)	6.7	4.7	9.3	6.8
Manganese (µg/100 g)	2.3	1.6	5.4	2.1
Phosphorus (mg/100 g)	65.6	51.4	75.3	68.4
Potassium (mg/100 g)	129	93	126	143
Selenium (µg/100 g)	2.2	1.8	4.0	2.9
Sodium (mg/100 g)	25	27	25	32
Zinc (mg/100 g)	0.43	0.36	1.88	1.09

[a & b] As for Table B22

Table B25: Fatty-acid composition of cooked (Ckd) and raw beef subcutaneous (subcut) and intermuscular (intermusc) fat as % of total fatty acids and g/100 g of the tissue (ND = not detectable)

	FAs as % of total FAs				FAs as g/100 g of item			
	Subcut. Fat		Intermusc. Fat		Subcut. Fat		Intermusc. Fat	
	Ckd	Raw	Ckd	Raw	Ckd	Raw	Ckd	Raw
C8:0 Caprylic	ND	ND	ND	ND	ND	ND	ND	ND
C10:0 Capric	0.05	0.05	0.07	0.06	0.03	0.03	0.03	0.03
C11:0 Undecanoic	ND	ND	ND	ND	ND	ND	ND	ND
C12:0 Lauric	0.10	0.08	0.09	0.10	0.06	0.05	0.04	0.05
C13:0 Tridecanoic	0.03	0.02	0.03	0.04	0.02	0.01	0.01	0.02
C14:0 Myristic	3.36	3.38	2.96	2.86	1.94	1.97	1.32	1.37
C14:1n5 c9 Myristoleic	0.76	0.69	0.47	0.31	0.44	0.40	0.21	0.15
C15:1n5 c10 Pentadecenoic	ND	ND	ND	ND	ND	ND	ND	ND
C16:0 Palmitic	25.88	25.64	24.86	23.80	14.94	14.94	11.09	11.41
C16:1n7 t9 Palmitelaidic	0.13	0.14	0.12	0.11	0.07	0.08	0.05	0.05
C16:1n7 c9 Palmitoleic	3.34	3.16	2.29	1.84	1.93	1.84	1.02	0.88
C17:0 Margaric	1.78	1.85	2.06	2.17	1.03	1.08	0.92	1.04
C17:1n7 c10 Heptadecenoic	ND	ND	ND	ND	ND	ND	ND	ND
C18:0 Stearic	21.01	22.82	26.27	30.07	12.13	13.30	11.72	14.42
C18:1n9 t9 Elaidic	0.28	0.29	0.27	0.27	0.16	0.17	0.12	0.13
C18:1n7 t11 Vaccenic	4.21	4.15	4.15	3.98	2.43	2.42	1.85	1.91
C18:1n9 c9 Oleic	34.31	33.17	31.89	29.95	19.81	19.33	14.23	14.36
C18:1n7 c11 Vaccenic	0.78	0.72	0.72	0.73	0.45	0.42	0.32	0.35
C18:2n6 t Linolelaidic	0.06	0.07	0.07	0.08	0.04	0.04	0.03	0.04
C18:2n6 c Linoleic	0.74	0.75	0.85	0.79	0.43	0.44	0.38	0.38
C20:0 Arachidic	0.14	0.17	0.18	0.27	0.08	0.10	0.08	0.13
C18:3n6 c Gamma linolenic	ND	ND	ND	ND	ND	ND	ND	ND
C20:1n9 c11 Eicosenoic	0.09	0.07	0.11	0.13	0.05	0.04	0.05	0.06
C18:3n3 c Alpha linolenic	0.88	0.88	0.87	0.94	0.51	0.51	0.39	0.45
CLA C18:2 c9 t11	1.20	1.14	0.90	0.83	0.69	0.66	0.40	0.40
CLA C18:2 t10 c12	ND	ND	ND	ND	ND	ND	ND	ND
C21:0 Heneicosanoic	0.71	0.63	0.52	0.42	0.41	0.37	0.23	0.20
C20:2n6 c Eicosadienoic	ND	ND	ND	ND	ND	ND	ND	ND
C22:0 Behenic	0.09	0.08	0.11	0.10	0.05	0.05	0.05	0.05
C20:3n6 c Eicosatrienoic	ND	ND	ND	ND	ND	ND	ND	ND
C22:1n9 c Erucic	ND	ND	ND	ND	ND	ND	ND	ND
C20:3n3 c Eicosatrienoic	ND	ND	ND	ND	ND	ND	ND	ND
C20:4n6 c Arachidonic	ND	ND	ND	ND	ND	ND	ND	ND
C23:0 Tricosanoic	ND	ND	ND	ND	ND	ND	ND	ND
C22:2n6 c Docosadienoic	ND	ND	ND	ND	ND	ND	ND	ND
C24:0 Lignoceric	ND	ND	ND	ND	ND	ND	ND	ND
C20:5n3 c EPA	ND	ND	ND	ND	ND	ND	ND	ND
C24:1n9 c15 Nervonic	ND	ND	ND	ND	ND	ND	ND	ND
C22:5n3 c DPA	0.06	0.05	0.16	0.15	0.04	0.03	0.07	0.07
C22:6n3 c ,19-DHA	ND	ND	ND	ND	ND	ND	ND	ND
For abbreviations below see p30								
SFA	53.15	54.73	57.14	59.89	30.69	31.90	25.49	28.72
MUFA	43.90	42.39	40.01	37.32	25.34	24.70	17.85	17.89
Trans MUFA	4.61	4.58	4.53	4.37	2.66	2.67	2.02	2.09
PUFA	2.95	2.88	2.85	2.79	1.70	1.68	1.27	1.34
P/S	0.06	0.05	0.05	0.05				
Total n-6 PUFA	0.81	0.82	0.92	0.88	0.47	0.48	0.41	0.42
Total n-3 PUFA	0.95	0.92	1.03	1.08	0.55	0.54	0.46	0.52
n-6/n-3	0.85	0.89	0.89	0.81				
LCN3FA	0.06	0.05	0.16	0.15	0.04	0.03	0.07	0.07
Total FAs (g/100 g)					57.73	58.28	44.62	47.95

g) ***Combining of Results for Beef Lean and Fat***

Table B26: Five examples of ways in which the nutrient or energy content of a cut or offal item may be calculated (rounded to 3 decimal places) from the information provided in previous tables. Calculations are shown either for the amount of nutrient per 100 g of the total product or per 100 g of the edible portion (excluding bone and waste). The steps involved are explained in rows [a] to [l] in the first column of the table.

	Vitamin E in **cooked striploin** (mg)	Vitamin A in **cooked rib-prepared** (µg)	Iron in **cooked rump centre** (mg)	Energy in **cooked naval-end brisket** (kJ)	Protein in **cooked hind shin** (g)
[a] proportion of muscle in 100 g of product	0.835	0.739	0.993	0.596	0.924
[b] Amount of nutrient in 100 g of muscle	0.53	8.8	2.96	1102	31.2
[c] \ Amount of nutrient from muscle in 100 g of product ([a] x [b])	0.443	6.503	2.939	656.792	28.829
[d] Proportion of subcutaneous fat in 100 g of product	0.158	0	0	0	0.037
[e] Amount of nutrient in 100 g of subcutaneous fat	1.46	65.4	0.47	30.69	6.5
[f] \ Amount of nutrient from subcutaneous fat in 100 g of product ([d] x [e])	0.231	0.000	0.000	0.000	0.241
[g] Proportion of intermuscular fat in 100 g of product	0.007	0.103	0.007	0.404	0.021
[h] Amount of nutrient in 100 g of intermuscular fat	1.460	38.400	1.180	25.490	7.900
[i] \ Amount of nutrient from intermuscular fat in 100 g of product ([g] x [h])	0.0102	3.9552	0.0083	10.2980	0.1659
[j] Total amount of nutrient in 100 g of the total product ([c] + [f] + [i])	**0.683**	**10.458**	**2.948**	**667.090**	**29.235**
[k] Proportion of bone + waste in the product	0	0.158	0	0	0.019
[l] Total amount of nutrient in 100 g of the edible tissue (fat + muscle) ([j] x (1/(1-[k]))	**0.683**	**12.421**	**2.948**	**667.090**	**29.801**

g) ***Amino-acid Composition of the Lean of Four Beef Cuts:***

Table B27: The amino-acid (AA) composition within the raw lean tissue of four beef cuts expressed as a percentage (g/100 g) of the raw weight.

	Beef cut			
g/100 g	Hindshin	Oyster Blade	Rump Centre	Striploin
Asparagine	1.74	1.62	1.81	1.88
Threonine	0.74	0.71	0.82	0.84
Serine	0.78	0.70	0.76	0.78
Glutamic acid	3.00	2.85	3.02	3.11
Proline	0.80	0.74	0.60	0.62
Glycine	1.49	1.21	0.89	1.09
Alanine	1.21	1.06	1.05	1.15
Valine	0.93	0.85	0.98	1.03
Isoleucine	0.87	0.80	0.93	0.97
Leucine	1.59	1.50	1.67	1.72
Tyrosine	0.69	0.67	0.76	0.77
Phenylalanine	0.83	0.78	0.86	0.87
Histidine	0.70	0.59	0.85	0.95
Lysine	1.74	1.56	1.72	1.78
Arginine	1.49	1.34	1.36	1.46
Taurine	0.05	0.06	0.03	0.02
Cysteine	0.24	0.24	0.26	0.33
Methionine	0.63	0.61	0.68	0.90
Tryptophan	0.21	0.20	0.25	0.24
Sum of all AAs	**19.70**	**18.03**	**19.27**	**20.49**

Table of Contents for the Lamb Section

L-1. Summary (Lamb Section)

1. The nutrient content of the raw and cooked lean tissue from 25 items including lamb cuts (18) and lamb offal items (7) are presented. The items to be analysed were chosen by members of the Meat Industry Association of New Zealand, and supplied as frozen samples from a range of meat plants located throughout New Zealand.
2. Analyses were based primarily on the lean tissue after bone and fat (subcutaneous and intermuscular) had been removed by boning knife. This was done to avoid having variation in the concentrations of nutrients between items being dominated by variation in the amount of dissectible fat present. Some analyses were also carried out on the dissected fat so that the composition of cuts with varying levels of fat could be estimated.
3. The levels of loss as purge are reported along with cooking losses. Cooking losses enabled the estimation of true percentage retention values for individual nutrients within the lean.
4. Eight to ten samples of each item were obtained for analysis, but the lean tissues from all samples were combined (separately for raw and cooked material) into a single composite sample for analysis. Thus, no measures of variation between samples of the same item were obtained for concentrations of nutrients, except in the case of intramuscular fat of the longissimus muscle of the boneless loin, in which case an almost two-fold range was shown for the eight samples.
5. Nutrients measured included those obtained from a basic proximate analysis (protein, water, lipid & ash) that enabled the calculation of energy content per unit weight, cholesterol, 10 vitamins, 11 minerals such as iron and zinc, and 40 fatty acids within the intramuscular fat together with several totals and ratios for various groups of fatty acids. In addition, estimates of the density of lean meat and fat are provided so that nutrient concentrations per unit weight can be converted to concentrations per unit volume.
6. For selected nutrients, results are presented as bar charts as well as in a tabular format.
7. Because of the amount of data presented in the report, no attempt is made in this summary to pick out the main points. It is noted, however, that there is no suggestion that the composition of New Zealand lamb has changed appreciably over the last 20 years, which is the time since previous analyses of this sort were published.
8. The information contained herein will be of value and interest to several groups of people including meat marketers (domestic as well as export markets), nutritionists, dietitians, the medical profession, and, probably most importantly, the lamb-consuming public.

L-2. Introduction (Lamb Section)

This section of the report provides the results of a project where the nutrient content of the lean parts of 25 lamb cuts and offal items was measured both as raw product as well as after cooking. Items to be analysed were selected by members of the New Zealand Meat Industry Association, with different items being supplied from different meat plants. The logistics of having the samples delivered to Massey University for dissection were managed by personnel employed by Beef and Lamb New Zealand (previously Meat & Wool New Zealand). Generally 10 samples of each item were provided with samples being large enough so that the dissected lean (muscle) of each sample when combined in a minced composite sample provided at least 3 kg of cooked and 3 kg of uncooked mince.

For most items 10 samples were processed, and then the lean tissues from all 10 samples were combined during the mincing procedure, so that only two samples per item (one cooked and one raw) were made available for freeze-drying. The one exception to this procedure was for the boneless loin cut, where sub-samples of the muscle tissue from each of 8 samples were kept separate in order to obtain some indication of the variability in intramuscular fat levels. Samples of subcutaneous and intermuscular fat from selected cuts were also analysed before and after cooking.

L-3. Material and Methods (Lamb Section)

a) ***Samples Analysed***: The 25 items analysed are listed in Table L1 along with their code number from "*The New Zealand Meat Specifications Guide"* (published by Meat & Wool New Zealand, Wellington). Table L1 also contains an indication of the cooking methods used for each item, but cooking procedures are given below in Section c) in more detail. Cooking methods used were those recommended by personnel at Beef + Lamb New Zealand Inc (www.beeflambnz.co.nz).

Table L1: A list of the 25 lamb cuts and lamb offal items processed, together with a brief description of the cooking procedures. The code, page number, and description are from "The New Zealand Meat Specification Guide" published by Meat & Wool New Zealand.

Cut Name (abbreviation, code, page)	**Description**	**Cooking method**[b]
1. Boneless Chump [BNC] (3270, p78)	Taken from a long leg by the removal of a short leg. The bone is removed.	Fast roast
2. Hind Shank (3701, p87)	Prepared from a bone-in leg by a straight cut through the stifle joint. The knuckle tip is removed.	Braise (3h)
3. Tunnel boned leg, chump off, shank off (3110, p76)	Prepared from a chump off, shank off femur bon leg by the tunnel bone removal of the femur bone.	Slow roast
4. Bone in Leg chop/steak (3015, p74)	Prepared from a short-cut, bone-in leg with chump off.	Fast fry
5. Rack – Fully frenched (3552, p82)	Derived from an 8 rib chump-off long loin by a right angled cut to the line of the backbone between the 12th and 13th vertebrae leaving a 1 rib loin (short rack) and the 7 rib rack. Cap off and fully frenched.	Fast roast
6. Rack – partly frenched	As for 5 above, but with fat and muscle tissue left on the ribs for about 25 mm lateral to the lateral edge of the eye muscle.	Fast roast
7 Tenderloin (3450, p83)	Tenderloin, side muscle off, butt off. The butt-off short tenderloin is taken from a 1 rib chump-off loin.	Fast fry
8. Boneless loin (3434, p83)	The eye of meat from a 1 rib shortloin with silverskin off.	Fast roast
9. Loin chop (3436,p81)	Cut from a 1 rib shortloin. Flap removed 75mm from eye.	Fast fry
10. Loin saddle (3321, p79)	Derived from an 8 rib chump-off saddle by separating at right angles to the backbone between the 12th and 13th thoracic vertebrae creating a 1 rib loin saddle and a 7 rib rack saddle.	Fast roast

	The flap is removed 25mm from the eye.	
11. Square cut shoulder (3661, p86)	Derived from a neck string off carcass. Taken from a bone-in forequarter by removing the shank and breast on a straight line parallel to the line of the back. The protruding neck is removed in line with the line of the back.	Slow roast
12. Boneless rolled netted shoulder (3620, p84)	Derived from a 5 rib forequarter by the removal of bones and "paddywack" (*ligamentum nuchea*).	Slow roast
13. Square cut shoulder chops (3666, p86)	Obtained from a square cut shoulder. After cutting 3 or 4 arm bone chops parallel to the line of the back, the shoulder chops a re cut from the remaining shoulder at right angles to the line of the back.	Braise
14. Foreshank (3711, p87)	The bone-in shank is removed from the shoulder by a cut through the arm bone joint. Cut in conjunction with a square cut shoulder. Knuckle tip is removed.	Braise
15. Breast (3801, p88)	Consists of the point end brisket removed from a bone-in 5 rib forequarter.	Braise
16. Boneless Flap (3820, p88)	Derived as an off-cut from a pistola, saddle or long loin. Consists of the abdominal wall tissues and rib ends. It is removed by a cut commencing below the precrural gland and continuing on a line parallel to the line of the back, to a specified distance from the eye at the 6th rib, determined by the specification of the primal cut. All bones and cartilage removed	Braise
17. Neck chops (3675, p86)	Originate from a bone-in full neck which provides up to four cervical vertebrae and associated muscle tissue cut into slices approximately 16mm thick.	Braise
18. Ground lamb (3299, p89)	Prepared from any boneless cut and processed to a uniform size.	Braise
19. Liver (0230, p98)	The complete liver with portal lymph glands retained, gall bladder and all fat removed.	Soak & fry
20. Kidney (0240, p98)	The whole enucleated (skinned) kidney with blood vessels, etc, removed.	Soak & fry
21. Heart (0220, p98)	The whole heart with the arteries and veins cut at their entry into the heart.	Soak & simmer
22. Sweetbreads (0217, p98)	The thymus gland extracted from the neck and heart regions with all fat removed.	Soak & simmer
23. Brains (0280, p99)	The complete brain, with or with out membrane. Blood stains are removed.	Soak & fry
24. Testes		Soak & fry
25. Tongue – Swiss cut (0212, p98)	The portion of the tongue remaining after the removal of the hyoid bones, a severe fat trim and removal of excess muscle from underneath the tongue.	Soak & simmer

[b] Further details on cooking methods are given in Section c) on page 48

b) ***Procedures up to Freeze-Drying***: The procedure up to the freeze-drying step is shown as a flow diagram in Figure L1.

Points to note about how the samples were obtained and processed are as follows:

1. Samples came from several different meat companies and from meat plants located in different regions of New Zealand.
2. Samples of cuts were from YM, YX, PX and PM carcasses (13.3 to 21.3 kg carcass weight; GR up to 12 mm) at approximately the ratio that these classes are available for lamb carcasses in New Zealand (3.5:2.5:1:1 kg, respectively). For offal items it was not possible to specify the class or weight of the corresponding lamb carcass.
3. Samples were received in frozen, vacuum-packs from mid-January to mid-July of 2010.

4. Most samples came as 10 packs of approximately 1 kg, but some came in fewer but larger packs that had to be sub-divided after partial thawing. In order make up at least 1 kg, several items included samples from several lambs (e.g. brains and tenderloins).
5. Every attempt was made to have equivalent sub-samples cooked and left uncooked.
6. For dissection the "waste" items that were included with the bone for weighing purposes included items such as cartilage, gristle, large blood vessels, blood clots, bruised tissue, valves and tubes with some offal items, and skin for the tongue.
7. Samples for analysis of subcutaneous and intermuscular fat were from loin saddles (3321) and boneless, rolled, netted shoulders (3620), respectively. Dissection was carried out by boning knife and the fat inevitably included small remnants of muscle, blood vessels, and exudate from muscle. Separation of fat was particularly difficult with cooked samples.

c) ***Cooking Methods*:**

Cuts To Fast Roast: Two thermocouple probes were inserted into the geometric centre of the roasts and roasted on fan-bake in an oven preheated to 200°C to an internal temperature of 70°C. Roasts were weighed before cooking and after a ~20 minute cooling time following cooking. Approximate cooking times were calculated as 15 minutes/500g.

-Chump/rump
-Saddle
-Fully frenched and partially frenched racks
-Boneless loin

Cuts to Slow Roast : As for fast roast except the oven temperature was 160°C, and the estimated time to reach an internal temperature of 70°C was 25-30 minutes/500g.

-Tunnel-boned leg
-Square cut shoulder
-Boneless, rolled, netted shoulder

Cuts to Fast Fry: A good quality non-stick skillet was heated over a moderate to high heat for 2 minutes before placing the cut in the skillet and turning when the internal temperature reached 35°C. The cut was removed when a final temperature of 70°C is reached. Items were weighed before cooking and ~20 minutes after cooking.

- Leg chop; about 3 minutes per side depending on thickness
- Chump chop; about 4 minutes per side depending on thickness
- Loin chop; about 4 minutes per side depending on thickness
- Tenderloin; about 4 minutes per side.

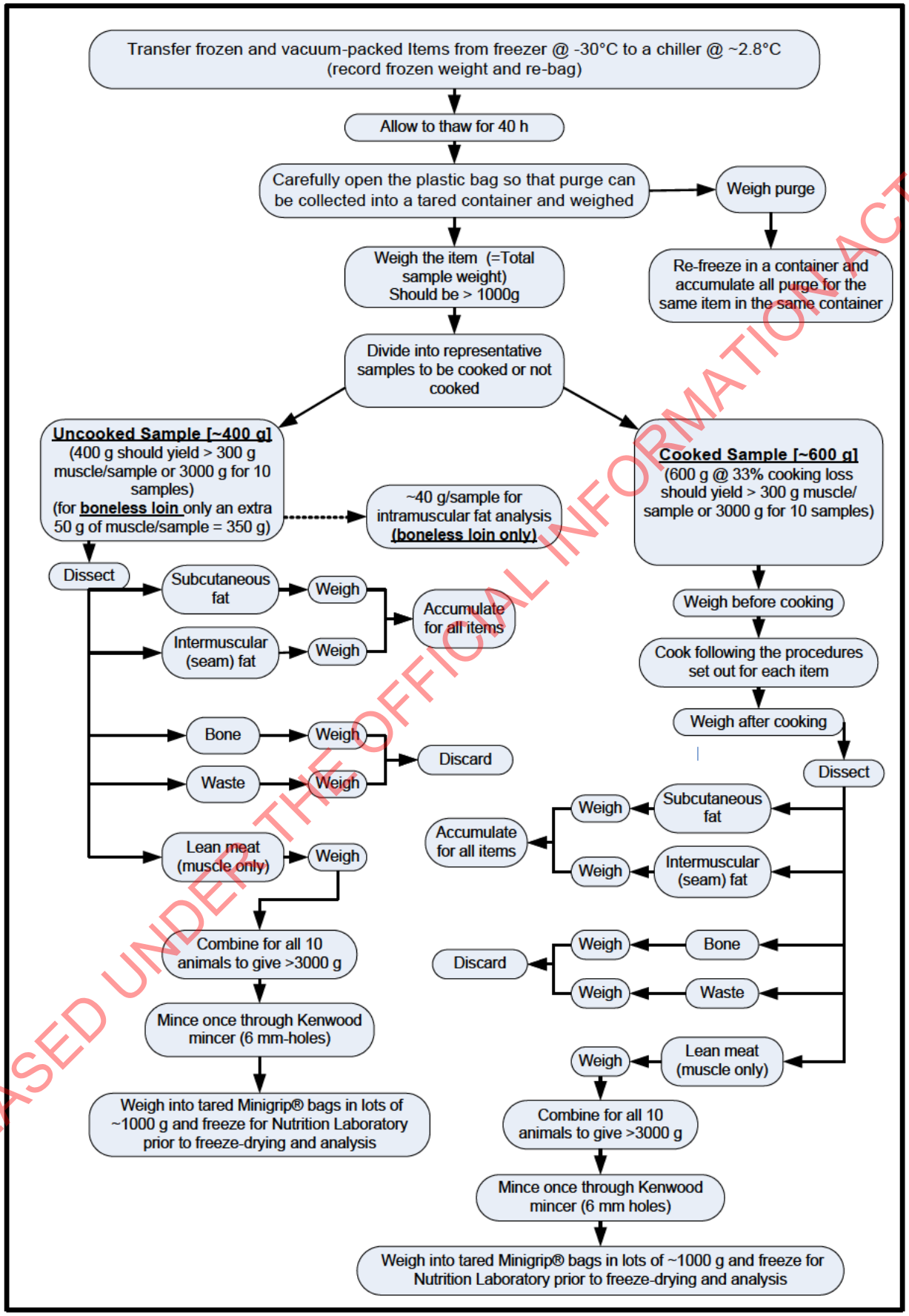
Chops, Etc to "Stew Or Braise" in Water: Both sides of an item were browned in a pre-heated non-stick skillet (2 minutes per side) and then transferred to a Pyrex casserole with added water (800 mL/kg of sample), covered with a tight-fitting lid, and cooked in an oven pre-heated to 160°C for the times given with each item.

- Shoulder/forequarter chops (2 hours)
- Lamb neck chops (4 hours)
- Breast; as 2.5cm cubes with browning for 4 minutes. (2 hours).
- Hind-Shank and Fore-shank – (3 hours after browning for 4 minutes).

Items to Boil or Simmer: Items in lots of about 500 g were placed in "Boil-in-the-Bag" bags with 400 mL water per 500 g of product. The bags were heat-sealed and cooked in a steam-jacket-heated kettle for the time specified, at temperatures between 95 and 100°C. After cooking the fluid was poured off and the sample re-weighed after cooling for ~20 minutes.

- Ground Lamb Mince – (20 min)
- Boneless Flap – (2 h)

Figure L1: A flow diagram summarizing the steps involved in processing the samples of lamb cuts and offal items up to the stage when they were ready to be freeze-dried.



Offal : All offal was trimmed of visible fat, membranous material, cores, tubes or valves and re-weighed. The weights of trimmings were recorded.

Livers, sweetbreads, brains, hearts, tongues and testes were soaked in five times their weight in cold water, three times for five minute each time (to remove as much blood as possible) before cooking.

- Liver – slices of ~15 mm were fried on moderate heat for 4 minutes per side.
- Kidneys –slices of ~15 mm were cut from halved kidneys and fried on moderate heat for 4 minutes per side.
- Hearts –The "Boil-in-the-Bag" procedure outlined above was used to simmer for 1.5 hours.
- Sweetbreads – The "Boil-in-the-Bag" procedure outlined above was used to simmer for 20 min. They were then drained and refreshed under cold running water for 30 seconds to cool. Membranes and black veins were removed after cooking.
- Tongues – The "Boil-in-the-Bag" procedure outlined above was used to simmer for 20 min. They were then drained and refreshed under cold running water for 30 seconds to cool. Skin was peeled and fat or bones were removed after cooking.
- Brains – The "Boil-in-the-Bag" procedure outlined above was used to simmer for 20 min. They were then drained and refreshed under cold running water for 30 seconds to cool. Each brain or lobe was cut into slices of about 15 mm and fried in a non-stick skillet on moderate heat for 3.5 min/side.
- Testes – The "Boil-in-the-Bag" procedure as outlined above was used to simmer for 20 min *(taking care not to over-boil to prevent testes "popping").* They were then drained and refreshed under cold running water for 30 seconds to cool. After peeling away the outer membrane, slices (~15 mm) were fried in a non-stick skillet on moderate heat for 2 minutes each side until the colour changed to golden.

d) ***Laboratory Procedures:*** Laboratory procedures for individual nutrients along with measures of the sensitivity of the methods are provided in Appendix 1. Prior to analysis the lots of approximately 1000 g of minced lean tissue were freeze-dried (approximately 3.5 days with a maximum temperature of 20°C in a Cuddons 0610 model freeze dryer) and then ground to a fine powder (Magimix Automatic 5100 food processor) in order to provide an homogenous product that could be sampled for all assays. These were stored in sealed plastic bags at less than -20°C.

e) ***Data Analysis:*** Because the analysis of nutrients was carried out on a single composite for the cooked and uncooked samples of each item, it was not possible to determine whether there were statistically significant differences between items or to determine the level of variability between samples within an item for nutrients, except in the case of intramuscular fat of the striploin cut.

It would have been possible to have determined the statistical significance of differences in the dissected composition between cuts and/or offal items, but there was little point in carrying out such analyses in light of the nature of the items. The averages and standard deviations in Table L3 provide an indication of the extent to which samples within the different items differed in their averages and degree of variation.

Paired t-tests were used to determine the significance of differences in dissectible components of each item before and after cooking.

Percent true retention values for individual nutrients as estimates of the amount of a nutrient in the raw lean sample that was retained in the cooked lean sample expressed as percentages, were calculated using the following equation:

%Retention = [(CookedConc) x ((100 – CookingLoss%)/100) x 100]/[UncookedConc]

A percentage retention of 100 indicates that all the nutrient has been retained and will often be associated with a higher concentration of the nutrient in the cooked sample because of the loss of water during cooking. A percent retention of greater than 100 suggests that the nutrient has been transferred to the lean tissue from other tissues during cooking. These estimated percent retention values are, however, approximations as they are based on average cooking loss percentages, and the samples cooked were not identical to the uncooked samples. Also, the percent retention value refers

to the lean tissue only, but the item was cooked before it had been dissected into its component parts. Therefore, any movement of a nutrient between the parts (muscle, fat & bone) during cooking will influence the value obtained.

Energy content was estimated from the content of protein and fat according to the following equation:

Energy(kJ/100 g) = [Protein(g/100g) x 16.7] + [Fat(g/100g) x 37.4]

The coefficients in this equation are those given by Livesey (2001; *British Journal of Nutrition, 85*: 271-287) for the calculation of metabolisable energy.

Energy in terms of kcal/100 g can be calculated by dividing the value in kJ/100 g by 4.184. Note that 1 kcal = 1 Calorie (with a capital "C").

L-4. Results (Lamb Section)

a) ***Cooking and Dissection results***: Summaries of results for the 25 items processed are given in Tables L2, L3, L4, & L5. Points to note from the data in Tables L2, L3, and L4 include the following:

1. For all items there were either 7, 8, 9, or 10 samples processed (Table L2). The mean weights for the different items varied widely with heavier weights for those items that were expected to have a high fat and/or bone content. Thus, items with mean frozen weights of >1800 g included boneless flap, breast, fore and hind shanks, loin saddle, fully frenched rack, and square-cut shoulder. There was also considerable variation between samples within some items as shown by the standard deviations (Table L2).
2. The purge percentage represents the loss in weight due to fluid loss during the standard thawing treatment of 40 ±1 hours at 2.5 to 3.0°C. For the lamb-cuts the purge percent varied from a low of 0.02% for the boneless flap and breast to a high of 5.5% for the boneless loin. It is not possible to be definite about the reasons for the differences in the purge percent, but they may have been due in part to the extent of fat cover, the sample size, and the extent to which the muscle had been cut across in preparing the samples of approximately 1 kg, as well as to any intrinsic differences in meat water-holding capacity.
3. The purge percentage for the offal items varied from a low value of 0.47% for the testes to a high of 6.09% for the liver. These items vary widely in their structure and the nature of the tissues they contain, so it is not possible to suggest meaningful reasons for the differences shown.
4. As with the beef samples, the purge percentages for most lamb items were characterised by having high standard deviations relative to the averages.
5. Comparisons of cooking loss percentages between the different items (Table L2) need to be made with care because of the different cooking procedures used as outlined above. Generally the cooking loss values for most items were less variable than those for purge percentages.
6. For the lamb cuts, average cooking loss percentage ranged from a low of 14.96% for loin saddle to a high of 38.51% for square-cut shoulder chops.
7. Cooking loss percentages for the offal items ranged from a low of 21.11% for liver samples to 47.49% for testes.
8. The compositions of the cooked and uncooked items are shown in Table L3 as percentages of the total following dissection of each item into the components shown using a boning knife. Thus, the precision with which the components were separated was not as great as would have been possible with a scalpel, forceps, and scissors, but doing it that way would have been much more time-consuming. When possible, the fat was separated into subcutaneous fat and intermuscular fat, but the distinction between these two depots (Table L4) was often difficult to make (particularly in cooked samples), in which case all the fat was designated intermuscular. The best measures of overall fatness are the "Total dissectible fat" values in Table L3.

9. Results for the dissectible composition of both raw and cooked samples indicated that there was considerable variation between samples within each item. Coefficients of variation (the SD expressed as a percentage of the average) were generally least for the lean portion for most items, largely because this portion usually made up the greatest percentage of the whole.

Points to note from the results in Table L5 include the following:

1. The characteristic of most interest in this table is the difference in the percentage of muscle or lean tissue in the raw samples relative to the cooked samples, but it can be seen that the values varied widely in both size and direction. The P values provide an indication of whether the differences are likely to be real or whether they probably arose by chance, with a lower P value indicating that the associated difference is more likely to be real. Differences are generally not considered to be significant if the P value is greater than 0.05, as was the case for most of the differences in Table L3.
2. Muscle or lean-tissue % made up a greater proportion ($P < 0.05$) of raw samples than cooked samples for fore-shank, hind-shank, kidney, sweetbreads, and testes, but raw samples contained a smaller percentage of muscle or lean-tissue for bone-in leg steak, boneless loin, tongue, and tunnel-boned leg. In some cases these differences were due to differences in the fat content and some to differences in bone and/or waste percentage.
3. Total fat % made up a greater proportion of raw samples than cooked samples (i.e. the difference in Table L5 is positive and the P value is less than 0.05) for bone-in leg steak, boneless loin, square-cut shoulder chops, neck chops, and tunnel-boned leg, but raw samples contained a smaller percentage of total fat for heart and sweetbreads.

Table L2: Results for lamb cuts and offal items showing the number of lots for each item (N) and the averages (±SD) for weight per lot, purge losses as a percentage of frozen weight, and cooking losses as a percentage of uncooked weight.

Cut or offal item	N[a]	Weight/lot[a] (g)	Purge (%)	Cooking loss (%)
FOREQUARTER ITEMS:				
Boneless, rolled, netted shoulder	7	1308.0 ±125.2	1.41 ± 0.61	26.11 ± 2.68
Breast	10	1945.6 ± 119.5	0.02 ± 0.04	35.54 ± 1.60
Fore-shank	10	1828.0 ± 336.0	0.18 ± 0.12	32.34 ± 2.07
Ground lamb	10	1523.2 ± 297.4	0.99 ± 0.52	18.39 ± 2.61
Neck chops	10	1541.5 ± 198.6	0.04 ± 0.04	35.01 ± 2.82
Rack – fully frenched	10	1831.8 ± 254.3	1.30 ± 0.69	16.15 ± 3.81
Rack – partly frenched	10	1537.8 ± 266.2	2.96 ± 2.51	16.16 ± 6.35
Square-cut shoulder	10	1808.2 ± 182.1	0.06 ± 0.04	17.35 ± 2.79
Square-cut shoulder chops	10	1736.8 ± 183.5	1.14 ± 0.53	38.51 ± 1.16
HINDQUARTER ITEMS				
Bone-in leg chop/steak	8	1069.8 ± 40.2	2.33 ± 0.46	17.57 ± 1.69
Boneless chump	8	1096.0 ± 148.9	3.08 ± 0.78	19.83 ± 4.53
Boneless flap	10	2131.2 ± 248.4	0.02 ± 0.04	26.90 ± 4.07
Boneless loin	8	1073.8 ± 217.5	5.46 ± 1.46	28.46 ±1.71
Hind-shank	10	1804.3 ± 188.3	0.20 ± 0.12	33.45 ± 1.87
Loin chop	10	1587.4 ± 141.5	1.54 ± 0.49	22.42 ± 3.37
Loin saddle	10	1988.0 ± 221.6	0.53 ± 0.26	14.96 ± 2.65
Tenderloin	9	882.76 ± 49.6	1.97 ± 0.82	26.08 ± 1.35
Tunnel-boned leg, chump-off, shank-off	8	1341.7 ± 128.4	0.50 ± 0.19	19.66 ± 4.85
OFFAL ITEMS				
Brains	10	1036.7 ± 73.2	1.47 ± 0.25	33.73 ± 3.78
Heart	10	996.3 ± 92.7	2.66 ± 1.00	39.34 ± 2.49
Kidney	10	1002.4 ± 69.7	4.17 ± 1.40	28.81 ± 2.37
Liver	10	934.9 ± 189.4	10.58 ± 1.33	25.90 ± 3.96
Sweetbread	10	914.0 ± 8.0	0.81 ± 0.40	29.20 ± 1.84
Testes	10	1041.5 ± 98.4	0.47 ± 0.34	47.49 ± 2.02
Tongue-Swiss cut	10	1511.8 ± 75.1	2.26 ± 0.23	25.91 ± 0.86

[a] N = the number of lots to produce at least 3 kg of raw and 3 kg of cooked lean tissue. For smaller items there were a number of individual items per lot.

Table L3: Results for lamb cuts and offal items showing the averages (±SD) for muscle, fat, and bone as determined by dissection with a boning knife before or after cooking. For offal items, "muscle" refers to all lean tissue that would normally be consumed.

Cut or offal item	Dissected Muscle %		Dissected fat %		Bone & Waste %	
	Raw	Cooked	Raw	Cooked	Raw	Cooked
FOREQUARTER ITEMS:						
Boneless, rolled, netted shoulder	77.1±5.2	77.3±5.5	20.5±5.6	20.2±4.7	2.4±1.4	2.5±1.3
Breast	35.2±2.7	35.4±1.6	38.9±3.6	36.6±2.4	25.9±3.5	28.0±2.5
Fore-shank	57.4±2.0	52.0±1.9	7.3±1.7	6.6±1.7	35.4±2.5	41.4±2.7
Ground lamb	-	-	-	-	-	-
Neck chops	57.7±2.5	58.1±3.1	10.8±2.4	7.5±3.1	31.6±2.9	34.4±2.7
Rack – fully frenched	70.6±3.2	71.6±2.7	3.4±1.2	3.5±1.3	26.1±3.4	25.0±1.9
Rack – partly frenched	64.9±5.3	66.8±4.3	11.7±3.4	10.3±3.5	23.4±3.2	22.9±3.1
Square-cut shoulder	58.4±4.6	55.8±10.5	17.2±2.4	17.4±6.2	24.5±3.8	26.9±4.6
Square-cut shoulder chops	60.7±5.5	60.8±4.2	17.3±4.9	13.3±3.1	22.0±5.0	26.0±4.0
HINDQUARTER ITEMS						
Bone-in leg chop/steak	73.0±5.0	78.9±3.9	12.5±2.1	9.1±1.5	14.5±4.1	12.0±3.9
Boneless chump	77.5±3.4	79.1±4.1	21.8±3.2	20.8±4.1	0.7±0.4	0.1±0.2
Boneless flap	69.7±9.2	66.7±6.6	29.9±9.4	32.2±6.4	0.4±0.8	1.1±1.1
Boneless loin	99.7±0.2	99.9±0.1	0.3±0.2	0.1±0.1	0	0
Hind-shank	62.2±3.1	59.1±1.8	9.2±2.5	7.4±1.4	28.6±2.2	33.4±2.2
Loin chop	57.0±3.1	56.0±2.1	22.7±4.3	21.7±3.9	20.3±2.7	22.4±2.6
Loin saddle	56.5±4.4	58.1±2.7	19.5±4.5	16.9±3.2	23.9±2.8	25.0±1.9
Tenderloin	99.4±0.5	99.7±0.2	0.7±0.5	0.3±0.2	0	0
Tunnel-boned leg, chump-off, shank-off	85.1±4.0	90.0±2.2	14.9±4.0	10.1±2.2	0.1±0.1	0
OFFAL ITEMS						
Brains	97.9±0.8	97.3±0.7	0	0	2.1±0.8	2.5±0.7
Heart	75.8±3.0	72.3±3.5	14.0±2.0	16.9±2.5	10.2±2.6	10.8±2.6
Kidney	96.4±0.4	95.2±0.4	0	0	3.6±0.4	4.8±0.4
Liver	99.6±0.2	99.0±0.6	0	0	0.4±0.2	1.0±0.6
Sweetbread	97.1±1.9	96.8±1.8	2.7±2.1	3.2±1.8	0.2±0.4	0
Testes	82.8±3.5	75.1±5.2	0.4±0.6	0	16.9±3.1	24.9±5.2
Tongue-Swiss cut	73.6±4.0	82.0±1.6	7.9±2.2	6.5±1.4	18.5±3.5	11.5±1.6

Table L4: Results for lamb cuts and offal items showing the averages (±SD) for the percentage of subcutaneous and intermuscular (seam) fat before or after cooking. Fat was designated intermuscular fat when there was difficulty in distinguishing between subcutaneous and intermuscular fat.

Cut or offal item	Subcutaneous fat %		Intermuscular fat %	
	Raw	Cooked	Raw	Cooked
FOREQUARTER ITEMS:				
Boneless, rolled, netted shoulder	8.9±6.0	7.9±3.1	11.6±2.3	12.3±4.2
Breast	15.2±4.2	12.6±3.0	23.7±2.7	24.0±2.7
Fore-shank	4.2±1.6	3.0±1.2	3.0±1.0	3.6±1.1
Ground lamb	-	-	-	-
Neck chops	5.0±1.1	3.2±1.5	5.8±1.6	4.4±1.9
Rack – fully frenched	0.8±0.7	0.7±0.5	2.6±0.8	2.8±1.0
Rack – partly frenched	7.1±2.2	5.2±2.0	4.6±2.2	5.2±2.0
Square-cut shoulder	6.1±3.0	3.9±1.1	11.1±3.9	13.5±7.0
Square-cut shoulder chops	5.6±2.2	6.3±1.5	11.7±4.0	7.0±2.9
HINDQUARTER ITEMS				
Bone-in leg chop/steak	5.9±1.5	5.4±2.0	6.6±2.4	3.7±1.4
Boneless chump	16.7±2.9	14.4±2.7	5.1±1.3	6.4±2.4
Boneless flap	17.5±4.5	20.9±6.0	12.5±5.9	11.3±3.2
Boneless loin	0	0	0.3±0.2	0.1±0.1
Hind-shank	7.5±2.3	4.8±1.3	1.7±0.6	2.6±0.9
Loin chop	15.5±3.5	14.3±3.6	7.2±1.5	7.4±1.5
Loin saddle	13.5±4.0	12.1±2.7	6.1±1.3	4.8±1.0
Tenderloin	0	0	0.7±0.5	0.3±0.2
Tunnel-boned leg, chump-off, shank-off	6.9±1.2	5.4±1.3	8.0±3.7	4.6±1.5
OFFAL ITEMS				
Brains	0	0	0	0
Heart	0	0	14.0±2.0	16.9±2.5
Kidney	0	0	0	0
Liver	0	0	0	0
Sweetbread	0	0	2.72±2.1	3.2±1.8
Testes	0	0	0.4±0.6	0
Tongue-Swiss cut	5.9±1.4	5.4±0.9	2.0±1.5	1.2±0.8

Table L5: Differences in the percentage composition of raw and cooked samples for the 25 lamb cut and offal items processed. The differences for muscle (or lean tissue for offal items), total fat, and bone and/or waste are expressed as the **raw value minus the cooked value**. Thus, positive values indicate that levels were higher in the uncooked (raw) sample. The statistical significance of differences are given as P values from t-tests. Items are listed in this table in alphabetical order.

	N	Δ-Muscle %		Δ-Total fat %		Δ-Bone and/or waste%	
		Mean ±SD	P	Mean ±SD	P	Mean ±SD	P
Bone-in leg steak	8	-5.93 ± 5.94	0.026	3.47 ± 2.18	0.003	2.46 ± 5.00	0.21
Boneless chump	8	-1.55 ± 3.34	0.23	1.01 ± 3.09	0.39	0.54 ± 0.44	0.010
Boneless flap	8	4.35 ± 8.84	0.21	-3.38 ± 9.30	0.34	-0.96 ± 1.33	0.08
Boneless loin	8	-0.21 ± 0.18	0.014	0.21 ± 0.18	0.014	-	-
Boneless rolled, netted shoulder	7	-0.24 ± 6.59	0.93	0.30 ± 5.81	0.90	-0.06 ± 1.73	0.93
Brains	10	0.38 ± 1.00	0.27	-	-	-0.38 ± 1.00	0.27
Breast	9	-0.22 ± 3.38	0.84	2.28 ± 5.10	0.19	-2.06 ± 5.05	0.23
Chops from square-cut shoulder	10	-0.07 ± 5.76	0.97	4.00 ± 3.74	0.008	-3.93 ± 5.52	0.051
Fore-shank	10	5.39 ± 2.64	0.0001	0.69 ± 2.60	0.42	-6.07 ± 3.30	0.0003
Ground lamb	10	-	-	-	-	-	-
Heart	10	3.57 ± 5.01	0.051	-2.97 ± 3.13	0.015	-0.59 ± 4.12	0.66
Hind shank	8	3.66 ±2.83	0.008	1.94 ± 2.51	0.07	-5.61 ± 3.32	0.002
Kidney	10	1.15 ± 0.39	<0.0001	-	-	-1.15 ± 0.39	<0.0001
Liver	10	0.62 ± 0.70	0.021*	-	-	-0.62 ± 0.70	0.021*
Loin chop	10	1.06 ± 3.51	0.37	0.99 ± 4.25	0.48	-2.04 ± 3.51	0.10
Loin saddle	7	-1.81 ± 5.42	0.41	2.94 ± 5.44	0.20	-1.13 ± 4.02	0.49
Neck chops	10	-0.39 ± 3.50	0.73	3.23 ± 3.85	0.026	-2.84 ± 4.05	0.054
Rack, fully frenched	10	-1.01 ± 4.25	0.47	-0.10 ± 2.02	0.88	1.11 ± 3.21	0.30
Rack, partly frenched	10	-1.91 ± 4.88	0.25	1.40 ± 5.37	0.43	0.51 ± 2.84	0.59
Square-cut shoulder	7	3.84 ± 14.56	0.51	-1.05 ±6.77	0.70	-2.79 ± 8.25	0.41
Sweetbreads	4	0.83 ± 0.49	0.043	-1.01 ± 0.59	0.042	0.18 ± 0.35	0.39
Tenderloin	9	-0.31 ± 0.47	0.08	0.31 ± 0.47	0.08	-	-
Testes	10	7.68 ± 6.60	0.005	0.36 ± 0.64	0.11	-8.03 ± 6.29	0.003
Tongue	9	-7.84 ± 3.54	0.0002	1.42 ± 2.40	0.11	6.41 ± 2.16	<0.0001
Tunnel-boned leg, chump- & shank-off	8	-4.90 ± 5.18	0.031	4.87 ± 5.16	0.032	0.04 ± 0.11	0.35

b) ***Nutrient Composition by Nutrient:*** Tables L6 to L12 below give the nutrient composition of the 25 lamb cuts and offal items arranged by each nutrient item, so that each table contains the information for all 25 items for several nutrients.

This is followed in Section c) where Tables L13 to L18 give the same information arranged so that all the nutrients for a particular item (lamb cut or offal item) are shown in the same table. The acronym "BDL" in these tables indicates that the nutrient concentration was below detectable limits.

Table L6: Composition of the cooked (CKD) and raw lean portion of 25 lamb cuts and offal items in terms of the concentrations of water, energy, protein and fat, together with estimated percentage true retention (%Ret) of each item.

	Water (%)			Energy (kJ/100 g)			Protein (%)			Fat (%)		
Cut or offal item	**Ckd**	**Raw**	**%Ret**	**Ckd**	**Raw**	**%Ret**	**Ckd**	**Raw**	**%Ret**	**Ckd**	**Raw**	**%Ret**
FOREQUARTER ITEMS:												
Boneless, rolled, netted shoulder	64.2	72.9	**65.1**	828	595	**102.8**	25.1	20.2	**91.9**	10.9	6.9	**117.2**
Breast	54.8	71.7	**49.2**	1126	604	**120.1**	28.2	18.3	**99.1**	17.5	8.0	**141.7**
Fore-shank	59.3	74.5	**53.9**	870	509	**115.7**	33.3	22.1	**102.2**	8.4	3.8	**150.9**
Ground lamb	66.6	69.3	**78.4**	802	803	**81.4**	22.6	20.3	**90.7**	11.3	12.4	**74.6**
Neck chops	54.6	72.4	**49.0**	1099	630	**113.4**	31.4	19.8	**102.8**	15.4	8.0	**125.2**
Rack - fully frenched	66.7	71.7	**78.0**	721	611	**99.0**	24.4	20.6	**99.2**	8.4	7.1	**98.6**
Rack - Partly frenched	65.0	70.2	**77.5**	805	667	**101.3**	24.4	20.7	**99.2**	10.6	8.6	**103.5**
Square-cut shoulder	65.0	72.5	**74.0**	798	640	**103.1**	25.1	19.7	**105.1**	10.1	8.3	**100.9**
Square-cut shoulder chops	55.4	72.0	**47.3**	1063	684	**95.6**	31.1	20.6	**92.6**	14.6	9.1	**98.6**
HINDQUARTER ITEMS:												
Bone-in leg chop/steak	67.6	74.3	**74.9**	677	526	**106.0**	26.3	21.1	**102.8**	6.3	4.6	**112.6**
Boneless chump	70.6	74.6	**75.9**	592	505	**94.0**	23.7	21.7	**87.6**	5.3	3.8	**110.1**
Boneless flap	60.1	69.5	**63.2**	974	749	**95.1**	27.9	21.7	**93.8**	13.6	10.3	**96.4**
Boneless loin	66.7	74.5	**64.0**	652	500	**93.3**	29.0	21.5	**96.5**	4.5	3.8	**85.3**
Hind-shank	60.9	74.5	**54.4**	818	466	**116.8**	32.5	20.4	**106.0**	7.4	3.4	**146.2**
Loin chop	60.2	71.4	**65.4**	858	591	**112.6**	27.4	20.0	**106.5**	10.7	6.9	**120.6**
Loin saddle	68.3	73.5	**79.0**	677	547	**105.2**	25.5	20.9	**104.1**	6.7	5.3	**107.1**
Tenderloin	66.4	74.4	**66.0**	646	486	**98.4**	27.9	20.5	**100.6**	4.8	3.8	**93.2**
Tunnel-boned leg, chump off, shank off	68.1	74.4	**73.6**	663	503	**106.0**	25.3	20.9	**97.1**	6.4	4.1	**126.4**
All-cuts averages	**63.4**	**72.7**	**66.1**	**815**	**590**	**103.3**	**27.3**	**20.6**	**98.8**	**9.6**	**6.6**	**111.6**
OFFAL ITEMS:												
Brains	73.1	78.5	**61.7**	643	489	**87.0**	14.0	11.3	**82.1**	10.9	8.0	**90.1**
Heart	66.6	77.8	**51.9**	671	440	**92.5**	26.3	18.1	**88.1**	6.2	3.7	**102.3**
Kidney	75.1	81.0	**66.0**	464	349	**94.5**	19.8	15.2	**92.6**	3.6	2.5	**99.7**
Liver	64.6	70.8	**67.6**	678	529	**94.3**	25.8	20.7	**92.0**	6.6	4.9	**98.8**
Sweetbread	72.6	79.5	**64.7**	600	436	**97.4**	21.1	15.8	**94.7**	6.6	4.6	**101.7**
Testes	74.0	85.0	**45.7**	522	279	**98.1**	21.0	11.4	**96.8**	4.6	2.4	**100.9**
Tongue - Swiss cut	58.7	66.5	**65.4**	1117	934	**88.6**	17.5	14.3	**90.9**	22.0	18.6	**87.7**
Offal averages	**69.2**	**77.0**	**60.4**	**670**	**493**	**93.2**	**20.7**	**15.2**	**91.0**	**8.6**	**6.3**	**97.3**

Table L7: Composition of the cooked (CKD) and raw lean portion of 25 lamb cuts and offal items in terms of the concentrations of ash, and vitamins B1, B2, and B3, together with estimated percentage true retention (%Ret) of each item.

	Ash (%)			Vitamin B1 (mg/100 g) (Thiamine)			Vitamin B2 (mg/100 g) (Riboflavin)			Vitamin B3 (mg/100 g) (Niacin)		
Cut or offal item	**Ckd**	**Raw**	**%Ret**	**Ckd**	**Raw**	**%Ret**	**Ckd**	**Raw**	**%Ret**	**Ckd**	**Raw**	**%Ret**
FOREQUARTER ITEMS:												
Boneless, rolled, netted shoulder	1.14	0.98	85.7	0.116	0.138	62.2	0.19	0.14	98.1	4.3	5.2	60.8
Breast	0.75	1.00	48.6	0.026	0.055	30.9	0.13	0.16	52.7	3.7	4.9	47.6
Fore-shank	0.96	1.02	64.0	0.044	0.101	29.2	0.15	0.10	96.6	4.1	4.5	62.2
Ground lamb	1.38	0.86	131.4	0.020	0.059	27.0	0.15	0.18	71.1	3.3	5.0	53.9
Neck chops	1.11	1.00	72.2	0.026	0.080	21.0	0.14	0.14	63.0	4.2	4.3	62.8
Rack - fully frenched	1.13	0.97	97.4	0.057	0.061	78.3	0.21	0.18	99.0	6.3	5.2	100.9
Rack - Partly frenched	1.09	0.94	96.9	0.060	0.084	60.1	0.20	0.19	88.9	6.7	5.7	97.8
Square-cut shoulder	1.09	0.98	92.4	0.056	0.099	46.2	0.23	0.16	116.9	4.2	3.5	101.1
Square-cut shoulder chops	1.18	1.00	72.4	0.031	0.068	28.4	0.21	0.18	73.1	2.9	3.9	46.1
HINDQUARTER ITEMS:												
Bone-in leg chop/steak	1.26	1.08	96.5	0.138	0.175	64.8	0.15	0.17	71.6	6.4	5.2	100.5
Boneless chump	1.20	1.24	77.2	0.138	0.154	71.8	0.19	0.13	118.1	3.6	5.3	54.5
Boneless flap	0.69	0.98	51.3	0.014	0.043	23.8	0.15	0.14	78.0	3.3	4.6	52.9
Boneless loin	1.30	1.17	79.5	0.062	0.072	61.1	0.19	0.16	82.5	7.1	6.4	80.3
Hind-shank	1.10	1.02	71.8	0.030	0.064	31.2	0.24	0.16	98.1	4.5	4.9	61.0
Loin chop	1.25	1.05	92.2	0.097	0.119	63.2	0.22	0.15	111.8	6.7	5.4	95.6
Loin saddle	1.10	1.04	89.9	0.119	0.118	85.3	0.22	0.14	138.5	6.4	5.9	92.5
Tenderloin	1.44	1.35	79.1	0.101	0.075	99.7	0.30	0.21	101.8	9.1	7.3	92.1
Tunnel-boned leg, chump off, shank off	1.17	1.14	82.6	0.107	0.140	61.3	0.25	0.20	98.7	5.9	5.2	90.4
All-cuts averages	**1.13**	**1.05**	**82.3**	**0.069**	**0.095**	**52.5**	**0.20**	**0.16**	**92.1**	**5.1**	**5.1**	**75.2**
OFFAL ITEMS:												
Brains	3.39	2.52	89.2	0.084	0.102	54.8	0.22	0.20	71.8	3.0	3.8	52.1
Heart	0.94	1.13	50.2	0.229	0.519	26.7	0.84	0.54	94.6	4.2	5.8	44.6
Kidney	1.41	1.19	84.3	0.462	0.413	79.5	1.53	1.28	85.1	9.1	8.4	76.6
Liver	1.56	1.36	84.5	1.57	1.21	96.1	5.27	4.21	92.8	12.8	13.7	69.2
Sweetbread	2.58	1.35	94.1	0.075	0.078	67.7	0.10	0.10	70.0	1.4	1.9	50.4
Testes	1.50	1.08	73.1	0.312	0.315	52.0	0.31	0.21	77.0	2.2	1.7	66.9
Tongue - Swiss cut	0.84	0.77	80.6	0.036	0.100	26.9	0.34	0.29	86.4	2.3	3.1	54.7
Offals averages	**1.75**	**1.34**	**79.4**	**0.395**	**0.391**	**57.7**	**1.23**	**0.98**	**82.5**	**5.0**	**5.5**	**59.2**

Table L8: Composition of the cooked (CKD) and raw lean portion of 25 lamb cuts and offal items in terms of the concentrations of vitamins B5, B6, B12, and vitamin A, together with estimated percentage true retention (%Ret) of each item.

	Vitamin B5 (mg/100 g) (pantothenic acid)			Vitamin B6 (mg/100 g) (Pyridoxine)			Vitamin B12 (µg/100 g) (Cyanocobalamin)			Vitamin A (µg/100 g) (Retinol)		
Cut or offal item	**Ckd**	**Raw**	**%Ret**	**Ckd**	**Raw**	**%Ret**	**Ckd**	**Raw**	**%Ret**	**Ckd**	**Raw**	**%Ret**
FOREQUARTER ITEMS:												
Boneless, rolled, netted shoulder	0.8	0.6	101.9	0.118	0.113	77.3	2.3	2.4	70.3	5.7	4.8	88.1
Breast	0.4	0.5	49.8	0.089	0.143	40.2	1.4	2.0	47.4	4.8	9.3	33.1
Fore-shank	0.5	0.5	72.0	0.077	0.101	51.2	1.4	2.2	41.6	3.1	3.1	67.7
Ground lamb	0.1	0.2	53.1	0.134	0.132	82.5	1.0	1.6	48.1	8.0	7.8	83.1
Neck chops	0.4	0.3	80.1	0.077	0.121	41.4	2.0	2.9	44.9	8.3	5.2	102.8
Rack - fully frenched	0.6	0.6	88.8	0.291	0.246	99.2	1.3	1.1	104.3	3.4	5.0	57.2
Rack - Partly frenched	0.4	0.5	72.9	0.170	0.181	79.0	1.2	1.3	83.3	4.3	5.0	72.3
Square-cut shoulder	0.5	0.3	137.0	0.189	0.140	111.7	2.7	2.3	95.5	1.2	4.1	24.3
Square-cut shoulder chops	0.6	0.3	127.4	0.110	0.063	106.8	2.4	2.5	59.0	7.8	6.3	76.8
HINDQUARTER ITEMS:												
Bone-in leg chop/steak	0.7	0.6	109.2	0.166	0.137	100.0	2.3	1.6	113.2	1.8	2.6	56.7
Boneless chump	0.9	0.8	86.5	0.175	0.150	93.6	2.1	2.1	80.2	5.0	4.6	87.7
Boneless flap	0.3	0.5	51.6	0.091	0.115	57.7	1.5	2.1	52.4	9.5	9.0	77.6
Boneless loin	0.8	0.5	103.1	0.205	0.176	83.4	1.4	1.1	88.7	0.9	1.7	35.4
Hind-shank	0.2	0.5	27.1	0.103	0.148	46.4	1.6	1.4	74.2	2.4	2.2	72.5
Loin chop	0.8	0.5	119.1	0.189	0.160	91.4	1.8	1.9	75.0	6.0	4.8	97.0
Loin saddle	0.5	0.4	98.4	0.206	0.175	100.1	1.6	1.1	122.2	4.8	4.4	93.7
Tenderloin	1.1	0.9	90.8	0.281	0.247	84.1	2.4	1.9	95.0	1.5	1.4	80.0
Tunnel-boned leg, chump off, shank off	0.8	0.7	97.6	0.275	0.225	98.4	1.6	1.9	66.8	2.5	3.2	61.4
All-cuts averages	**0.6**	**0.5**	**87.0**	**0.164**	**0.154**	**80.2**	**1.8**	**1.9**	**75.7**	**4.5**	**4.7**	**70.4**
OFFAL ITEMS:												
Brains	1.9	1.9	65.2	0.081	0.087	61.7	9.5	10.0	63.3	2.3	3.1	50.0
Heart	1.8	2.2	49.4	0.125	0.144	52.8	9.2	8.4	66.3	3.5	5.4	40.2
Kidney	4.6	3.2	101.2	0.230	0.173	94.7	55.6	50.4	78.5	85.2	61.3	98.8
Liver	5.2	5.6	69.5	0.187	0.218	67.8	57.5	59.0	72.2	19872.0	15434.0	101.6
Sweetbread	0.7	1.0	51.7	BDL	BDL	-	2.5	2.6	68.1	8.4	5.8	103.9
Testes	0.8	0.9	46.2	0.038	0.033	59.7	8.9	9.9	47.1	21.5	10.1	112.2
Tongue - Swiss cut	0.6	0.4	97.4	0.077	0.097	59.2	5.2	6.1	63.4	1.4	5.4	19.3
Offals averages	**2.2**	**2.2**	**68.7**	**0.123**	**0.125**	**66.0**	**21.2**	**20.9**	**65.6**	**2856.3**	**2217.9**	**72.1**

Table L9: Composition of the cooked (CKD) and raw lean portion of 25 lamb cuts and offal items in terms of the concentrations of vitamins D3, 25-OH D3, vitamin E, and cholesterol, together with estimated percentage true retention (%Ret) of each item. It was not possible to obtain reliable values for vitamin D3 for the brain because of interfering substances.

	Vitamin D3 (µg/100 g)			25-OH Vit D3 (µg/100 g)			Vitamin E (mg/100 g)			Cholesterol (mg/100 g)		
Cut or offal item	**Ckd**	**Raw**	**%Ret**	**Ckd**	**Raw**	**%Ret**	**Ckd**	**Raw**	**%Ret**	**Ckd**	**Raw**	**%Ret**
FOREQUARTER ITEMS:												
Boneless, rolled, netted shoulder	0.05	0.04	102.3	0.162	0.184	65.1	0.34	0.21	123.3	78.7	57.6	101.0
Breast	0.04	0.04	68.1	0.106	0.102	66.9	0.39	0.31	82.1	101.8	65.0	101.0
Fore-shank	0.04	0.02	146.0	0.135	0.137	66.4	0.43	0.18	164.2	114.8	64.6	120.2
Ground lamb	0.04	0.03	119.5	0.083	0.113	59.4	0.40	0.24	133.6	71.2	63.5	91.6
Neck chops	0.04	0.02	106.3	0.117	0.118	64.1	0.57	0.24	153.1	121.3	70.8	111.4
Rack - fully frenched	0.14	0.09	127.2	0.288	0.182	132.7	0.29	0.32	76.3	72.1	61.9	97.7
Rack - Partly frenched	0.03	0.02	131.0	0.081	0.048	141.9	0.37	0.28	111.9	76.4	63.5	100.8
Square-cut shoulder	0.12	0.17	59.1	0.176	0.165	88.1	0.22	0.40	45.2	70.5	55.6	104.9
Square-cut shoulder chops	0.18	0.12	91.2	0.109	0.168	39.7	0.63	0.39	99.5	99.1	59.1	103.2
HINDQUARTER ITEMS:												
Bone-in leg chop/steak	0.04	0.03	117.3	0.104	0.167	51.0	0.20	0.14	123.2	78.3	65.8	98.0
Boneless chump	0.02	0.02	97.0	0.093	0.109	68.6	0.33	0.32	81.5	74.4	65.3	91.4
Boneless flap	0.03	0.03	92.1	0.076	0.092	60.2	0.34	0.37	68.4	78.2	58.0	98.5
Boneless loin	0.03	0.03	97.3	0.145	0.095	109.5	0.34	0.33	73.6	86.3	65.6	94.1
Hind-shank	0.04	0.04	60.2	0.142	0.156	60.7	0.52	0.29	117.3	115.5	61.8	124.4
Loin chop	0.06	0.05	90.2	0.081	0.085	74.0	0.36	0.22	129.6	85.0	66.2	99.6
Loin saddle	0.02	0.02	97.8	0.180	0.166	92.3	0.28	0.22	108.2	78.1	66.1	100.5
Tenderloin	0.04	0.02	123.2	0.105	0.094	82.9	0.55	0.41	100.1	94.1	68.5	101.5
Tunnel-boned leg, chump off, shank off	0.01	0.01	50.2	0.110	0.127	69.3	0.33	0.30	89.0	79.3	64.3	99.1
All-cuts averages	**0.05**	**0.04**	**98.7**	**0.127**	**0.128**	**77.4**	**0.38**	**0.29**	**104.5**	**87.5**	**63.5**	**102.2**
OFFAL ITEMS:												
Brains	-	-	-	0.053	0.057	61.8	1.12	0.87	85.4	2559.2	2099.6	80.8
Heart	0.05	0.03	102.4	0.229	0.182	76.3	0.63	0.65	58.8	186.4	119.4	94.7
Kidney	0.21	0.13	116.8	0.275	0.276	70.8	0.57	0.42	95.9	507.5	369.1	97.9
Liver	BDL	BDL	-	0.525	0.497	83.4	1.13	0.86	103.7	566.0	386.0	108.7
Sweetbread	0.16	0.13	84.2	0.171	0.077	157.0	1.13	0.69	116.0	462.4	230.0	142.3
Testes	0.02	0.01	134.2	0.133	0.152	45.8	0.85	0.31	144.1	523.4	392.8	70.0
Tongue - Swiss cut	0.30	0.12	178.1	0.113	0.181	46.4	0.16	0.57	21.5	125.6	87.9	105.8
Offals averages	**0.15**	**0.08**	**123.1**	**0.214**	**0.203**	**77.4**	**0.80**	**0.62**	**102.3**	**704.4**	**526.4**	**100.0**

Table L10: Composition of the cooked (CKD) and raw lean portion of 25 lamb cuts and offal items in terms of the concentrations of calcium, copper, iodine, and iron, together with estimated percentage true retention (%Ret) of each item.

	Calcium (mg/100 g)			Copper (mg/100 g)			Iodine (µg/100 g)			Iron (mg/100 g)		
Cut or offal item	**Ckd**	**Raw**	**%Ret**	**Ckd**	**Raw**	**%Ret**	**Ckd**	**Raw**	**%Ret**	**Ckd**	**Raw**	**%Ret**
FOREQUARTER ITEMS:												
Boneless, rolled, netted shoulder	7.29	4.74	113.7	0.12	0.09	94.1	1.2	1.3	63.6	1.4	1.2	87.9
Breast	25.39	13.29	123.1	0.14	0.09	99.7	1.2	2.8	28.2	1.9	1.1	106.4
Fore-shank	11.27	7.06	108.0	0.14	0.09	106.4	1.4	1.5	62.3	2.2	1.4	110.7
Ground lamb	4.02	4.08	80.4	0.10	0.09	90.3	2.5	2.5	79.8	1.3	1.0	99.6
Neck chops	58.10	22.50	167.8	0.12	0.09	92.2	3.0	2.1	95.2	2.3	1.2	119.5
Rack - fully frenched	11.30	7.70	123.1	0.13	0.10	101.2	2.7	1.7	133.2	1.8	1.4	105.9
Rack - Partly frenched	22.20	11.50	161.8	0.12	0.11	89.7	1.3	1.0	102.3	1.6	1.4	96.8
Square-cut shoulder	14.07	12.15	95.7	0.11	0.09	102.5	2.5	2.2	93.4	1.5	1.1	108.0
Square-cut shoulder chops	39.97	26.58	92.5	0.14	0.09	99.3	1.4	1.6	54.3	1.9	1.2	98.7
HINDQUARTER ITEMS:												
Bone-in leg chop/steak	10.49	10.69	80.9	0.16	0.12	108.8	0.5	0.4	111.2	2.0	1.6	102.2
Boneless chump	4.35	4.37	79.8	0.16	0.14	90.2	1.6	0.8	160.3	1.7	1.5	91.2
Boneless flap	8.50	6.71	92.6	0.09	0.07	98.8	1.7	1.7	73.1	1.2	1.0	92.0
Boneless loin	6.18	4.23	104.5	0.17	0.13	94.1	2.8	1.2	166.9	2.1	1.6	94.6
Hind-shank	7.78	5.03	102.8	0.16	0.11	96.9	1.2	1.0	80.6	2.1	1.5	96.6
Loin chop	41.50	18.40	175.0	0.15	0.12	101.3	1.5	2.3	50.2	1.9	1.5	95.9
Loin saddle	7.60	6.90	93.7	0.14	0.12	100.8	1.2	1.0	101.5	1.6	1.5	88.2
Tenderloin	5.18	4.04	94.8	0.18	0.14	98.1	2.2	0.8	203.3	2.1	1.6	96.2
Tunnel-boned leg, chump off, shank off	4.08	3.93	83.4	0.16	0.12	101.3	1.4	1.7	66.2	1.7	1.4	98.3
All-cuts averages	**16.07**	**9.66**	**109.6**	**0.14**	**0.11**	**98.1**	**1.7**	**1.5**	**95.9**	**1.8**	**1.4**	**99.4**
OFFAL ITEMS:												
Brains	5.70	3.60	104.9	0.28	0.30	62.9	1.8	1.4	88.1	1.2	1.1	74.8
Heart	5.48	4.65	71.6	0.64	0.41	94.5	1.7	1.4	74.0	4.9	3.3	91.2
Kidney	9.47	7.91	85.3	0.41	0.36	81.9	5.9	4.6	91.5	14.7	6.6	158.6
Liver	5.00	4.20	88.7	13.4	11.4	87.1	4.7	5.8	59.6	5.4	4.6	86.4
Sweetbread	5.80	3.5	117.3	0.08	0.06	88.5	6.7	3.1	107.1	1.1	0.8	93.6
Testes	8.21	5.29	81.4	0.13	0.09	73.5	3.8	5.2	38.5	1.7	1.1	78.0
Tongue - Swiss cut	6.36	6.05	77.9	0.20	0.15	96.7	1.9	1.3	109.1	1.7	1.2	103.2
Offal averages	**6.57**	**5.03**	**89.6**	**2.1**	**1.8**	**83.6**	**3.7**	**3.2**	**81.1**	**4.4**	**2.7**	**98.0**

Table L11: Composition of the cooked (CKD) and raw lean portion of 25 lamb cuts and offal items in terms of the concentrations of magnesium, manganese, phosphorus, and potassium, together with estimated percentage true retention (%Ret) of each item.

	Magnesium (mg/100 g)			Manganese (µg/100 g)			Phosphorus (mg/100 g)			Potassium (mg/100 g)		
Cut or offal item	**Ckd**	**Raw**	**%Ret**	**Ckd**	**Raw**	**%Ret**	**Ckd**	**Raw**	**%Ret**	**Ckd**	**Raw**	**%Ret**
FOREQUARTER ITEMS:												
Boneless, rolled, netted shoulder	23.4	20.8	83.1	10.2	8.8	85.2	197	175	83.3	337	325	76.5
Breast	20.1	21.0	61.8	BDL	7.5	-	152	180	54.4	183	293	40.1
Fore-shank	22.8	20.5	75.4	9.9	8.8	76.3	173	170	68.9	258	309	56.6
Ground lamb	14.9	18.1	67.0	BDL	7.0	-	122	156	63.8	162	281	47.0
Neck chops	22.4	20.3	71.7	10.1	7.3	90.3	194	175	72.0	289	323	58.1
Rack - fully frenched	23.7	22.9	86.7	8.7	8.1	89.9	200	192	87.0	330	334	83.0
Rack - Partly frenched	23.9	22.1	90.4	10.3	9.1	94.7	209	185	94.8	323	309	87.7
Square-cut shoulder	22.3	20.1	91.7	8.7	8.3	86.9	197	175	93.0	334	307	89.8
Square-cut shoulder chops	21.7	21.2	63.0	10.9	8.1	82.2	175	189	56.7	213	321	40.8
HINDQUARTER ITEMS:												
Bone-in leg chop/steak	27.0	24.2	91.9	10.0	7.9	104.2	223	198	93.0	373	350	87.8
Boneless chump	24.6	24.5	80.6	13.2	13.0	81.4	205	201	81.6	339	346	78.6
Boneless flap	18.1	19.2	68.9	BDL	BDL	-	137	164	60.7	186	303	44.8
Boneless loin	27.8	26.2	75.9	10.4	9.8	75.5	234	217	77.0	355	368	68.9
Hind-shank	22.6	21.9	68.6	10.7	10.6	67.1	180	185	64.7	258	327	52.5
Loin chop	27.1	22.7	92.6	9.3	8.8	82.2	233	189	95.4	367	327	87.2
Loin saddle	24.2	23.5	87.5	10.0	9.4	89.6	205	193	90.1	345	356	82.5
Tenderloin	31.2	26.3	87.8	16.0	12.3	96.2	268	222	89.2	433	381	84.0
Tunnel-boned leg, chump off, shank off	26.0	24.0	87.2	12.5	10.7	94.1	213	197	86.5	369	344	86.2
All-cuts averages	**23.5**	**22.2**	**79.5**	**10.7**	**9.2**	**86.4**	**195**	**187**	**78.5**	**303**	**328**	**69.5**
OFFAL ITEMS:												
Brains	15.4	13.5	75.6	35.9	30.7	77.6	384	327	77.9	258	307	55.6
Heart	21.9	20.2	65.8	27.7	22.2	75.8	237	204	70.5	187	277	41.0
Kidney	19.1	15.6	87.0	104.5	84.1	88.5	312	245	90.8	271	231	83.6
Liver	20.9	17.9	86.3	370.0	330.0	81.9	459	381	89.3	287	285	74.8
Sweetbread	24.7	19.8	85.1	16.6	12.7	84.7	550	422	88.1	354	435	57.5
Testes	16.4	11.0	78.6	44.2	29.2	79.4	302	179	88.5	265	265	52.5
Tongue - Swiss cut	15.2	15.0	74.8	19.6	17.9	81.4	143	142	74.3	132	207	47.2
Offal averages	**19.1**	**16.1**	**79.0**	**88.4**	**75.3**	**81.3**	**341**	**271**	**82.8**	**251**	**287**	**58.9**

Table L12: Composition of the cooked (CKD) and raw lean portion of 25 lamb cuts and offal items in terms of the concentrations of selenium, sodium, and zinc, together with estimated percentage true retention (%Ret) of each item.

	Selenium (µg/100 g)			Sodium (mg/100 g)			Zinc (mg/100 g)		
Cut or offal item	**Ckd**	**Raw**	**%Ret**	**Ckd**	**Raw**	**%Ret**	**Ckd**	**Raw**	**%Ret**
FOREQUARTER ITEMS:									
Boneless, rolled, netted shoulder	4.7	3.3	**105.4**	65	65	**74.1**	5.0	3.8	**97.3**
Breast	6.4	4.0	**103.1**	86	107	**51.8**	4.8	2.9	**105.3**
Fore-shank	9.9	7.0	**96.0**	77	82	**63.8**	7.1	4.3	**112.0**
Ground lamb	6.8	4.7	**118.0**	34	57	**49.1**	3.4	2.8	**100.0**
Neck chops	7.8	4.8	**106.7**	97	81	**77.9**	5.7	3.5	**106.7**
Rack - fully frenched	4.4	2.9	**127.7**	67	63	**89.7**	2.6	2.2	**96.0**
Rack - Partly frenched	4.3	3.6	**99.3**	72	67	**90.8**	2.9	2.7	**91.2**
Square-cut shoulder	6.8	5.3	**105.4**	80	73	**89.8**	4.6	3.6	**106.2**
Square-cut shoulder chops	11.8	7.4	**98.0**	59	82	**44.2**	6.2	3.3	**115.7**
HINDQUARTER ITEMS:									
Bone-in leg chop/steak	3.7	3.2	**95.5**	67	64	**85.8**	3.9	3.2	**102.5**
Boneless chump	6.0	4.4	**108.8**	61	62	**79.6**	3.2	2.9	**90.0**
Boneless flap	7.8	3.7	**153.1**	54	87	**45.6**	4.2	3.2	**97.7**
Boneless loin	5.5	2.9	**136.9**	57	60	**67.3**	2.7	2.1	**92.0**
Hind-shank	9.2	4.7	**130.6**	72	82	**58.6**	5.4	3.5	**104.4**
Loin chop	7.3	5.5	**101.5**	84	77	**84.5**	3.5	2.7	**100.4**
Loin saddle	4.0	4.2	**81.2**	76	75	**85.7**	3.0	2.5	**100.9**
Tenderloin	6.5	5.0	**96.6**	59	49	**88.4**	2.8	2.2	**95.9**
Tunnel-boned leg, chump off, shank off	4.6	3.6	**101.6**	62	60	**83.1**	3.7	3.3	**91.0**
All cuts averages	**6.5**	**4.5**	**109.2**	**68**	**72**	**72.8**	**4.2**	**3.0**	**100.3**
OFFAL ITEMS:									
Brains	16.3	13.5	**80.2**	101	117	**57.4**	1.3	1.1	**80.4**
Heart	20.3	10.9	**113.2**	67	94	**43.2**	2.7	1.7	**97.5**
Kidney	105.0	93.6	**79.8**	199	168	**84.5**	2.4	1.8	**92.9**
Liver	19.0	11.1	**126.6**	59	59	**73.8**	5.1	3.4	**109.5**
Sweetbread	14.9	12.3	**85.6**	52	56	**66.3**	1.9	1.4	**97.5**
Testes	53.0	26.2	**106.3**	118	119	**52.0**	2.1	1.1	**97.1**
Tongue - Swiss cut	9.1	5.4	**124.4**	52	77	**50.2**	2.1	1.6	**98.6**
Offals averages	**33.9**	**24.7**	**102.3**	**93**	**99**	**61.1**	**2.5**	**1.7**	**96.2**

c) ***Nutrient Composition by Lamb Cut or Offal Item:***

Table L13: Composition of the cooked (Ckd) and raw lean portion of lamb cuts including boneless, rolled, netted shoulder, breast, fore-shank, and ground lamb.

	Boneless, rolled, netted shoulder		Breast		Fore-shank		Ground lamb	
Nutrient item	**Ckd**	**Raw**	**Ckd**	**Raw**	**Ckd**	**Raw**	**Ckd**	**Raw**
Water (%)	64.2	72.9	54.8	71.7	59.3	74.5	66.6	69.3
Energy (kJ/100 g)	828	595	1126	604	870	509	802	803
Protein (%)	25.1	20.2	28.2	18.3	33.3	22.1	22.6	20.3
Fat (%)	10.9	6.9	17.5	8.0	8.4	3.8	11.3	12.4
Ash (%)	1.14	0.98	0.75	1.00	0.96	1.02	1.38	0.86
Vitamin B1 (mg/100 g) (Thiamine)	0.116	0.138	0.026	0.055	0.044	0.101	0.020	0.059
Vitamin B2 (mg/100 g) (Riboflavin)	0.19	0.14	0.13	0.16	0.15	0.10	0.15	0.18
Vitamin B3 (mg/100 g) (Niacin)	4.3	5.2	3.7	4.9	4.1	4.5	3.3	5.0
Vitamin B5 (mg/100 g) (Pantothenic acid)	0.8	0.6	0.4	0.5	0.5	0.5	0.1	0.2
Vitamin B6 (mg/100 g) (Pyridoxine)	0.118	0.113	0.089	0.143	0.077	0.101	0.134	0.132
Vitamin B12 (µg/100 g) (Cyanocobalamin)	2.3	2.4	1.4	2.0	1.4	2.2	1.0	1.6
Vitamin A (µg/100 g)	5.7	4.8	4.8	9.3	3.1	3.1	8.0	7.8
Vitamin D3 (µg/100 g)	0.05	0.04	0.04	0.04	0.04	0.02	0.04	0.03
25-OH Vitamin D3 (µg/100 g)	0.162	0.184	0.106	0.102	0.135	0.137	0.083	0.113
Vitamin E (mg/100 g)	0.34	0.21	0.39	0.31	0.43	0.18	0.40	0.24
Cholesterol (mg/100 g)	78.7	57.6	101.8	65.0	114.8	64.6	71.2	63.5
Calcium (mg/100 g)	7.29	4.74	25.39	13.29	11.27	7.06	4.02	4.08
Copper (mg/100 g)	0.12	0.09	0.14	0.09	0.14	0.09	0.10	0.09
Iodine (µg/100 g)	1.2	1.3	1.2	2.8	1.4	1.5	2.5	2.5
Iron (mg/100 g)	1.4	1.2	1.9	1.1	2.2	1.4	1.3	1.0
Magnesium (mg/100 g)	23.4	20.8	20.1	21.0	22.8	20.5	14.9	18.1
Manganese (µg/100 g)	10.2	8.8	BDL	7.5	9.9	8.8	BDL	7.0
Phosphorus (mg/100 g)	197	175	152	180	173	170	122	156
Potassium (mg/100 g)	337	325	183	293	258	309	162	281
Selenium (µg/100 g)	4.7	3.3	6.4	4.0	9.9	7.0	6.8	4.7
Sodium (mg/100 g)	65	65	86	107	77	82	34	57
Zinc (mg/100 g)	5.0	3.8	4.8	2.9	7.1	4.3	3.4	2.8

Table L14: Composition of the cooked (Ckd) and raw lean portion of lamb cuts including neck chops, fully-frenched rack, partly-frenched rack, and square-cut shoulder.

	Neck chops		Rack - fully frenched		Rack - Partly frenched		Square-cut shoulder	
Nutrient item	**Ckd**	**Raw**	**Ckd**	**Raw**	**Ckd**	**Raw**	**Ckd**	**Raw**
Water (%)	54.6	72.4	66.7	71.7	65.0	70.2	65.0	72.5
Energy (kJ/100 g)	1099	630	721	611	805	667	798	640
Protein (%)	31.4	19.8	24.4	20.6	24.4	20.7	25.1	19.7
Fat (%)	15.4	8.0	8.4	7.1	10.6	8.6	10.1	8.3
Ash (%)	1.11	1.00	1.13	0.97	1.09	0.94	1.09	0.98
Vitamin B1 (mg/100 g) (Thiamine)	0.026	0.080	0.057	0.061	0.060	0.084	0.056	0.099
Vitamin B2 (mg/100 g) (Riboflavin)	0.14	0.14	0.21	0.18	0.20	0.19	0.23	0.16
Vitamin B3 (mg/100 g) (Niacin)	4.2	4.3	6.3	5.2	6.7	5.7	4.2	3.5
Vitamin B5 (mg/100 g) (Pantothenic acid)	0.4	0.3	0.6	0.6	0.4	0.5	0.5	0.3
Vitamin B6 (mg/100 g) (Pyridoxine)	0.077	0.121	0.291	0.246	0.170	0.181	0.189	0.140
Vitamin B12 (µg/100 g) (Cyanocobalamin)	2.0	2.9	1.3	1.1	1.2	1.3	2.7	2.3
Vitamin A (µg/100 g)	8.3	5.2	3.4	5.0	4.3	5.0	1.2	4.1
Vitamin D3 (µg/100 g)	0.04	0.02	0.14	0.09	0.03	0.02	0.12	0.17
25-OH Vitamin D3 (µg/100 g)	0.117	0.118	0.288	0.182	0.081	0.048	0.176	0.165
Vitamin E (mg/100 g)	0.57	0.24	0.29	0.32	0.37	0.28	0.22	0.40
Cholesterol (mg/100 g)	121.3	70.8	72.1	61.9	76.4	63.5	70.5	55.6
Calcium (mg/100 g)	58.10	22.50	11.30	7.70	22.20	11.50	14.07	12.15
Copper (mg/100 g)	0.10	0.09	0.13	0.11	0.12	0.11	0.11	0.09
Iodine (µg/100 g)	2.5	2.5	2.7	1.7	1.3	1.0	2.5	2.2
Iron (mg/100 g)	1.3	1.0	1.8	1.4	1.6	1.4	1.5	1.1
Magnesium (mg/100 g)	14.9	18.1	23.7	22.9	23.9	22.1	22.3	20.1
Manganese (µg/100 g)	BDL	7.0	8.7	8.1	10.3	9.1	8.7	8.3
Phosphorus (mg/100 g)	122	156	200	192	209	185	197	175
Potassium (mg/100 g)	162	281	330	334	323	309	334	307
Selenium (µg/100 g)	6.8	4.7	4.4	2.9	4.3	3.6	6.8	5.3
Sodium (mg/100 g)	34	57	67	63	72	67	80	73
Zinc (mg/100 g)	3.4	2.8	2.6	2.2	2.9	2.7	4.6	3.6

Table L15: Composition of the cooked (Ckd) and raw lean portion of lamb cuts including square-cut shoulder chops, bone-in leg chop/steak, boneless chump, and boneless flap.

	Square-cut shoulder chops		Bone-in leg chop/steak		Boneless chump		Boneless flap	
Nutrient item	**Ckd**	**Raw**	**Ckd**	**Raw**	**Ckd**	**Raw**	**Ckd**	**Raw**
Water (%)	65.0	72.5	67.6	74.3	70.6	74.6	60.1	69.5
Energy (kJ/100 g)	798	640	677	526	592	505	974	749
Protein (%)	25.1	19.7	26.3	21.1	23.7	21.7	27.9	21.7
Fat (%)	10.1	8.3	6.3	4.6	5.3	3.8	13.6	10.3
Ash (%)	1.09	0.98	1.26	1.08	1.20	1.24	0.69	0.98
Vitamin B1 (mg/100 g) (Thiamine)	0.056	0.099	0.138	0.175	0.138	0.154	0.014	0.043
Vitamin B2 (mg/100 g) (Riboflavin)	0.23	0.16	0.15	0.17	0.19	0.13	0.15	0.14
Vitamin B3 (mg/100 g) (Niacin)	4.2	3.5	6.4	5.2	3.6	5.3	3.3	4.6
Vitamin B5 (mg/100 g) (Pantothenic acid)	0.5	0.3	0.7	0.6	0.9	0.8	0.3	0.5
Vitamin B6 (mg/100 g) (Pyridoxine)	0.110	0.063	0.166	0.137	0.175	0.150	0.091	0.115
Vitamin B12 (µg/100 g) (Cyanocobalamin)	2.7	2.3	2.3	1.6	2.1	2.1	1.5	2.1
Vitamin A (µg/100 g)	1.2	4.1	1.8	2.6	5.0	4.6	9.5	9.0
Vitamin D3 (µg/100 g)	0.12	0.17	0.04	0.03	0.02	0.02	0.03	0.03
25-OH Vitamin D3 (µg/100 g)	0.176	0.165	0.104	0.167	0.093	0.109	0.076	0.092
Vitamin E (mg/100 g)	0.22	0.40	0.20	0.14	0.33	0.32	0.34	0.37
Cholesterol (mg/100 g)	70.5	55.6	78.3	65.8	74.4	65.3	78.2	58.0
Calcium (mg/100 g)	39.97	26.58	10.49	10.69	4.35	4.37	8.50	6.71
Copper (mg/100 g)	0.14	0.09	0.16	0.12	0.16	0.14	0.10	0.07
Iodine (µg/100 g)	1.4	1.6	0.5	0.4	1.6	0.8	1.7	1.7
Iron (mg/100 g)	1.9	1.2	2.0	1.6	1.7	1.5	1.2	1.0
Magnesium (mg/100 g)	21.7	21.2	27.0	24.2	24.6	24.5	18.1	19.2
Manganese (µg/100 g)	10.9	8.1	10.0	7.9	13.2	13.0	BDL	BDL
Phosphorus (mg/100 g)	175	189	223	198	205	201	137	164
Potassium (mg/100 g)	213	321	373	350	339	346	186	303
Selenium (µg/100 g)	11.8	7.4	3.7	3.2	6.0	4.4	7.8	3.7
Sodium (mg/100 g)	59	82	67	64	61	62	54	87
Zinc (mg/100 g)	6.2	3.3	3.9	3.2	3.2	2.9	4.2	3.2

Table L16: Composition of the cooked (Ckd) and raw lean portion of lamb cuts including boneless loin, hind-shank, loin chop, and loin saddle.

	Boneless loin		Hind-shank		Loin chop		Loin saddle	
Nutrient item	**Ckd**	**Raw**	**Ckd**	**Raw**	**Ckd**	**Raw**	**Ckd**	**Raw**
Water (%)	66.7	74.5	60.9	74.5	60.2	71.4	72.8	72.9
Energy (kJ/100 g)	652	500	818	466	858	591	677	547
Protein (%)	29.0	21.5	32.5	20.4	27.4	20.0	25.5	20.9
Fat (%)	4.5	3.8	7.4	3.4	10.7	6.9	6.7	5.3
Ash (%)	1.30	1.17	1.10	1.02	1.25	1.05	1.10	1.04
Vitamin B1 (mg/100 g) (Thiamine)	0.062	0.072	0.030	0.064	0.097	0.119	0.119	0.118
Vitamin B2 (mg/100 g) (Riboflavin)	0.19	0.16	0.24	0.16	0.22	0.15	0.22	0.14
Vitamin B3 (mg/100 g) (Niacin)	7.1	6.4	4.5	4.9	6.7	5.4	6.4	5.9
Vitamin B5 (mg/100 g) (Pantothenic acid)	0.8	0.5	0.2	0.5	0.8	0.5	0.5	0.4
Vitamin B6 (mg/100 g) (Pyridoxine)	0.205	0.176	0.103	0.148	0.189	0.160	0.206	0.175
Vitamin B12 (µg/100 g) (Cyanocobalamin)	1.4	1.1	1.6	1.4	1.8	1.9	1.6	1.1
Vitamin A (µg/100 g)	0.9	1.7	2.4	2.2	6.0	4.8	4.8	4.4
Vitamin D3 (µg/100 g)	0.03	0.03	0.04	0.04	0.06	0.05	0.02	0.02
25-OH Vitamin D3 (µg/100 g)	0.145	0.095	0.142	0.156	0.081	0.085	0.180	0.166
Vitamin E (mg/100 g)	0.34	0.33	0.52	0.29	0.36	0.22	0.28	0.22
Cholesterol (mg/100 g)	86.3	65.6	115.5	61.8	85.0	66.2	78.1	66.1
Calcium (mg/100 g)	6.18	4.23	7.78	5.03	41.50	18.40	7.60	6.90
Copper (mg/100 g)	0.17	0.13	0.16	0.11	0.15	0.12	0.14	0.12
Iodine (µg/100 g)	2.8	1.2	1.2	1.0	1.5	2.3	1.2	1.0
Iron (mg/100 g)	2.1	1.6	2.1	1.5	1.9	1.5	1.6	1.5
Magnesium (mg/100 g)	27.8	26.2	22.6	21.9	27.1	22.7	24.2	23.5
Manganese (µg/100 g)	10.4	9.8	10.7	10.6	9.3	8.8	10.0	9.4
Phosphorus (mg/100 g)	234	217	180	185	233	189	205	193
Potassium (mg/100 g)	355	368	258	327	367	327	345	356
Selenium (µg/100 g)	5.5	2.9	9.2	4.7	7.3	5.5	4.0	4.2
Sodium (mg/100 g)	57	60	72	82	84	77	76	75
Zinc (mg/100 g)	2.7	2.1	5.4	3.5	3.5	2.7	3.0	2.5

Table L17: Composition of the cooked (Ckd) and raw lean portion of lamb cuts including tenderloin, and tunnel-boned leg (chump-off, shank-off), together with lamb brains, and heart. It was not possible to obtain reliable values for vitamin D3 for the brain because of interfering substances.

	Tenderloin		Tunnel-boned leg, chump off, shank off		Brains		Heart	
Nutrient item	**Ckd**	**Raw**	**Ckd**	**Raw**	**Ckd**	**Raw**	**Ckd**	**Raw**
Water (%)	66.4	74.4	68.1	74.4	73.1	78.5	66.6	77.8
Energy (kJ/100 g)	646	486	663	503	643	489	671	440
Protein (%)	27.9	20.5	25.3	20.9	14.0	11.3	26.3	18.1
Fat (%)	4.8	3.8	6.4	4.1	10.9	8.0	6.2	3.7
Ash (%)	1.44	1.35	1.17	1.14	3.39	2.52	0.94	1.13
Vitamin B1 (mg/100 g) (Thiamine)	0.101	0.075	0.107	0.140	0.084	0.102	0.229	0.519
Vitamin B2 (mg/100 g) (Riboflavin)	0.30	0.21	0.25	0.20	0.22	0.20	0.84	0.54
Vitamin B3 (mg/100 g) (Niacin)	9.1	7.3	5.9	5.2	3.0	3.8	4.2	5.8
Vitamin B5 (mg/100 g) (Pantothenic acid)	1.1	0.9	0.8	0.7	1.9	1.9	1.8	2.2
Vitamin B6 (mg/100 g) (Pyridoxine)	0.281	0.241	0.275	0.225	0.081	0.087	0.125	0.144
Vitamin B12 (µg/100 g) (Cyanocobalamin)	2.4	1.9	1.6	1.9	9.5	10.0	9.2	8.4
Vitamin A (µg/100 g)	1.5	1.4	2.5	3.2	2.3	3.1	3.5	5.4
Vitamin D3 (µg/100 g)	0.04	0.02	0.01	0.01	-	-	0.05	0.03
25-OH Vitamin D3 (µg/100 g)	0.105	0.094	0.110	0.127	0.053	0.057	0.229	0.182
Vitamin E (mg/100 g)	0.55	0.41	0.33	0.30	1.12	0.87	0.63	0.65
Cholesterol (mg/100 g)	94.1	68.5	79.3	64.3	2559.2	2099.6	186.4	119.4
Calcium (mg/100 g)	5.18	4.04	4.08	3.93	5.70	3.60	5.48	4.65
Copper (mg/100 g)	0.18	0.14	0.16	0.12	0.28	0.30	0.64	0.41
Iodine (µg/100 g)	2.2	0.8	1.4	1.7	1.8	1.4	1.7	1.4
Iron (mg/100 g)	2.1	1.6	1.7	1.4	1.2	1.1	4.9	3.3
Magnesium (mg/100 g)	31.2	26.3	26.0	24.0	15.4	13.5	21.9	20.2
Manganese (µg/100 g)	16.0	12.3	12.5	10.7	35.9	30.7	27.7	22.2
Phosphorus (mg/100 g)	268	222	213	197	384	327	237	204
Potassium (mg/100 g)	433	381	369	344	258	307	187	277
Selenium (µg/100 g)	6.5	5.0	4.6	3.6	16.3	13.5	20.3	10.9
Sodium (mg/100 g)	59	49	62	60	101	117	67	94
Zinc (mg/100 g)	2.8	2.2	3.7	3.3	1.3	1.1	2.7	1.7

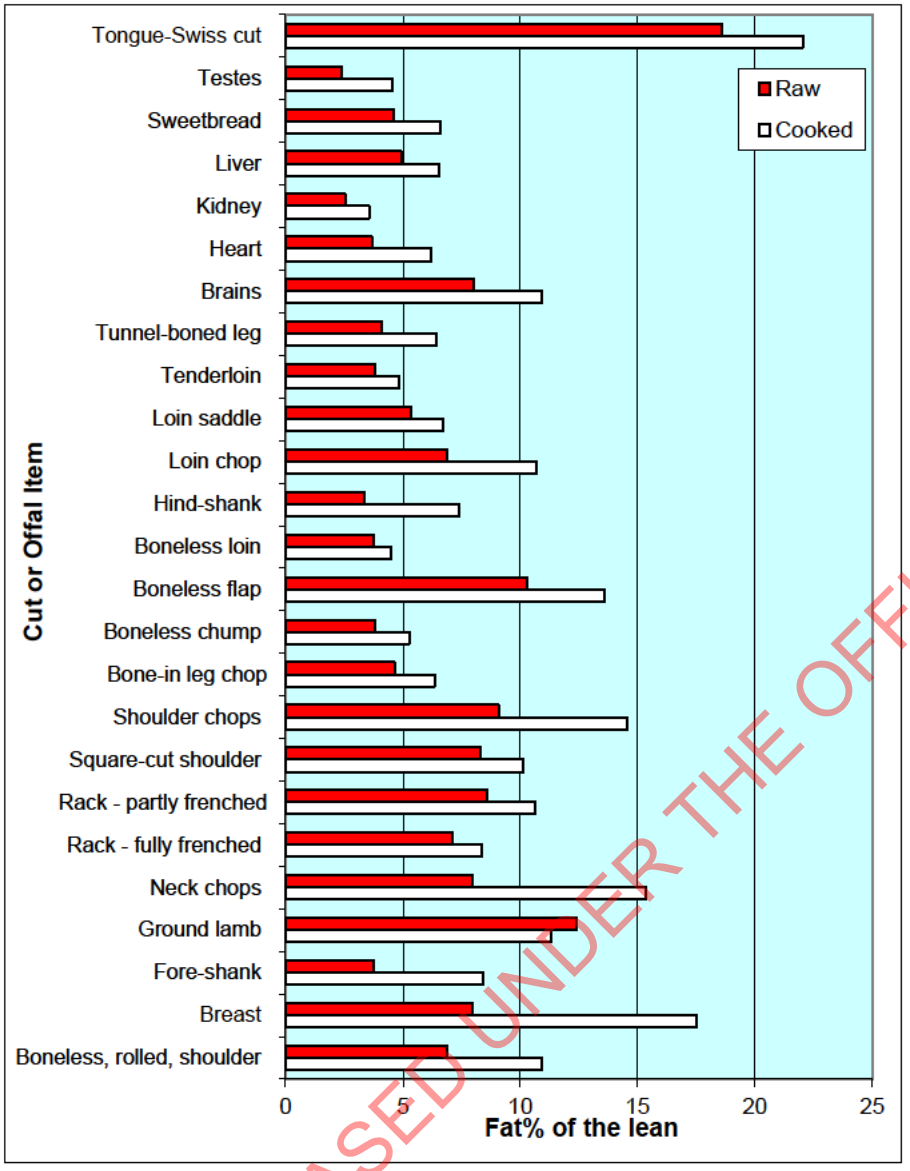
Table L18: Composition of the cooked (Ckd) and raw lean portion of lamb offal items including kidney, liver, sweetbread, and testes.

	Kidney		Liver		Sweetbread		Testes	
Nutrient item	**Ckd**	**Raw**	**Ckd**	**Raw**	**Ckd**	**Raw**	**Ckd**	**Raw**
Water (%)	75.1	81.0	64.6	70.8	72.6	79.5	74.0	85.0
Energy (kJ/100 g)	464	349	678	529	600	436	522	279
Protein (%)	19.8	15.2	25.8	20.7	21.1	15.8	21.0	11.4
Fat (%)	3.6	2.5	6.6	4.9	6.6	4.6	4.6	2.4
Ash (%)	1.41	1.19	1.56	1.36	2.58	1.94	1.50	1.08
Vitamin B1 (mg/100 g) (Thiamine)	0.462	0.413	1.570	1.210	0.075	0.078	0.312	0.315
Vitamin B2 (mg/100 g) (Riboflavin)	1.53	1.28	5.27	4.21	0.10	0.10	0.31	0.21
Vitamin B3 (mg/100 g) (Niacin)	9.1	8.4	12.8	13.7	1.4	1.9	2.2	1.7
Vitamin B5 (mg/100 g) (Pantothenic acid)	4.6	3.2	5.2	5.6	0.7	1.0	0.8	0.9
Vitamin B6 (mg/100 g) (Pyridoxine)	0.230	0.173	0.187	0.218	BDL	BDL	0.038	0.033
Vitamin B12 (µg/100 g) (Cyanocobalamin)	55.6	50.4	57.5	59.0	2.5	2.6	8.9	9.9
Vitamin A (µg/100 g)	85.2	61.3	19872	15434	8.4	5.8	21.5	10.1
Vitamin D3 (µg/100 g)	0.21	0.13	BDL	BDL	0.16	0.13	0.02	0.01
25-OH Vitamin D3 (µg/100 g)	0.275	0.276	0.525	0.497	0.171	0.077	0.133	0.152
Vitamin E (mg/100 g)	0.57	0.42	1.12	0.86	1.13	0.69	0.85	0.31
Cholesterol (mg/100 g)	507.5	369.1	566.0	386.0	462.4	230.0	523.4	392.8
Calcium (mg/100 g)	9.47	7.91	5.00	4.20	5.80	3.50	8.21	5.29
Copper (mg/100 g)	0.42	0.36	13.40	11.40	0.08	0.06	0.13	0.09
Iodine (µg/100 g)	5.9	4.6	4.7	5.8	6.7	3.1	3.8	5.2
Iron (mg/100 g)	14.7	6.6	5.4	4.6	1.1	0.8	1.7	1.1
Magnesium (mg/100 g)	19.1	15.6	20.9	17.9	24.7	19.8	16.4	11.0
Manganese (µg/100 g)	104.5	84.1	370.0	330.0	16.6	12.7	44.2	29.2
Phosphorus (mg/100 g)	312	245	459	381	550	422	302	179
Potassium (mg/100 g)	271	231	287	285	354	435	265	265
Selenium (µg/100 g)	105.0	93.6	19.0	11.1	14.9	12.3	53.0	26.2
Sodium (mg/100 g)	199	168	59	59	52	56	118	119
Zinc (mg/100 g)	2.4	1.8	5.1	3.4	1.9	1.4	2.1	1.1

Table L19: Composition of the cooked (Ckd) and raw lean portion of lamb tongue (Swiss-cut).

	Tongue - Swiss cut	
Nutrient item	**Ckd**	**Raw**
Water (%)	58.7	66.5
Energy (kJ/100 g)	1117	934
Protein (%)	17.5	14.3
Fat (%)	22.0	18.6
Ash (%)	0.84	0.77
Vitamin B1 (mg/100 g) (Thiamine)	0.036	0.100
Vitamin B2 (mg/100 g) (Riboflavin)	0.34	0.29
Vitamin B3 (mg/100 g) (Niacin)	2.3	3.1
Vitamin B5 (mg/100 g) (Pantothenic acid)	0.6	0.4
Vitamin B6 (mg/100 g) (Pyridoxine)	0.077	0.097
Vitamin B12 (µg/100 g) (Cyanocobalamin)	5.2	6.1
Vitamin A (µg/100 g)	1.4	5.4
Vitamin D3 (µg/100 g)	0.15	0.07
25-OH Vitamin D3 (µg/100 g)	0.113	0.181
Vitamin E (mg/100 g)	0.16	0.57
Cholesterol (mg/100 g)	125.6	87.9
Calcium (mg/100 g)	6.36	6.05
Copper (mg/100 g)	0.20	0.15
Iodine (µg/100 g)	1.9	1.3
Iron (mg/100 g)	1.7	1.2
Magnesium (mg/100 g)	15.2	15.0
Manganese (µg/100 g)	19.6	17.9
Phosphorus (mg/100 g)	143	142
Potassium (mg/100 g)	132	207
Selenium (µg/100 g)	9.1	5.4
Sodium (mg/100 g)	52	77
Zinc (mg/100 g)	2.1	1.6

Figure L2: The percentage of fat and concentration of cholesterol in the cooked and raw lean portion of 25 lamb cuts and offal items.



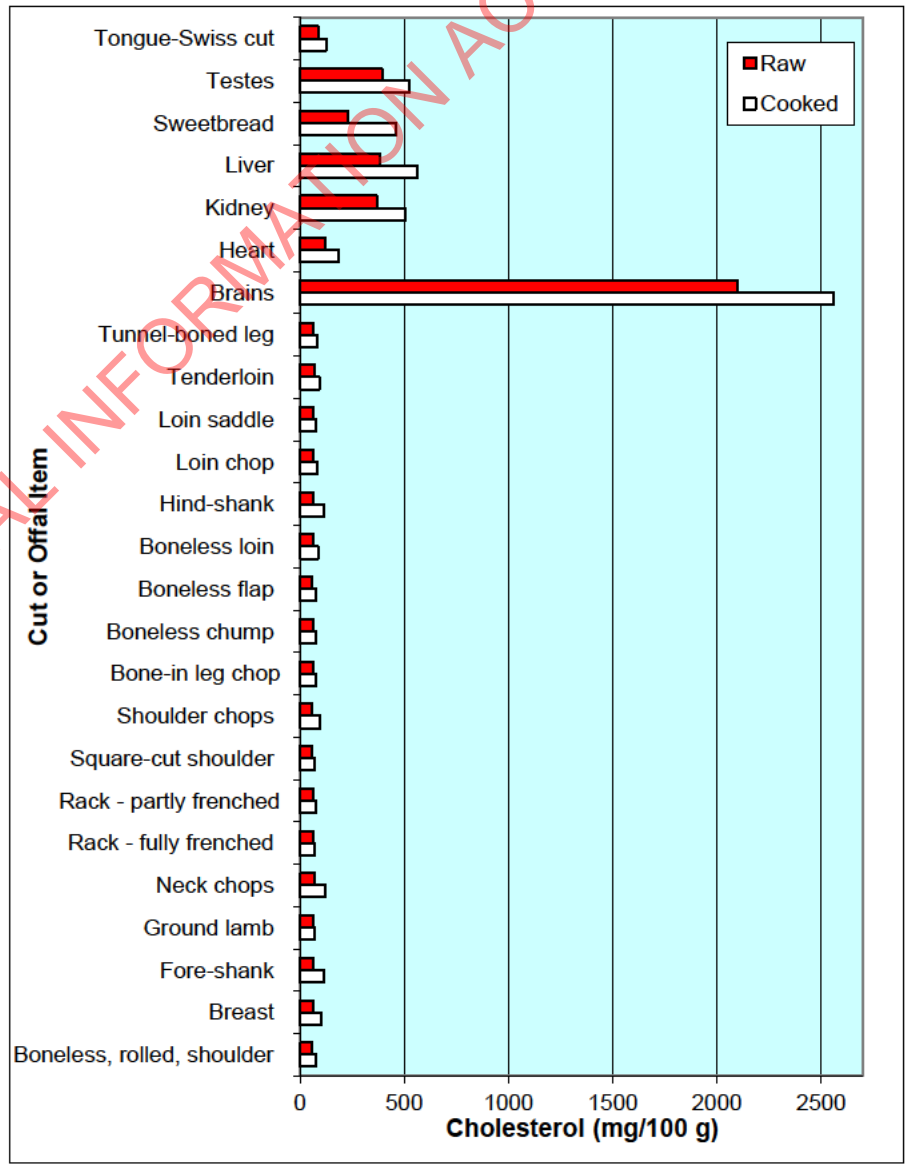
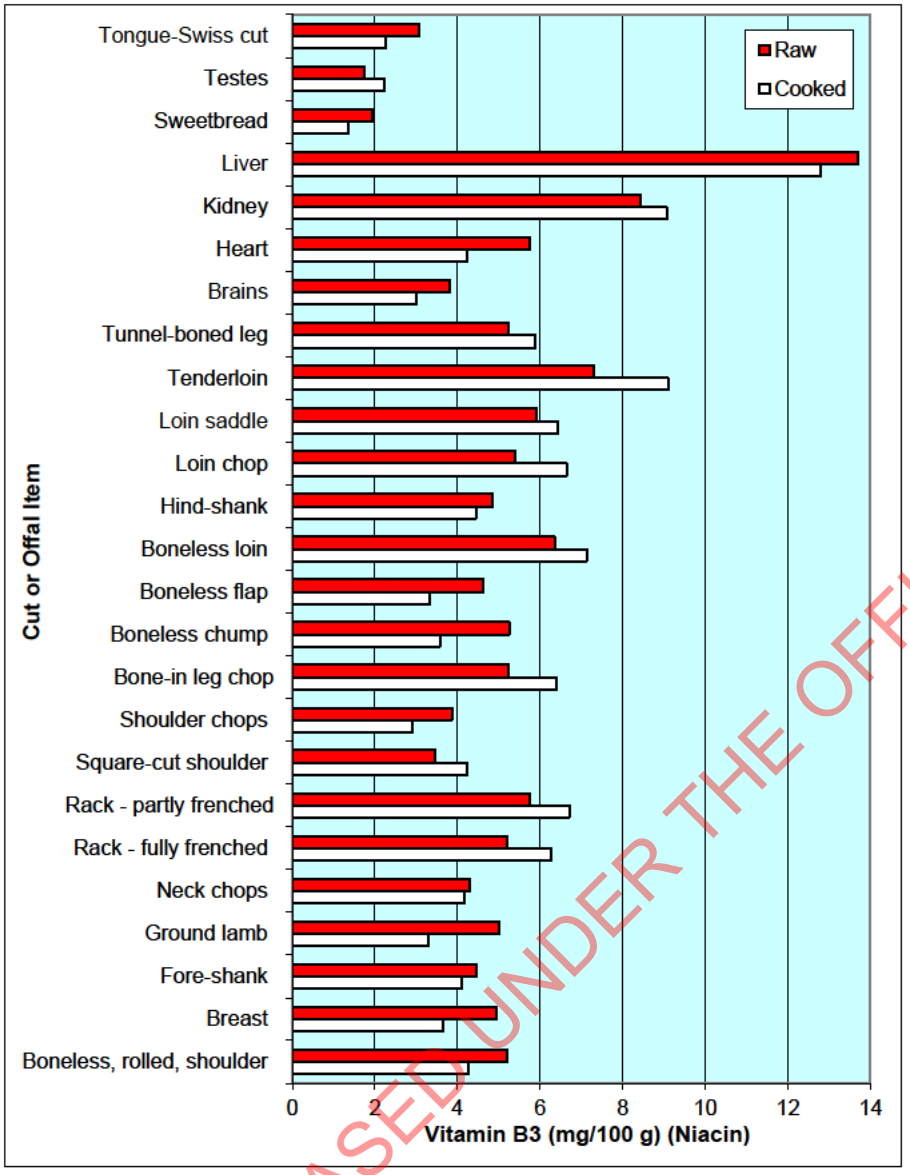


Figure L3: Concentrations of vitamin B3 (niacin) and vitamin E in the cooked and raw lean portion of 25 lamb cuts and offal items.



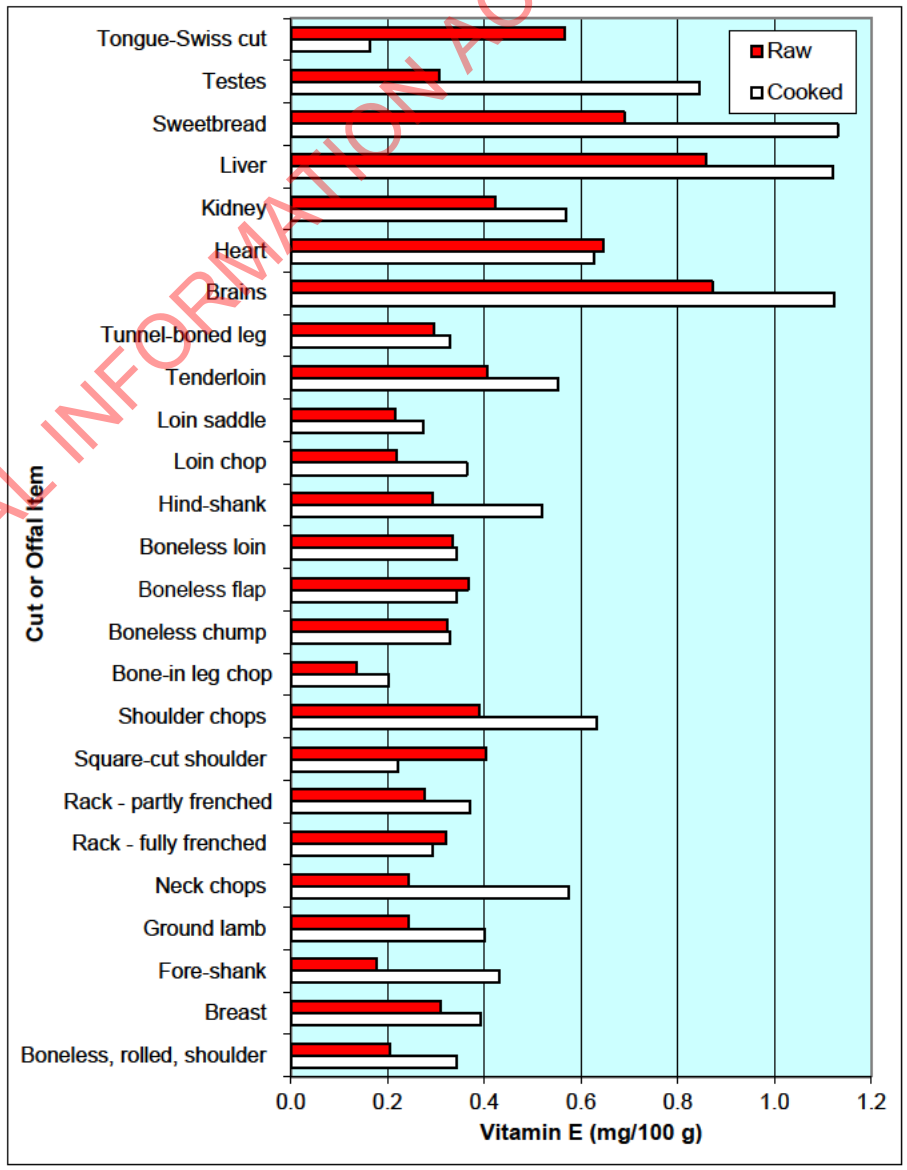
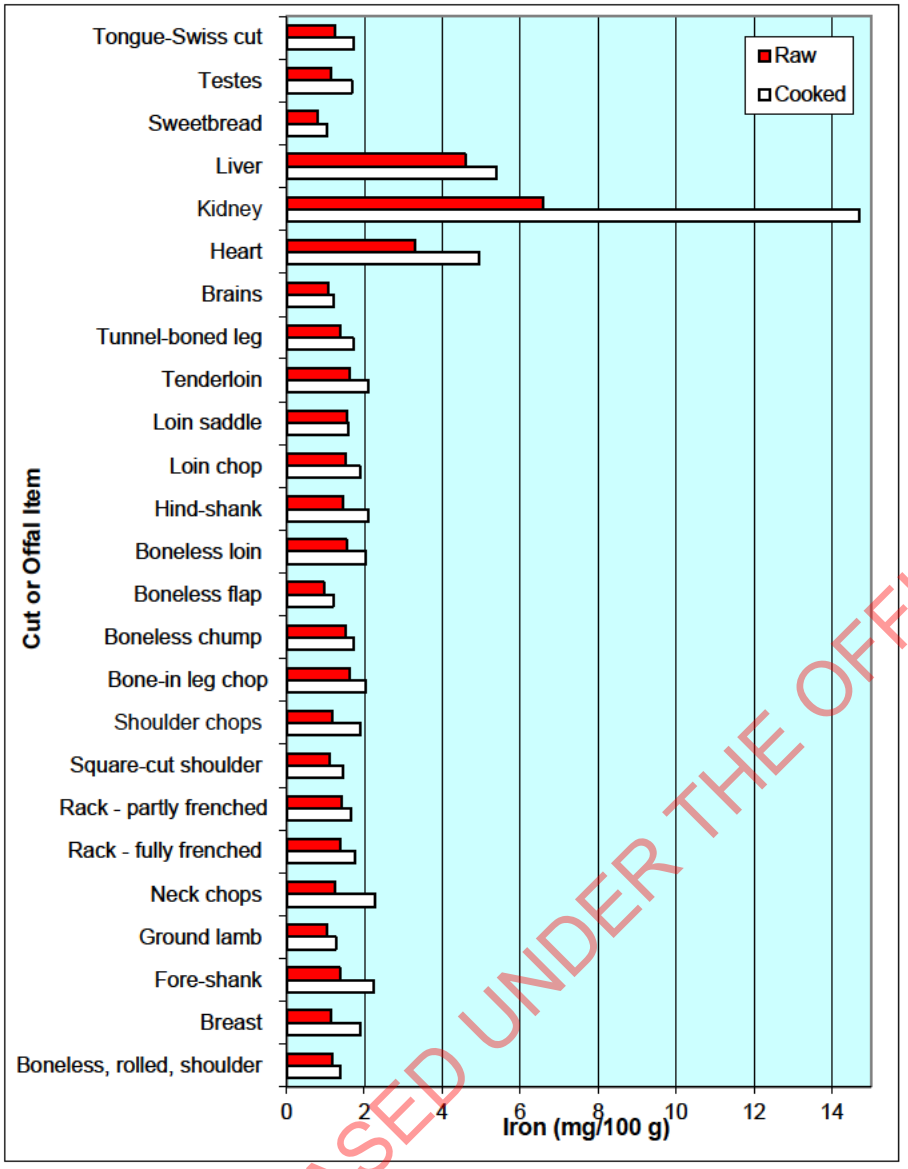


Figure L4: The concentrations of iron and zinc in the cooked and raw lean portion of 25 lamb cuts and offal items.



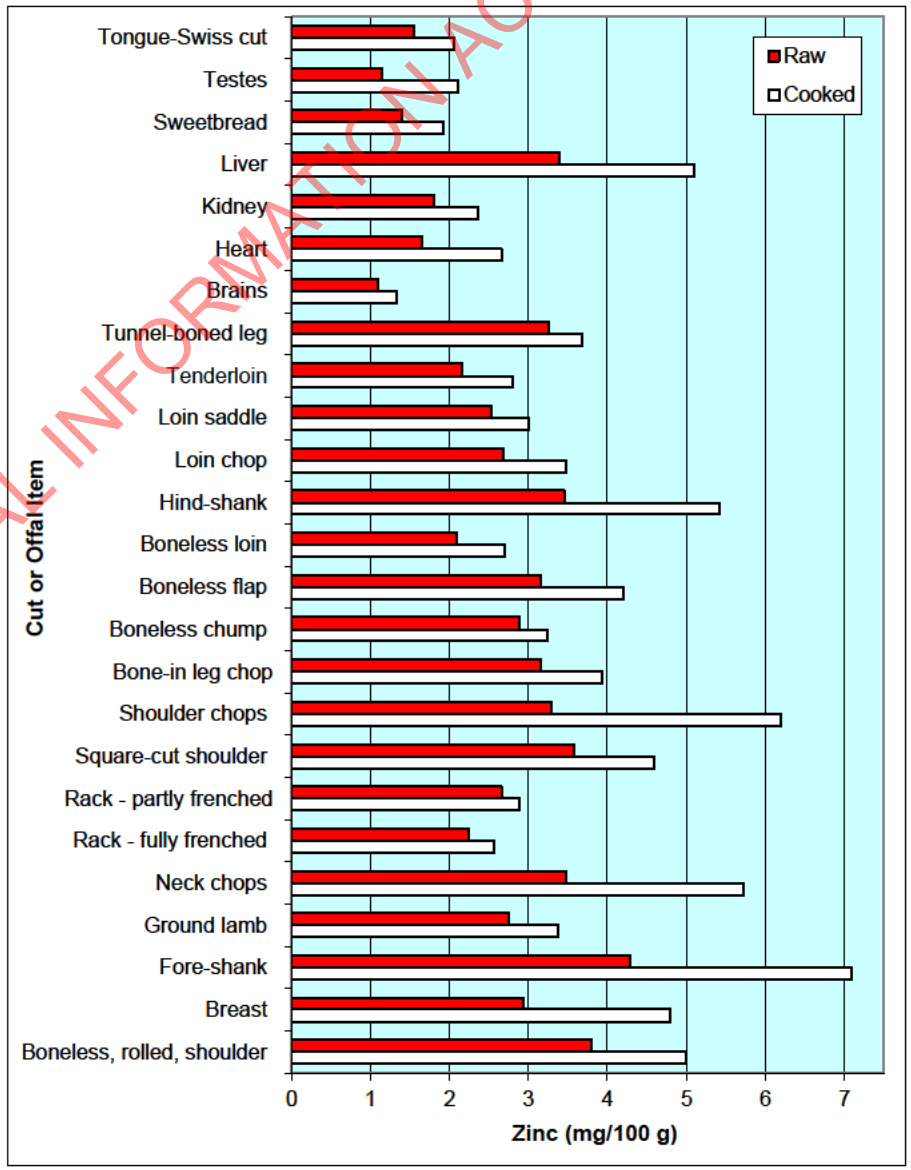
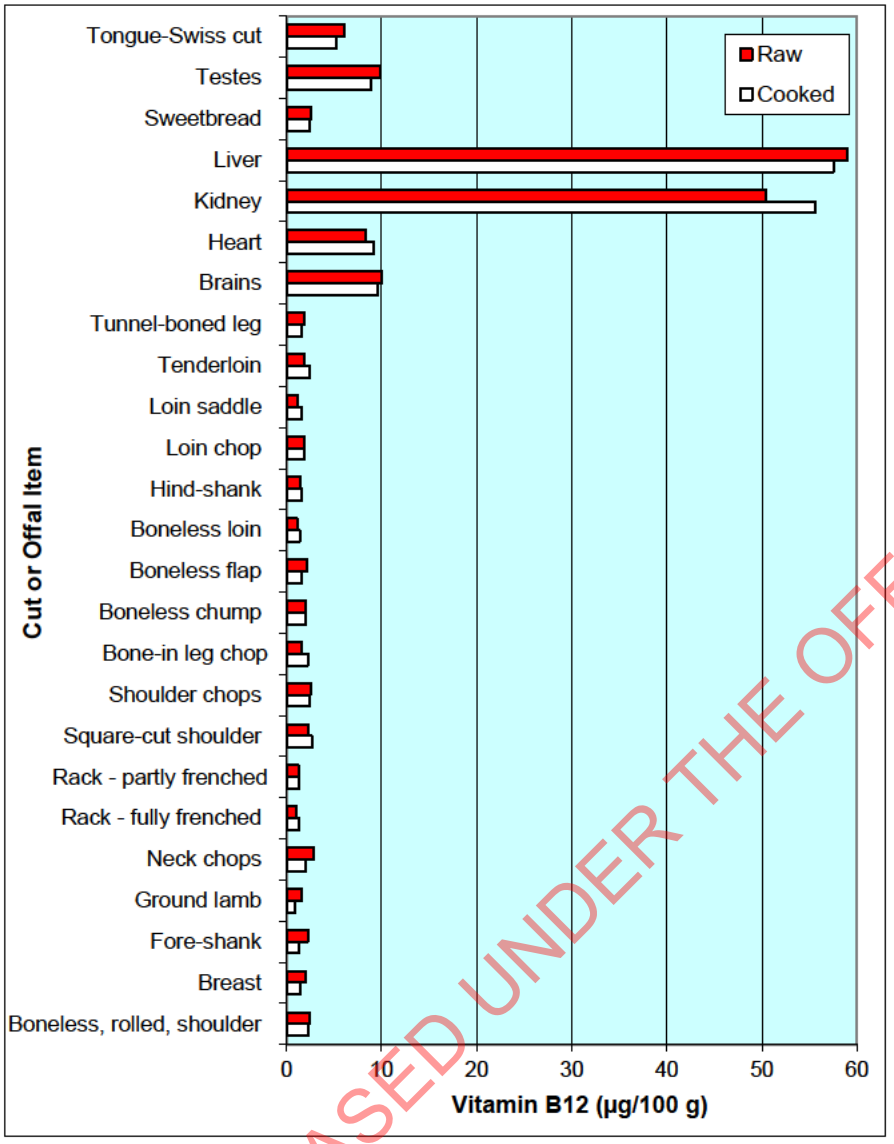
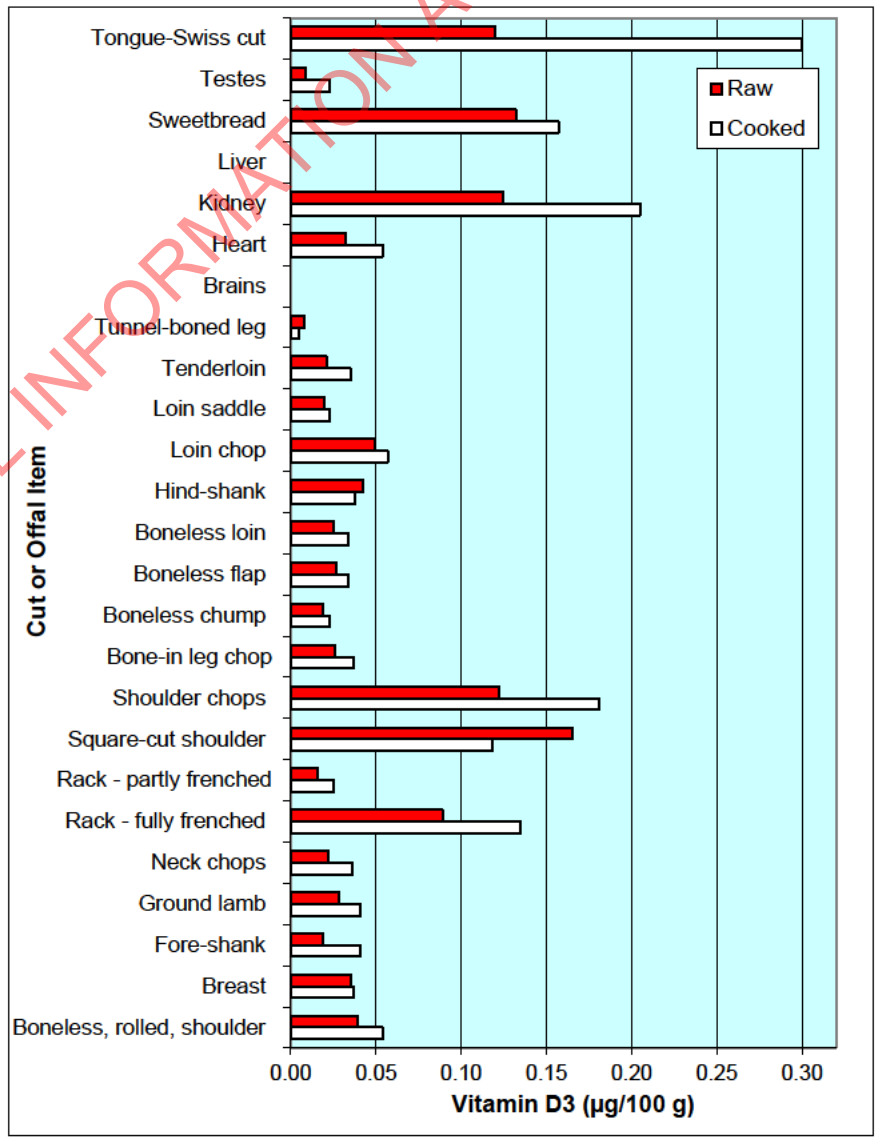


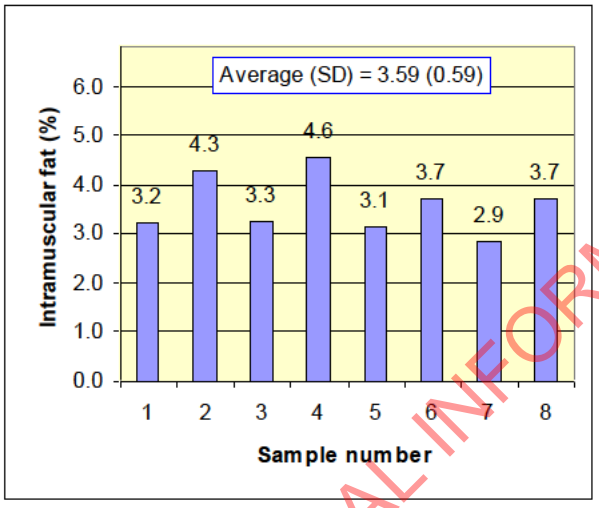
Figure L5: The concentrations vitamin B12 and vitamin D3 in the cooked and raw lean portion of 25 lamb cuts and offal items. Concentrations of vitamin D3 in the brain were not measurable due to interfering substances.





d) ***Variability Within Lamb Boneless Loin Intramuscular Fat:*** All the results presented in Tables L6 to L19 and in Figures L2 to L5 are those obtained on composite samples as explained in Figure L1, so that no measures are given of how the composition varied between the 7 to 10 individual samples that contributed to the composite samples analysed. In order to provide an indication of the sort of variation that might be expected, internal samples of the longissimus muscle from each of 8 boneless loins were analysed for fat content only. The results shown in Figure L6 indicate quite a wide variation with a coefficient of variation of 16.5%.

Figure L6: Variation in the intramuscular fat concentrations in 8 samples from within the longissimus muscle of 8 lamb boneless loin cuts.



This variation in intramuscular fat within one muscle taken from different animals provides some indication of the likely variation within other muscles and also of the possible variation in concentrations of nutrients other than fat. Fat is likely to be one of the more variable components within meat, but the almost two-fold range in intramuscular fat% shown in Figure L6 will influence the concentration of other nutrients in muscle if the concentration of a nutrient is appreciably higher in muscle than in intramuscular fat (i.e. the fat will have a diluting effect).

The mean level of intramuscular fat of 3.59% shown in Figure L6 is lower than the value for boneless loin raw lean tissue of 3.80% shown in Table L6 because the former value refers to an internal muscle sample that would not include any of the small remnants of subcutaneous fat or intermuscular fat that would remain on the surface of the muscles following dissection with a knife and designated here as lean muscle tissue.

e) ***Fatty-Acid Composition of Lamb Intramuscular Fat:*** Table L20, which extends over the following five pages, gives the fatty acid composition of the lean portion of 25 raw or cooked lamb cuts and lamb offal items expressed as a percentage of the sum of all fatty acids. The amount of any fatty acid relative to product weight can be calculated from the percentages given and the total FAs (g/100 g) given at the bottom of each column in Table L20. The separate part at the bottom of each column in Table L20 and also Tables L21 and L22 give characteristics that combine a number of the fatty acids in various ways. Explanations of some of the abbreviations used in Tables L20, L21, and L22 are as follows:

SFA	Saturated fatty acids
MUFA	Monounsaturated fatty acids
PUFA	Polyunsaturated fatty acids
P/S	Ratio of PUFA to SFA
n-6/n-3	Ratio of n-3 to n-6 polyunsaturated fatty acids (= omega-3 to omega 6 PUFA)
LCN3FA	Long-chain n-3 fatty acids (C20:3n3 + EPA + DPA + DHA)
Total FAs (g/100 g)	The sum of weights of all fatty acids relative to raw or cooked (Ckd) weight.
EPA, DPA, & DHA	Eicosapentaenoic acid, docosapentaenoic acid, & docosahexaenoic acid

Table L20: Fatty acid composition of the cooked (Ckd) and raw lean portions of lamb cuts and offal items expressed as a percentage of total fatty acids (ND = not detectable).

Fatty acid (% of total fatty acids except for Total FAs and the ratios)	Boneless Shoulder		Breast		Fore-Shank		Ground Lamb		Neck Chops	
	Ckd	Raw	Ckd	Raw	Ckd	Raw	Ckd	Raw	Ckd	Raw
C8:0 Caprylic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C10:0 Capric	0.29	0.28	0.27	0.23	0.23	0.20	0.25	0.25	0.28	0.22
C11:0 Undecanoic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C12:0 Lauric	0.37	0.36	0.29	0.24	0.38	0.30	0.26	0.24	0.27	0.20
C13:0 Tridecanoic	ND	ND	ND	ND	ND	ND	ND	0.08	ND	<0.01
C14:0 Myristic	3.92	3.63	3.51	3.14	3.69	3.33	2.82	3.05	2.99	2.76
C14:1n5 c9 Myristoleic	0.13	0.15	0.14	0.16	0.16	0.22	0.07	0.06	0.10	0.10
C15:1n5 c10 Pentadecenoic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C16:0 Palmitic	23.81	23.96	23.34	23.86	22.10	22.36	23.08	23.52	22.17	22.43
C16:1n7 t9 Palmitelaidic	0.14	0.16	0.17	0.13	0.21	ND	0.18	0.15	0.08	0.49
C16:1n7 c9 Palmitoleic	1.28	1.43	1.52	1.57	1.65	1.67	1.06	1.02	1.13	1.06
C17:0 Margaric	2.28	2.28	2.22	2.39	1.84	1.97	2.59	2.60	2.67	2.50
C17:1n7 c10 Heptadecenoic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C18:0 Stearic	22.12	20.83	23.40	22.79	19.41	18.07	27.71	28.02	26.48	26.20
C18:1n9 t9 Elaidic	0.54	0.17	0.19	0.40	0.19	0.22	0.30	0.31	0.39	0.40
C18:1n7 t11 Vaccenic	3.42	2.87	3.87	3.73	3.58	2.93	4.46	4.77	4.45	3.65
C18:1n9 c9 Oleic	31.70	33.41	31.96	34.60	34.82	35.45	29.34	28.72	31.35	31.78
C18:1n7 c11 Vaccenic	0.58	0.68	0.64	0.68	0.69	0.85	0.59	0.48	0.57	0.56
C18:2n6 t Linolelaidic	0.08	ND	ND	ND	ND	ND	ND	ND	ND	ND
C18:2n6 c Linoleic	2.54	2.72	1.78	2.08	2.97	3.76	1.93	1.67	1.96	2.32
C20:0 Arachidic	0.12	ND	0.19	0.10	0.09	ND	0.19	0.16	0.16	0.16
C18:3n6 c Gamma linolenic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C20:1n9 c11 Eicosenoic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C18:3n3 c Alpha linolenic	2.16	2.25	1.70	1.73	1.81	2.35	1.76	1.39	1.86	2.00
CLA C18:2-c9,t11	2.14	1.92	2.49	ND	2.48	2.15	1.74	2.02	1.47	1.28
CLA C18:2- t10,c12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C21:0 Heneicosanoic	0.98	1.08	1.07	0.99	1.57	1.50	0.75	0.80	0.74	0.66
C20:2n6 c Eicosadienoic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C22:0 Behenic	0.14	0.16	0.30	0.23	0.17	0.23	ND	ND	0.07	0.19
C20:3n6 c Eicosatrienoic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C22:1n9 c13 Erucic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C20:3n3 c Eicosatrienoic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C20:4n6 c Arachidonic	0.51	0.60	0.33	0.32	0.74	0.93	0.31	0.25	0.27	0.40
C23:0 Tricosanoic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C22:2n6 c Docosadienoic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C24:0 Lignoceric	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C20:5n3 c EPA	0.35	0.47	0.26	0.31	0.51	0.71	0.32	0.20	0.20	0.34
C24:1n9 c15 Nervonic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C22:5n3 c DPA	0.40	0.43	0.36	0.33	0.51	0.59	0.29	0.24	0.24	0.30
C22:6n3 c DHA	ND	0.14	ND	ND	0.20	0.23	ND	ND	0.09	<0.01
SFA	54.03	52.58	54.59	53.96	49.48	47.97	57.65	58.72	55.84	55.32
MUFA	37.79	38.89	38.49	41.27	41.31	41.33	35.99	35.51	38.08	38.04
PUFA	8.18	8.53	6.92	4.77	9.21	10.70	6.36	5.77	6.08	6.63
P/S	0.15	0.16	0.13	0.09	0.19	0.22	0.11	0.10	0.11	0.12
n-6/n-3	1.08	1.01	0.91	1.01	1.23	1.21	0.95	1.05	0.94	1.03
LCN3FA	0.75	1.04	0.62	0.64	1.22	1.52	0.61	0.44	0.52	0.64
Total FAs (g/100 g)	6.15	4.13	11.22	5.17	5.49	2.75	7.69	8.38	11.05	5.71

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Fatty acid (% of total fatty acids except for Total FAs and the ratios)	Rack Fully-Frenched		Rack Partly Frenched		Square-cut Shoulder		Square-cut Shoulder Chops		Bone-in Leg Steaks	
	Ckd	Raw	Ckd	Raw	Ckd	Raw	Ckd	Raw	Ckd	Raw
C8:0 Caprylic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C10:0 Capric	0.27	0.25	0.24	0.19	0.19	0.20	0.38	0.23	0.32	0.32
C11:0 Undecanoic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C12:0 Lauric	0.31	0.27	0.26	0.18	0.24	0.26	0.52	0.35	0.45	0.42
C13:0 Tridecanoic	<0.01	<0.01	ND	ND	<0.01	ND	ND	ND	ND	ND
C14:0 Myristic	3.39	3.11	3.25	2.68	2.96	3.01	3.62	3.66	4.21	4.06
C14:1n5 c9 Myristoleic	0.12	0.11	0.11	0.10	0.08	0.10	0.12	0.15	0.23	0.25
C15:1n5 c10 Pentadecenoic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C16:0 Palmitic	23.34	22.63	23.01	22.28	21.88	21.58	22.32	23.00	23.32	23.15
C16:1n7 t9 Palmitelaidic	0.17	0.22	0.22	0.21	0.21	0.19	0.18	0.19	0.28	0.35
C16:1n7 c9 Palmitoleic	1.07	1.01	1.21	1.11	1.03	1.21	1.28	1.26	1.61	1.67
C17:0 Margaric	2.10	2.19	2.11	2.09	2.12	2.03	2.32	2.29	1.89	1.82
C17:1n7 c10 Heptadecenoic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C18:0 Stearic	22.77	24.71	24.34	24.70	24.60	21.95	22.54	21.62	17.13	16.57
C18:1n9 t9 Elaidic	0.38	0.50	0.66	0.59	0.47	0.46	0.40	0.44	0.47	0.39
C18:1n7 t11 Vaccenic	4.59	5.40	5.27	5.09	5.52	4.69	4.36	3.87	3.89	4.41
C18:1n9 c9 Oleic	32.48	31.15	29.78	30.64	31.59	34.60	32.67	32.76	33.76	34.20
C18:1n7 c11 Vaccenic	0.54	0.58	0.62	0.60	0.59	0.59	0.58	0.62	0.72	0.74
C18:2n6 t Linolelaidic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C18:2n6 c Linoleic	2.13	1.95	2.19	2.23	2.38	2.30	2.28	2.55	3.07	3.00
C20:0 Arachidic	0.13	0.12	0.14	0.13	0.14	0.12	<0.01	0.10	ND	ND
C18:3n6 c Gamma linolenic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C20:1n9 c11 Eicosenoic	<0.01	<0.01	ND	ND	<0.01	<0.01	ND	ND	ND	ND
C18:3n3 c Alpha linolenic	1.85	1.76	1.93	2.13	1.73	1.71	1.90	2.12	2.00	2.00
CLA C18:2-c9,t11	1.91	1.75	2.30	2.40	1.99	2.36	2.26	2.21	2.67	2.46
CLA C18:2- t10,c12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C21:0 Heneicosanoic	1.18	1.14	1.46	1.22	1.22	1.35	1.26	1.05	1.56	1.69
C20:2n6 c Eicosadienoic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C22:0 Behenic	0.16	0.14	ND	0.15	0.18	0.19	ND	ND	0.13	ND
C20:3n6 c Eicosatrienoic	<0.01	<0.01	ND	ND	<0.01	<0.01	0.21	ND	ND	ND
C22:1n9 c13 Erucic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C20:3n3 c Eicosatrienoic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C20:4n6 c Arachidonic	0.37	0.30	0.36	0.47	0.32	0.40	0.25	0.32	0.84	0.90
C23:0 Tricosanoic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C22:2n6 c Docosadienoic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C24:0 Lignoceric	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C20:5n3 c EPA	0.39	0.30	0.25	0.43	0.24	0.33	0.15	0.22	0.67	0.73
C24:1n9 c15 Nervonic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C22:5n3 c DPA	0.35	0.31	0.28	0.37	0.32	0.36	0.27	0.28	0.60	0.66
C22:6n3 c DHA	<0.01	0.11	ND	ND	<0.01	<0.01	0.10	0.70	0.19	0.22

SFA	53.65	54.55	54.81	53.62	53.53	50.70	52.97	52.31	49.01	48.04
MUFA	39.35	38.97	37.87	38.36	39.48	41.83	39.59	39.29	40.95	42.00
PUFA	7.00	6.48	7.32	8.03	6.98	7.47	7.44	8.40	10.03	9.96
P/S	0.13	0.12	0.13	0.15	0.13	0.15	0.14	0.16	0.20	0.21
n-6/n-3	0.96	0.91	1.04	0.92	1.18	1.12	1.13	0.86	1.13	1.08
LCN3FA	0.74	0.72	0.53	0.80	0.56	0.69	0.53	1.20	1.46	1.60
Total FAs (g/100 g)	6.09	5.70	6.87	5.31	6.70	5.61	10.59	6.58	4.01	3.26

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Fatty acid (% of total fatty acids except for Total FAs and the ratios)	Boneless Chump		Boneless Flap		Boneless Loin		Hind-Shank		Loin Chops	
	Ckd	Raw	Ckd	Raw	Ckd	Raw	Ckd	Raw	Ckd	Raw
C8:0 Caprylic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C10:0 Capric	0.31	0.27	0.24	0.23	0.28	0.29	0.19	0.19	0.26	0.26
C11:0 Undecanoic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C12:0 Lauric	0.32	0.25	0.21	0.21	0.27	0.26	0.30	0.33	0.34	0.32
C13:0 Tridecanoic	ND	ND	ND	ND	ND	ND	ND	ND	<0.01	<0.01
C14:0 Myristic	3.46	2.83	2.67	3.09	3.00	2.90	3.27	2.83	3.41	3.62
C14:1n5 c9 Myristoleic	ND	ND	ND	0.08	0.23	0.21	0.20	0.23	0.11	0.15
C15:1n5 c10 Pentadecenoic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C16:0 Palmitic	23.73	22.43	24.07	25.52	24.47	24.44	22.33	21.74	22.89	22.34
C16:1n7 t9 Palmitelaidic	0.20	0.14	0.15	0.12	0.19	ND	0.27	0.27	0.17	0.17
C16:1n7 c9 Palmitoleic	1.29	1.24	1.26	1.29	1.38	1.17	1.70	1.59	1.09	1.16
C17:0 Margaric	2.14	1.92	2.51	2.50	1.75	1.80	1.87	1.87	2.28	2.22
C17:1n7 c10 Heptadecenoic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C18:0 Stearic	21.19	20.49	25.29	23.53	19.49	19.44	17.80	16.63	25.12	23.59
C18:1n9 t9 Elaidic	0.24	ND	0.17	0.17	0.16	ND	0.27	0.28	0.43	0.42
C18:1n7 t11 Vaccenic	3.59	2.82	4.01	3.72	2.72	2.36	3.69	3.17	4.47	4.15
C18:1n9 c9 Oleic	31.54	33.61	31.00	32.31	33.22	33.95	35.50	36.13	30.21	31.58
C18:1n7 c11 Vaccenic	0.69	0.71	0.66	0.58	0.69	0.71	0.76	0.82	0.54	0.63
C18:2n6 t Linolelaidic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C18:2n6 c Linoleic	3.12	3.98	1.83	1.64	3.56	3.82	3.09	3.88	2.21	2.43
C20:0 Arachidic	ND	ND	0.09	0.12	ND	ND	ND	ND	0.13	0.13
C18:3n6 c Gamma linolenic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C20:1n9 c11 Eicosenoic	ND	ND	ND	ND	ND	ND	ND	ND	0.10	<0.01
C18:3n3 c Alpha linolenic	2.76	2.98	1.66	1.75	2.33	2.45	2.08	2.58	2.11	2.18
CLA C18:2-c9,t11	1.84	1.76	1.92	1.637	1.49	1.54	2.29	2.35	1.71	1.71
CLA C18:2- t10,c12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C21:0 Heneicosanoic	1.18	1.08	0.81	0.83	0.98	0.91	1.74	1.31	1.00	1.13
C20:2n6 c Eicosadienoic	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.14
C22:0 Behenic	0.15	0.30	ND	ND	0.22	0.23	0.37	0.40	0.17	0.19
C20:3n6 c Eicosatrienoic	ND	ND	ND	ND	0.19	ND	ND	ND	0.07	0.13
C22:1n9 c13 Erucic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C20:3n3 c Eicosatrienoic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C20:4n6 c Arachidonic	0.72	1.09	0.52	0.27	1.10	1.32	0.88	1.41	0.37	0.50
C23:0 Tricosanoic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C22:2n6 c Docosadienoic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C24:0 Lignoceric	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C20:5n3 c EPA	0.75	1.07	0.68	0.18	1.18	1.08	0.59	0.93	0.36	0.40
C24:1n9 c15 Nervonic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C22:5n3 c DPA	0.57	0.75	0.26	0.22	0.77	0.89	0.61	0.86	0.32	0.35
C22:6n3 c DHA	0.22	0.29	ND	ND	0.32	0.23	0.20	0.21	0.13	0.12

SFA	52.48	49.57	55.89	56.03	50.47	50.27	47.87	45.29	55.60	53.80
MUFA	37.54	38.52	37.25	38.27	38.58	38.40	42.39	42.50	37.12	38.25
PUFA	9.98	11.91	6.86	5.70	10.95	11.33	9.74	12.21	7.29	7.94
P/S	0.19	0.24	0.12	0.10	0.22	0.23	0.20	0.27	0.13	0.15
n-6/n-3	0.89	1.00	0.90	0.89	1.05	1.10	1.15	1.15	0.91	1.05
LCN3FA	1.54	2.10	0.94	0.40	2.28	2.20	1.39	2.00	0.81	0.87
Total FAs (g/100 g)	3.45	2.61	9.18	7.10	3.20	2.40	5.12	2.39	7.40	5.25

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Fatty acid (% of total fatty acids except for Total FAs and the ratios)	Loin Saddle		Tenderloin		Tunnel-Boned Leg		Brains		Heart	
	Ckd	Raw	Ckd	Raw	Ckd	Raw	Ckd	Raw	Ckd	Raw
C8:0 Caprylic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C10:0 Capric	0.21	0.30	0.27	0.18	0.28	0.29	ND	ND	0.27	0.17
C11:0 Undecanoic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C12:0 Lauric	0.28	0.37	0.20	0.17	0.25	0.23	ND	ND	0.31	0.31
C13:0 Tridecanoic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C14:0 Myristic	2.95	3.58	2.24	2.27	2.97	2.64	0.53	0.49	2.84	2.36
C14:1n5 c9 Myristoleic	0.12	0.18	0.29	0.19	0.18	<0.01	ND	ND	0.10	0.17
C15:1n5 c10 Pentadecenoic	ND	ND	0.06	ND	ND	ND	0.86	ND	ND	ND
C16:0 Palmitic	21.99	22.80	20.74	21.38	22.32	21.55	20.85	19.35	16.79	15.40
C16:1n7 t9 Palmitelaidic	0.21	0.25	0.29	0.15	0.16	0.27	ND	ND	0.16	0.30
C16:1n7 c9 Palmitoleic	1.05	1.22	1.02	0.99	1.33	1.41	0.64	0.41	0.66	0.71
C17:0 Margaric	2.37	1.95	2.02	2.17	2.21	1.84	0.63	1.66	1.91	1.80
C17:1n7 c10 Heptadecenoic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C18:0 Stearic	25.32	20.56	22.28	22.24	18.74	18.62	21.76	22.37	27.34	24.47
C18:1n9 t9 Elaidic	0.35	0.40	0.46	0.34	0.38	0.49	ND	0.26	0.31	0.29
C18:1n7 t11 Vaccenic	4.74	4.91	3.71	3.24	3.60	3.06	ND	0.85	3.60	2.97
C18:1n9 c9 Oleic	30.24	31.98	32.05	32.46	36.16	36.44	24.11	22.00	19.27	17.87
C18:1n7 c11 Vaccenic	0.58	0.68	0.64	0.68	0.70	0.78	3.52	4.37	1.14	1.34
C18:2n6 t Linolelaidic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C18:2n6 c Linoleic	2.66	2.90	4.30	4.56	2.88	3.78	0.58	0.28	11.59	14.05
C20:0 Arachidic	0.18	0.27	0.18	0.22	<0.01	<0.01	0.57	0.31	0.16	0.18
C18:3n6 c Gamma linolenic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C20:1n9 c11 Eicosenoic	ND	ND	<0.01	<0.01	<0.01	<0.01	ND	ND	ND	ND
C18:3n3 c Alpha linolenic	2.01	2.09	2.86	2.98	2.61	2.88	ND	ND	3.77	4.36
CLA C18:2-c9,t11	1.56	1.93	1.30	0.86	1.93	1.64	ND	ND	1.46	1.51
CLA C18:2- t10,c12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C21:0 Heneicosanoic	1.17	1.29	1.01	0.87	1.16	1.03	ND	ND	1.02	1.02
C20:2n6 c Eicosadienoic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C22:0 Behenic	0.17	0.31	0.55	0.39	0.21	0.23	2.33	1.99	0.56	0.76
C20:3n6 c Eicosatrienoic	0.15	0.15	0.15	0.25	<0.01	0.21	0.50	0.67	0.15	0.31
C22:1n9 c13 Erucic	ND	ND	ND	ND	ND	ND	0.33	1.54	ND	ND
C20:3n3 c Eicosatrienoic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C20:4n6 c Arachidonic	0.59	0.70	1.27	1.24	0.57	0.80	5.23	5.30	3.02	4.15
C23:0 Tricosanoic	ND	ND	ND	ND	ND	ND	ND	ND	0.16	0.40
C22:2n6 c Docosadienoic	ND	ND	ND	0.11	ND	ND	ND	ND	ND	ND
C24:0 Lignoceric	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C20:5n3 c EPA	0.50	0.59	0.95	1.01	0.65	0.95	ND	ND	1.67	2.71
C24:1n9 c15 Nervonic	ND	ND	<0.01	<0.01	ND	ND	4.32	3.80	ND	ND
C22:5n3 c DPA	0.43	0.48	0.75	0.73	0.52	0.67	1.45	1.90	1.08	1.46
C22:6n3 c DHA	0.13	0.14	0.41	0.31	0.20	0.20	11.80	12.44	0.67	0.94

SFA	54.66	51.42	49.48	49.89	48.14	46.42	46.67	46.18	51.36	46.87
MUFA	37.30	39.61	38.52	38.06	42.51	42.44	33.78	33.22	25.24	23.63
PUFA	8.05	8.97	12.00	12.05	9.36	11.14	19.55	20.59	23.40	29.49
P/S	0.15	0.17	0.24	0.24	0.19	0.24	0.42	0.45	0.46	0.63
n-6/n-3	1.11	1.13	1.15	1.23	0.87	1.02	0.48	0.44	2.05	1.95
LCN3FA	1.06	1.21	2.12	2.05	1.37	1.82	13.25	14.35	3.42	5.11
Total FAs (g/100 g)	4.70	3.91	3.71	4.42	4.33	3.00	2.92	2.24	3.99	2.19

Document 3

Fatty acid (% of total fatty acids except for Total FAs and the ratios)	Kidneys		Liver		Sweetbread		Testes		Tongue, Swiss-Cut	
	Ckd	Raw	Ckd	Raw	Ckd	Raw	Ckd	Raw	Ckd	Raw
C8:0 Caprylic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C10:0 Capric	<0.01	0.51	ND	ND	0.21	<0.01	ND	<0.01	0.17	0.11
C11:0 Undecanoic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C12:0 Lauric	<0.01	0.17	<0.01	<0.01	0.17	<0.01	<0.01	<0.01	0.20	0.17
C13:0 Tridecanoic	ND	ND	ND	ND	ND	ND	ND	ND	ND	<0.01
C14:0 Myristic	0.40	1.24	0.52	0.58	2.38	1.97	1.05	1.38	2.28	2.32
C14:1n5 c9 Myristoleic	0.25	0.26	ND	<0.01	<0.01	<0.01	<0.01	<0.01	0.16	0.17
C15:1n5 c10 Pentadecenoic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C16:0 Palmitic	15.37	16.33	15.11	15.16	22.26	20.73	33.28	39.22	18.67	18.41
C16:1n7 t9 Palmitelaidic	0.43	0.48	0.57	0.53	0.20	0.29	0.34	0.57	0.18	0.19
C16:1n7 c9 Palmitoleic	0.41	0.45	1.07	1.07	0.98	0.86	0.69	0.78	1.69	1.69
C17:0 Margaric	1.66	1.68	2.18	2.11	2.16	2.01	0.71	0.73	2.32	2.22
C17:1n7 c10 Heptadecenoic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C18:0 Stearic	20.50	22.26	28.47	27.61	22.62	26.18	9.17	10.50	20.40	20.30
C18:1n9 t9 Elaidic	0.23	0.19	0.44	0.44	0.56	0.67	0.28	<0.01	0.48	0.63
C18:1n7 t11 Vaccenic	1.33	1.97	3.66	3.57	2.95	4.64	0.62	0.45	3.85	4.06
C18:1n9 c9 Oleic	16.05	17.81	17.96	18.55	33.57	30.50	16.55	17.37	39.74	39.71
C18:1n7 c11 Vaccenic	1.07	1.01	0.64	0.51	1.21	1.28	3.55	3.55	0.74	0.81
C18:2n6 t Linolelaidic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C18:2n6 c Linoleic	11.05	8.75	4.55	4.77	2.55	2.38	1.83	1.57	2.52	2.58
C20:0 Arachidic	0.25	ND	0.13	<0.01	0.14	<0.01	0.19	<0.01	0.13	0.07
C18:3n6 c Gamma linolenic	ND	ND	<0.01	<0.01	ND	ND	ND	ND	ND	ND
C20:1n9 c11 Eicosenoic	<0.01	ND	<0.01	<0.01	0.30	0.38	0.30	0.34	<0.01	0.18
C18:3n3 c Alpha linolenic	3.49	2.88	4.16	4.27	1.42	1.42	0.30	<0.01	1.72	2.06
CLA C18:2-c9,t11	0.87	0.86	1.45	1.59	1.28	1.75	<0.01	<0.01	2.62	2.34
CLA C18:2- t10,c12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C21:0 Heneicosanoic	0.84	0.92	ND	ND	0.83	1.04	<0.01	<0.01	1.25	1.18
C20:2n6 c Eicosadienoic	ND	ND	<0.01	<0.01	ND	ND	ND	<0.01	ND	ND
C22:0 Behenic	1.83	1.21	0.61	0.86	0.77	0.84	0.72	0.59	0.14	0.06
C20:3n6 c Eicosatrienoic	0.53	0.51	0.41	0.42	0.25	<0.01	3.19	2.48	ND	ND
C22:1n9 c13 Erucic	ND	ND	<0.01	<0.01	ND	ND	ND	ND	ND	ND
C20:3n3 c Eicosatrienoic	ND	ND	<0.01	<0.01	ND	ND	0.18	<0.01	ND	ND
C20:4n6 c Arachidonic	8.86	8.28	3.80	3.86	1.10	0.93	6.44	5.00	0.24	0.22
C23:0 Tricosanoic	0.31	0.62	0.46	0.508	ND	ND	ND	ND	ND	ND
C22:2n6 c Docosadienoic	ND	ND	<0.01	<0.01	ND	ND	ND	ND	ND	ND
C24:0 Lignoceric	1.31	1.07	0.39	0.345	ND	ND	0.46	0.69	ND	ND
C20:5n3 c EPA	6.84	5.40	3.99	4.00	0.60	0.77	1.15	1.01	0.17	0.16
C24:1n9 c15 Nervonic	0.56	0.48	<0.01	<0.01	0.17	<0.01	0.47	0.62	ND	ND
C22:5n3 c DPA	2.98	2.55	4.35	4.19	0.96	0.97	1.31	0.87	0.27	0.26
C22:6n3 c DHA	2.60	2.08	5.07	5.08	0.36	0.38	17.20	12.26	0.06	0.09
SFA	42.46	46.03	47.87	47.17	51.54	52.78	45.59	53.10	45.56	44.85
MUFA	20.33	22.66	24.35	24.67	39.95	38.62	22.79	23.69	46.84	47.43
PUFA	37.21	31.31	27.78	28.16	8.51	8.60	31.61	23.21	7.60	7.71
P/S	0.88	0.68	0.58	0.60	0.17	0.16	0.69	0.44	0.17	0.17
n-6/n-3	1.29	1.36	0.50	0.52	1.17	0.94	0.57	0.64	1.24	1.09
LCN3FA	12.41	10.03	13.41	13.26	1.92	2.12	19.84	14.15	0.50	0.50
Total FAs (g/100 g)	2.22	1.73	4.11	3.22	4.62	2.90	3.20	1.47	16.57	13.50

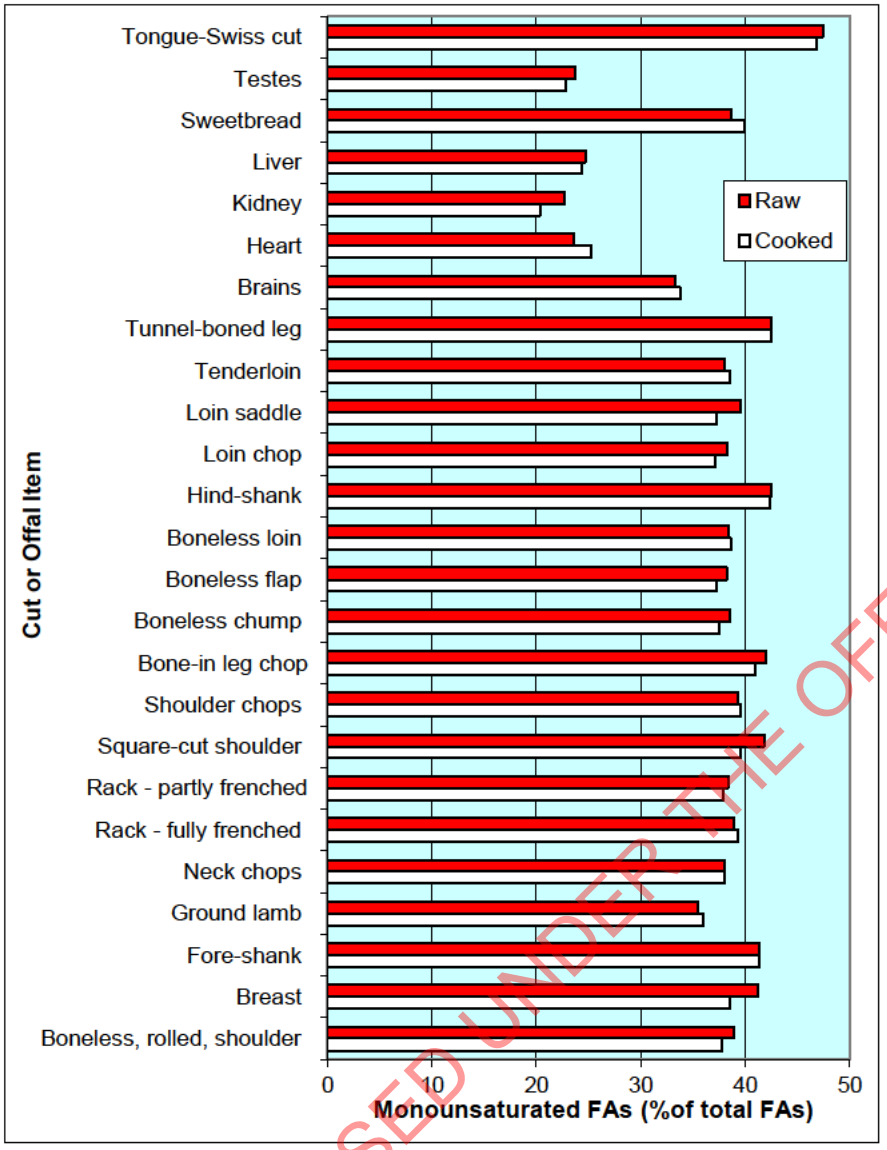
Table L21: A summary of fatty-acid characteristics for cooked cut and offal items of lamb expressed as g/100 g of the lean tissue (except in the case of the ratios of P/S and n-6/n-3) rather than as a percentage of total fatty acids as shown in Table L20.

	SFA	MUFA	Trans MUFA	PUFA	P/S	n-6 PUFA	n-3 PUFA	n-6/ n-3	LCn3FA	Total FA
	COOKED ITEMS (lean part only)									
FOREQUARTER ITEMS:										
Boneless, Rolled, Netted Shoulder	3.32	2.32	0.252	0.503	0.151	0.193	0.179	1.078	0.046	6.15
Breast	6.12	4.32	0.475	0.776	0.127	0.237	0.260	0.909	0.070	11.22
Fore-Shank	2.72	2.27	0.219	0.506	0.186	0.204	0.166	1.227	0.067	5.49
Ground Lamb	4.44	2.77	0.380	0.489	0.110	0.173	0.182	0.949	0.047	7.69
Neck Chops	6.17	4.21	0.544	0.672	0.109	0.247	0.263	0.937	0.058	11.05
Rack - Fully Frenched	3.27	2.40	0.313	0.427	0.130	0.152	0.158	0.965	0.045	6.09
Rack - Partly Frenched	3.76	2.60	0.422	0.503	0.134	0.175	0.169	1.036	0.037	6.87
Square-cut Shoulder	3.59	2.64	0.415	0.468	0.130	0.181	0.153	1.184	0.037	6.70
Square-cut Shoulder Chops	5.61	4.19	0.523	0.788	0.140	0.291	0.257	1.133	0.056	10.59
HINDQUARTER ITEMS:										
Bone-in Leg Chop/Steak	1.96	1.64	0.186	0.402	0.205	0.157	0.139	1.130	0.058	4.01
Boneless Chump	1.81	1.30	0.139	0.344	0.190	0.133	0.148	0.894	0.053	3.45
Boneless Flap	5.13	3.42	0.397	0.630	0.123	0.215	0.239	0.902	0.086	9.18
Boneless Loin	1.61	1.23	0.098	0.350	0.217	0.155	0.147	1.055	0.073	3.20
Hind-Shank	2.45	2.17	0.217	0.498	0.203	0.204	0.178	1.145	0.071	5.12
Loin Chop	4.11	2.75	0.375	0.539	0.131	0.197	0.216	0.909	0.060	7.40
Loin Saddle	2.57	1.75	0.250	0.378	0.147	0.160	0.145	1.107	0.050	4.70
Tenderloin	1.84	1.43	0.166	0.445	0.242	0.212	0.185	1.150	0.079	3.71
Tunnel-Boned Leg, Chump off, Shank off	2.08	1.84	0.179	0.405	0.194	0.149	0.172	0.868	0.059	4.33
All cuts averages	**3.48**	**2.51**	**0.308**	**0.507**	**0.160**	**0.191**	**0.186**	**1.032**	**0.058**	**6.50**
OFFAL ITEMS:										
Brains	1.36	0.99	0.000	0.572	0.419	0.184	0.387	0.476	0.387	2.92
Heart	2.05	1.01	0.162	0.933	0.456	0.588	0.286	2.054	0.136	3.99
Kidney	0.94	0.45	0.044	0.826	0.876	0.454	0.353	1.286	0.275	2.22
Liver	1.97	1.00	0.290	1.143	0.580	0.360	0.723	0.498	0.552	4.11
Sweetbread	2.38	1.85	0.172	0.393	0.165	0.180	0.154	1.169	0.089	4.62
Testes	1.46	0.73	0.039	1.012	0.693	0.367	0.645	0.569	0.635	3.20
Tongue - Swiss Cut	7.55	7.76	0.746	1.259	0.167	0.456	0.368	1.242	0.082	16.57
Offals averages	**2.63**	**2.04**	**0.208**	**0.767**	**0.417**	**0.341**	**0.342**	**1.081**	**0.249**	**5.43**

Table L22: A summary of fatty-acid characteristics for each uncooked (raw) cut and offal item of lamb expressed as g/100 g of the lean tissue (except in the case of the ratios of P/S and n-6/n-3) rather than as a percentage of total fatty acids as shown in Table L20.

	SFA	MUFA	Trans MUFA	PUFA	P/S	n-6 PUFA	n-3 PUFA	n-6/n-3	LCn3FA	Total FA
	UNCOOKED (RAW) ITEMS (lean part only)									
FOREQUARTER ITEMS:										
Boneless, Rolled, Netted Shoulder	2.17	1.61	0.132	0.352	0.162	0.137	0.136	1.008	0.043	4.13
Breast	2.79	2.13	0.220	0.247	0.088	0.124	0.123	1.012	0.033	5.17
Fore-Shank	1.32	1.14	0.087	0.294	0.223	0.129	0.106	1.212	0.042	2.75
Ground Lamb	4.92	2.98	0.439	0.484	0.098	0.161	0.154	1.049	0.037	8.38
Neck Chops	3.16	2.17	0.259	0.379	0.120	0.155	0.151	1.029	0.036	5.71
Rack - Fully Frenched	3.11	2.22	0.349	0.369	0.119	0.128	0.141	0.905	0.041	5.70
Rack - Partly Frenched	2.85	2.04	0.313	0.426	0.150	0.143	0.156	0.922	0.042	5.31
Square-cut Shoulder	2.85	2.35	0.299	0.419	0.147	0.152	0.135	1.123	0.039	5.61
Square-cut Shoulder Chops	3.44	2.58	0.296	0.553	0.161	0.189	0.219	0.864	0.079	6.58
HINDQUARTER ITEMS:										
Bone-in Leg Chop/Steak	1.57	1.37	0.168	0.325	0.207	0.127	0.117	1.084	0.052	3.26
Boneless Chump	1.29	1.01	0.077	0.311	0.240	0.132	0.133	0.997	0.055	2.61
Boneless Flap	3.98	2.72	0.285	0.404	0.102	0.136	0.153	0.889	0.028	7.10
Boneless Loin	1.21	0.92	0.057	0.272	0.225	0.123	0.112	1.104	0.053	2.40
Hind-Shank	1.08	1.01	0.089	0.292	0.270	0.126	0.109	1.153	0.048	2.39
Loin Chop	2.82	2.01	0.249	0.417	0.148	0.167	0.160	1.047	0.045	5.25
Loin Saddle	2.01	1.55	0.218	0.351	0.175	0.146	0.129	1.133	0.047	3.91
Tenderloin	2.21	1.68	0.166	0.533	0.242	0.273	0.222	1.225	0.091	4.42
Tunnel-Boned Leg, Chump off, Shank off	1.40	1.27	0.114	0.333	0.238	0.143	0.141	1.018	0.054	3.00
All cuts averages	**2.45**	**1.82**	**0.212**	**0.376**	**0.173**	**0.150**	**0.144**	**1.043**	**0.048**	**4.65**
OFFAL ITEMS:										
Brains	1.04	0.74	0.025	0.462	0.446	0.140	0.322	0.435	0.322	2.24
Heart	1.03	0.52	0.078	0.646	0.629	0.405	0.208	1.953	0.112	2.19
Kidney	0.80	0.39	0.046	0.541	0.680	0.303	0.223	1.359	0.173	1.73
Liver	1.52	0.79	0.242	0.906	0.597	0.291	0.564	0.516	0.427	3.22
Sweetbread	1.53	1.12	0.162	0.249	0.163	0.096	0.102	0.938	0.061	2.90
Testes	0.79	0.35	0.015	0.339	0.430	0.132	0.207	0.641	0.207	1.47
Tongue - Swiss Cut	6.06	6.40	0.658	1.041	0.172	0.379	0.346	1.094	0.068	13.50
Offals averages	**1.82**	**1.47**	**0.175**	**0.598**	**0.445**	**0.249**	**0.282**	**0.991**	**0.196**	**3.89**

Figure L7: The P/S ratio and the percentage of MUFA in the fatty acids of the cooked and raw lean portion of 25 lamb cuts and offal items.



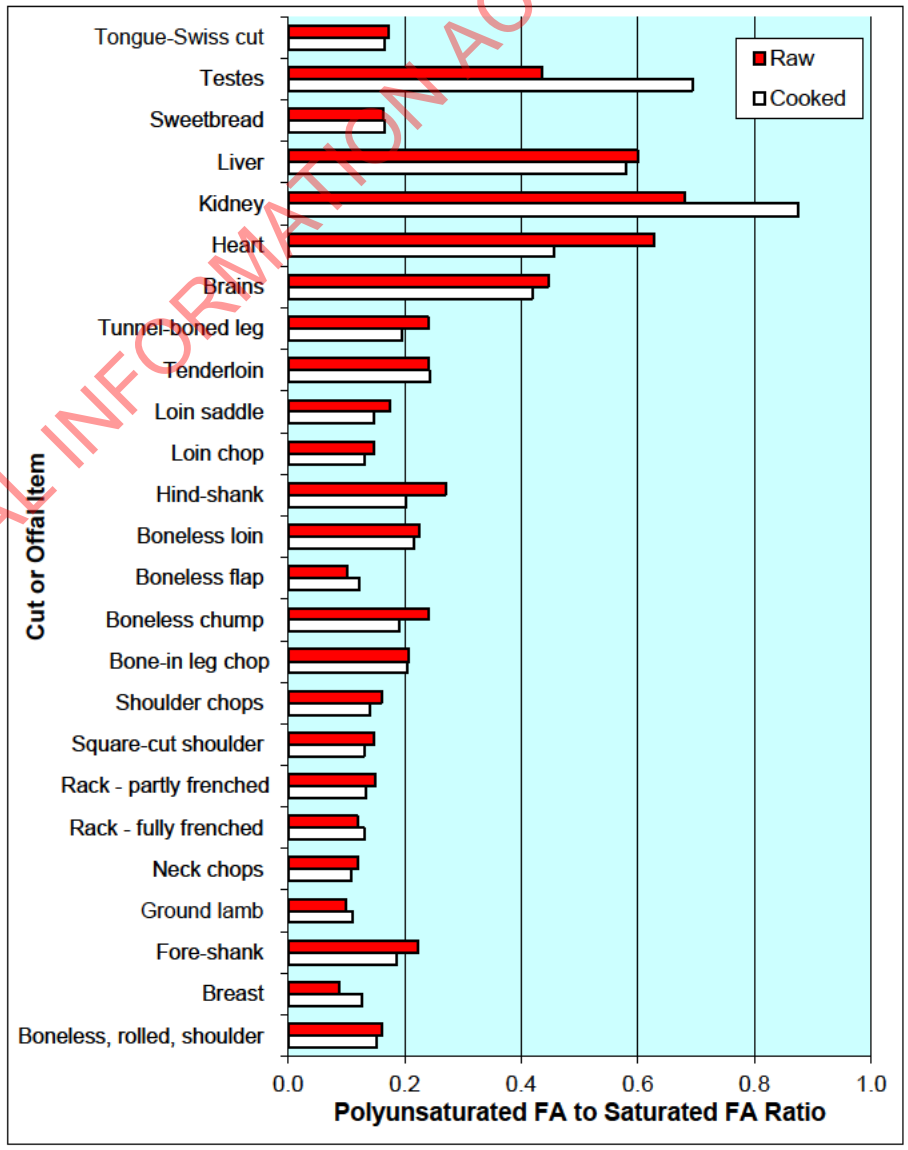
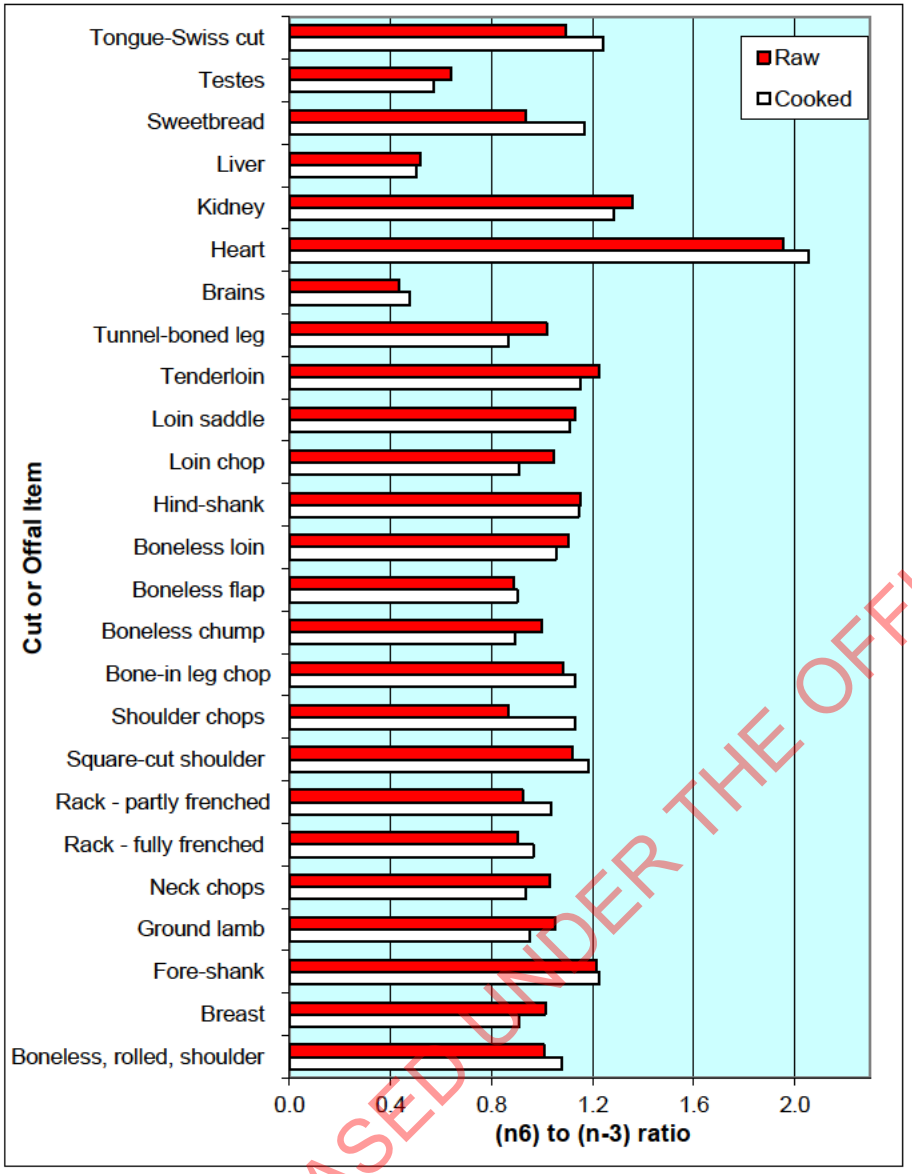
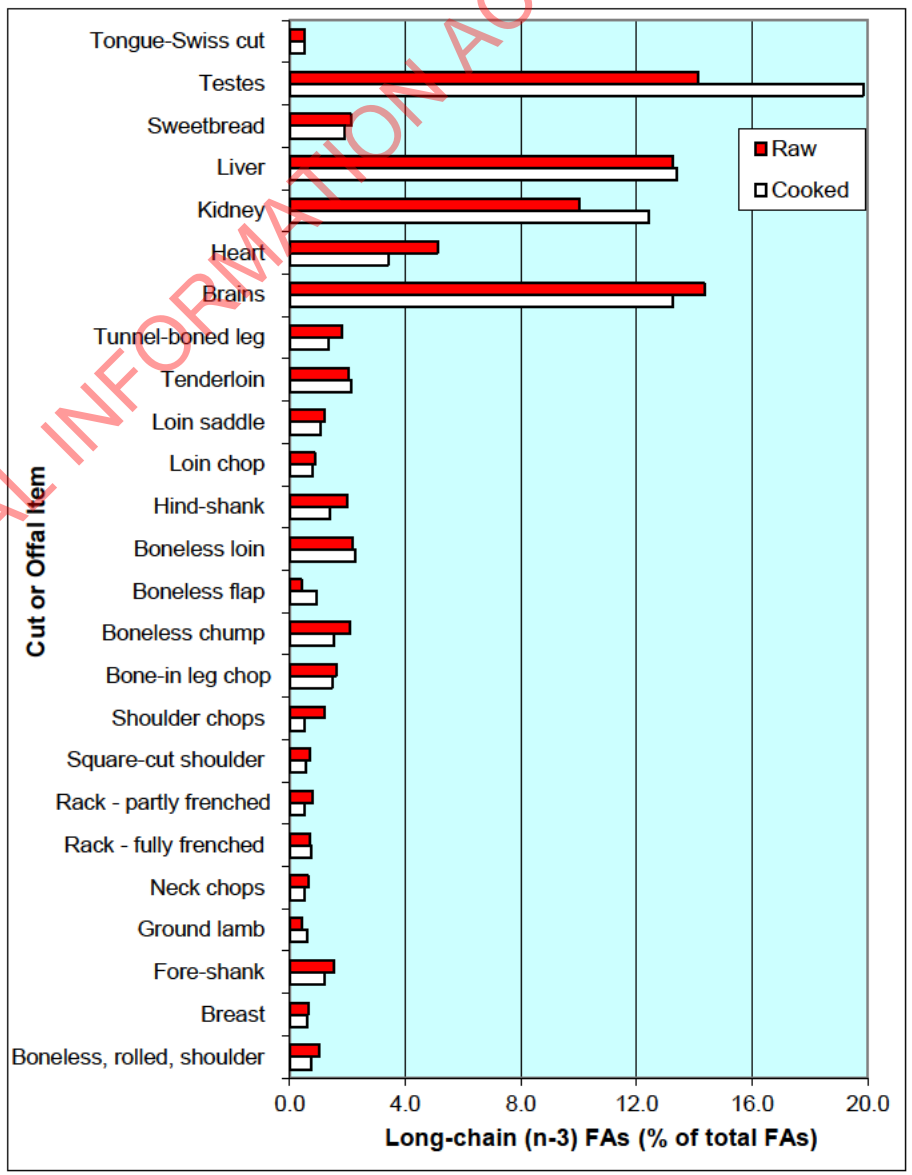


Figure L8: The (n-6) to (n-3) ratio and concentrations of the long-chain n-3 fatty acids in the cooked and raw lean portion of 25 lamb cuts and offal items.





f) ***Composition of Lamb Fat Tissue Samples***: Concentrations of nutrients in dissected subcutaneous and intermuscular fat tissue from selected raw and cooked cuts are shown in Tables L23 (proximate composition and cholesterol) L24 (vitamins), L25 (minerals, and L26 (fatty acids).

Table L23 : Lamb fat (subcutaneous and intermuscular) composition in terms of energy, proximate composition and cholesterol for both cooked (Ckd) and raw samples.

	Subcutaneous Fat[a]		Intermuscular Fat[b]	
	Ckd	Raw	Ckd	Raw
Water (%)	21.8	19.2	29.6	25.4
Energy (kJ/100 g)	2791	2913	2478	2640
Energy (kcal/100 g)	667.0	696.3	592.2	631.0
Protein (%)	5.2	3.9	8.5	4.6
Fat (%)	72.3	76.2	62.4	68.5
Ash (%)	0.1	0.3	0.4	0.2
Cholesterol (mg/100 g)	65.7	77.9	82.1	75.5

[a] Subcutaneous fat from lamb loin saddle cuts (3321)
[b] Intermuscular (seam) fat from lamb boneless, rolled netted shoulder cuts (3620)

Table L24: Lamb fat (subcutaneous and intermuscular) composition in terms of the concentration of vitamins for both cooked (Ckd) and raw samples (BDL = below detectable limit).

	Subcutaneous Fat[a]		Intermuscular Fat[b]	
	Ckd	Raw	Ckd	Raw
Vitamin B1 (mg/100 g) (Thiamine)	0.094	0.088	0.131	0.094
Vitamin B2 (mg/100 g) (Riboflavin)	0.058	0.038	0.104	0.035
Vitamin B3 (mg/100 g) (Niacin)	1.53	1.06	1.74	1.13
Vitamin B5 (mg/100 g) (Pantothenic acid)	0.2	BDL	0.2	0.1
Vitamin B6 (mg/100 g) (Pyridoxine)	0.061	0.033	0.067	0.052
Vitamin B12 (µg/100 g) (Cyanocobalamin)	0.7	0.4	0.7	0.4
Vitamin A (µg/100 g)	60.4	43.8	33.9	46.0
Vitamin D3 (µg/100 g)	BDL	BDL	0.23	0.26
25-OH Vitamin D3 (µg/100 g)	0.80	0.66	0.86	0.70
Vitamin E (mg/100 g)	1.02	1.18	0.94	0.84

[a, b] As for Table L23

Table L25: Lamb fat (subcutaneous and intermuscular) composition in terms of the concentration of minerals for both cooked (Ckd) and raw samples.

	Subcutaneous Fat[a]		Intermuscular Fat[b]	
	Ckd	Raw	Ckd	Raw
Calcium (mg/100 g)	5.6	2.6	6.4	4.7
Copper (mg/100 g)	0.03	0.02	0.04	0.02
Iodine (µg/100 g)	2.3	2.7	0.7	1.1
Iron (mg/100 g)	0.70	0.47	1.39	0.72
Magnesium (mg/100 g)	9.5	4.9	11.8	6.4
Manganese (µg/100 g)	5.0	1.7	6.4	2.5
Phosphorus (mg/100 g)	83.7	45.4	118.3	60.5
Potassium (mg/100 g)	165	93	198	119
Selenium (µg/100 g)	2.1	1.3	2.3	2.3
Sodium (mg/100 g)	43	28	52	34
Zinc (mg/100 g)	1.03	0.46	1.77	0.87

[a, b] As for Table L23

Table L26: Fatty-acid composition of cooked (Ckd) and raw lamb subcutaneous (Subcut) and intermuscular (Intermusc) fat as % of total fatty acids and g/100 g of the tissue (ND = not detectable).

	FAs as % of total FAs				FAs as g/100 g of item			
	Subcut. Fat		Intermusc. Fat		Subcut. Fat		Intermusc. Fat	
	Ckd	Raw	Ckd	Raw	Ckd	Raw	Ckd	Raw
C8:0 Caprylic	0.05	0.02	ND	ND	0.03	0.01	ND	ND
C10:0 Capric	0.12	0.15	0.12	0.15	0.07	0.09	0.06	0.08
C11:0 Undecanoic	ND	ND	ND	ND	ND	ND	ND	ND
C12:0 Lauric	0.11	0.14	0.14	0.14	0.06	0.08	0.06	0.07
C13:0 Tridecanoic	0.03	0.03	0.04	0.02	0.02	0.02	0.02	0.01
C14:0 Myristic	2.41	2.69	2.84	2.57	1.30	1.53	1.33	1.36
C14:1n5 c9 Myristoleic	0.04	0.05	0.07	0.04	0.02	0.03	0.04	0.02
C15:1n5 c10 Pentadecenoic	ND	ND	ND	ND	ND	ND	ND	ND
C16:0 Palmitic	19.59	21.04	20.25	20.86	10.60	12.00	9.49	11.02
C16:1n7 t9 Palmitelaidic	0.15	0.15	0.18	0.15	0.08	0.08	0.08	0.08
C16:1n7 c9 Palmitoleic	0.82	0.94	1.04	0.84	0.44	0.54	0.49	0.45
C17:0 Margaric	2.52	2.60	2.40	2.46	1.36	1.48	1.12	1.30
C17:1n7 c10 Heptadecenoic	ND	ND	ND	ND	ND	ND	ND	ND
C18:0 Stearic	32.90	29.68	29.97	31.56	17.80	16.92	14.05	16.67
C18:1n9 t9 Elaidic	0.42	0.42	0.37	0.46	0.23	0.24	0.17	0.24
C18:1n7 t11 Vaccenic	7.52	6.47	7.10	7.02	4.07	3.69	3.33	3.71
C18:1n9 c9 Oleic	26.98	29.45	28.73	27.23	14.60	16.80	13.47	14.38
C18:1n7 c11 Vaccenic	0.49	0.54	0.52	0.54	0.26	0.31	0.25	0.28
C18:2n6 t Linolelaidic	0.07	0.07	0.06	0.13	0.04	0.04	0.03	0.07
C18:2n6 c Linoleic	1.04	0.90	1.10	1.02	0.56	0.51	0.52	0.54
C20:0 Arachidic	0.17	0.12	0.14	0.14	0.09	0.07	0.07	0.07
C18:3n6 c Gamma linolenic	ND	ND	ND	ND	ND	ND	ND	ND
C20:1n9 c11 Eicosenoic	0.06	0.05	0.04	0.04	0.03	0.03	0.02	0.02
C18:3n3 c Alpha linolenic	1.22	1.12	1.30	1.22	0.66	0.64	0.61	0.64
CLA C18:2 c9 t11	1.84	1.87	1.95	2.00	1.00	1.06	0.91	1.05
CLA C18:2 t10 c12	ND	ND	ND	ND	ND	ND	ND	ND
C21:0 Heneicosanoic	1.10	1.11	1.22	0.99	0.60	0.63	0.57	0.52
C20:2n6 c Eicosadienoic	ND	ND	ND	ND	ND	ND	ND	ND
C22:0 Behenic	0.25	0.31	0.32	0.32	0.14	0.18	0.15	0.17
C20:3n6 c Eicosatrienoic	ND	ND	ND	ND	ND	ND	ND	ND
C22:1n9 c Erucic	ND	ND	ND	ND	ND	ND	ND	ND
C20:3n3 c Eicosatrienoic	ND	ND	ND	ND	ND	ND	ND	ND
C20:4n6 c Arachidonic	ND	ND	ND	ND	ND	ND	ND	ND
C23:0 Tricosanoic	ND	ND	ND	ND	ND	ND	ND	ND
C22:2n6 c Docosadienoic	ND	ND	ND	ND	ND	ND	ND	ND
C24:0 Lignoceric	ND	ND	ND	ND	ND	ND	ND	ND
C20:5n3 c EPA	ND	ND	ND	ND	ND	ND	ND	ND
C24:1n9 c15 Nervonic	ND	ND	ND	ND	ND	ND	ND	ND
C22:5n3 c DPA	0.10	0.10	0.10	0.10	0.05	0.05	0.05	0.05
C22:6n3 c 19-DHA	ND	ND	ND	ND	ND	ND	ND	ND
For abbreviations below see p 75								
SFA	59.25	57.89	57.43	59.21	32.05	33.02	26.92	31.28
MUFA	36.48	38.05	38.06	36.32	19.74	21.70	17.84	19.18
Trans MUFA	8.09	7.03	7.64	7.62	4.38	4.01	3.58	4.03
PUFA	4.28	4.05	4.51	4.47	2.31	2.31	2.11	2.36
P/S	0.07	0.07	0.08	0.08				
Total n-6 PUFAs	1.12	0.97	1.16	1.15	0.60	0.55	0.55	0.61
Total n-3 PUFAs	1.32	1.22	1.40	1.32	0.71	0.70	0.65	0.70
n-6/n-3	0.85	0.79	0.83	0.87				
LCN3FA	0.10	0.10	0.10	0.10	0.05	0.05	0.05	0.05
Total FAs (g/100 g)					54.10	57.03	46.87	52.82

g) ***Combining of Results for Lamb Lean and Fat:***

Table L27: Five examples of ways in which the nutrient or energy content of a cut or offal item may be calculated from the information provided in previous tables. Calculations are shown either for the amount of nutrient per 100 g of the total product or per 100 g of the edible portion (excluding bone and waste). The steps involved are explained in rows [a] to [l].

	Vitamin E in **cooked boneless loin** (mg)	Vitamin A in **cooked fore-shank** (µg)	Iron in **cooked boneless chump** (mg)	Energy in **cooked boneless flap** (kJ)	Protein in **cooked neck chop** (g)
[a] proportion of muscle in 100 g of product	0.999	0.52	0.791	0.667	0.581
[b] Amount of nutrient in 100 g of muscle	0.34	3.10	1.70	974	31.4
[c] \ Amount of nutrient from muscle in 100 g of product ([a] x [b])	0.340	1.612	1.345	649.7	18.243
[d] Proportion of subcutaneous fat in 100 g of product	0	0.03	0.144	0.209	0.032
[e] Amount of nutrient in 100 g of subcutaneous fat	1.02	60.4	0.7	2791	5.2
[f] \ Amount of nutrient from subcutaneous fat in 100 g of product ([d] x [e])	0	1.812	0.101	583.3	0.166
[g] Proportion of intermuscular fat in 100 g of product	0.001	0.036	0.064	0.113	0.044
[h] Amount of nutrient in 100 g of intermuscular fat	0.094	33.9	1.39	2478.0	8.5
[i] \ Amount of nutrient from intermuscular fat in 100 g of product ([g] x [h])	0.0001	1.220	0.089	280.0	0.374
[j] Total amount of nutrient in 100 g of the total product ([c] + [f] + [i])	**0.340**	**4.64**	**1.53**	**1513**	**18.78**
[k] Proportion of bone + waste in the product	0	0.414	0.001	0.011	0.344
[l] Total amount of nutrient in 100 g of the edible tissue (fat + muscle) ([j] x (1/(1-[k]))	**0.340**	**7.93**	**1.54**	**1530**	**28.63**

h) ***Amino-acid Composition of the Lean Tissue from Four Lamb Cuts:***

Table L28: The amino-acid (AA) composition within the lean tissue of four lamb cuts expressed as a percentage (g/100 g) of raw weight.

	Lamb cut			
Amino acid (g/100 g)	Boneless Chump	Boneless Loin	Hind-Shank	Boneless Rolled Shoulder
Asparagine	1.88	1.89	1.86	1.64
Threonine	1.02	1.05	1.03	0.90
Serine	0.76	0.74	0.73	0.63
Glutamic acid	3.03	2.98	3.00	2.69
Proline	0.69	0.67	0.69	0.64
Glycine	0.90	0.87	0.92	0.89
Alanine	1.08	1.07	1.06	0.96
Valine	1.10	1.12	1.09	0.96
Isoleucine	0.96	0.99	0.96	0.84
Leucine	1.68	1.68	1.65	1.47
Tyrosine	0.76	0.75	0.75	0.65
Phenylalanine	0.87	0.85	0.84	0.74
Histidine	0.44	0.53	0.43	0.37
Lysine	1.98	1.91	1.82	1.62
Arginine	1.43	1.45	1.45	1.31
Taurine	0.09	0.03	0.14	0.08
Cysteine	0.29	0.25	0.28	0.27
Methionione	0.75	0.66	0.68	0.65
Tryptophan	0.24	0.25	0.22	0.22
Sum of all AAs	**19.97**	**19.74**	**19.58**	**17.51**

Appendix 1: Laboratory Procedures

Table A1-1: A summary of the procedures and methods used for the laboratory measurement of nutrients in raw and cooked samples of beef cuts and offal items. Lists of abbreviations and references are provided after the table.

	Method	Reference	LOD	LOQ
Moisture	Convection oven 16hr @ 105°C	AOAC 950.46 (AOAC, 2005)	0.05%	0.1%
Protein	Nitrogen by Leco total combustion method, N-P = 6.25	AOAC 968.06	0.05%	0.1%
Fat	Acid Digestion followed by Mojonnier extraction	AOAC 954.02		0.1%
Cholesterol	Saponification, GC	AOAC 933.08, 970.50, 970.51	0.5mg/100g	1.0 mg/100g
B1	Acid Hyd, dephosphorylation, HPLC with thiochrome deriv.	EN 14122:2003	0.004mg/100g	0.013 mg/100g
B2	Acid Hyd, dephosphorylation, HPLC using fluorometric detection.	EN 14152:2003	0.002 mg/100g	0.006 mg/100g
B3	Acid/alkaline extr , HPLC using fluorimetric detection.	EN 15652:2009	0.005 mg/100g	0.015 mg/100g
B5	HPLC	Davidek et al. (1985)	0.5mg/100g	1.0 mg/100g
B6	Acid hydr, dephosphorylation, HPLC using fluorometric detection	EN 14164:2008	0.022 mg/100g	0.074 mg/100g
B12	Two stage homogenisation, Radioisotopic dilution	Green et al. (1974)	0.5 µg/100g	
Vitamin A (Retinol)	Saponify, then extract with hexane:ethyl acetate, HPLC	AOAC 974.29(4), modified	6.25 µg/100g	
Vitamin D3	Saponify, then extract with hexane, clean-up by SPE (semi-prep silica column), and an amine column, and then separation by HPLC using a Diode Array	AOAC 2004.05; Purchas et al. (2007)	0.01 µg/100g	0.02µg/100g
Vitamin E	Saponify, then extract with hexane:ethyl acetate, HPLC	AOAC 975.43, modified	0.08mg/100g	0.20mg/100g
Fatty acids	Dried sample methylated with Methanolic HCl, into toluene & GC analysis	Sukhija & Palmquist (1988)	0.01g/100g	0.03g/100g
CLA's	Fat is extracted with CHCl3-MeOH, methylated with Na methoxide, GC	Meat Lipid Research, AAFC Lacombe SOP #A D1002, Alberta, Canada.	0.01g/100g	0.03g/100g
25-OH vit D3	Acetonitrile extraction followed by Radioimmune assay	Diasorin kit (Stillwater, Minnesota) from Immuno Pty Ltd		0.05 µg/100g
Amino acids	HCL hydrolysis followed by HPLC determination	AOAC 994.12	0.01%	0.02%
Cys/met	Performic acid oxidation followed by HPLC determination	AOAC 994.12	0.01%	0.02%
Tryptophan	Alkaline hydrolysis followed by HPLC determination	AOAC 988.15 Limit of uncertainty = 6.50%		
Iodine	TMAH digestion followed by ICP-MS	Fecher et al. (1998)	0.01 mg/kg	
Selenium	TMAH digestion followed by ICP-MS	Fecher et al. (1998)	0.02 mg/kg	

Minerals	Acid digestion followed by ICP	AOAC 984.27		
Ash	Furnace at 550°C for 16hours	AOAC 942.05	0.05%	0.1%
Calcium (Ca)	Acid digestion followed by ICP	AOAC 984.27	0.003g/100 g	0.006g/100 g
Copper (Cu)	Acid digestion followed by ICP	AOAC 984.27 (modified)	0.1mg/kg	0.2mg/kg
Iron (Fe)	Acid digestion followed by ICP	AOAC 984.27 (modified)	0.7mg/kg	0.7mg/kg
Magnesium (Mg)	Acid digestion followed by ICP	AOAC 984.27 (modified)	0.0003g/100g	0.0006g/100g
Manganese (Mn)	Acid digestion followed by ICP	AOAC 984.27 (modified)	0.07mg/kg	0.2mg/kg
Phosphorus (P)	Acid digestion followed by ICP	AOAC 984.27	0.001g/100g	0.002g/100g
Potassium (K)	Acid digestion followed by ICP	AOAC 984.27	0.003g/100g	0.006g/100g
Sodium (Na)	Acid digestion followed by ICP	AOAC 984.27	0.003g/100g	0.006g/100g
Zinc (Zn)	Acid digestion followed by ICP	AOAC 984.27 (modified)	0.8mg/kg	0.8mg/kg

Abbreviations:

AOAC	Association of Official Analytical Chemists
CHCl3	Chloroform
CLA's	Conjugated linoleic acids
Cys/met	Cysteine and methionine
Deriv	Derivitisation
EN	European Standard (same status as British Standard)
Extr	Extraction
GC	Gas chromatography
HCl	Hydrochloric acid
HPLC	High-pressure liquid chromatography
Hyd	Hydrolysis
ICP	Inductively-coupled plasma spectroscopy
ICP-MS	Inductively-coupled plasma spectroscopy – Mass spectroscopy
LOD	Limit of detection expressed relative to the weight of the freeze-dried sample
LOQ	Limit of quantification expressed relative to the weight of the freeze-dried sample
MeOH	Methanol
N	Nitrogen
P	Protein
SPE	Solid-phase extraction
TMAH	Tetramethylammonium hydroxide

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Table A1-2: The yield (%) of freeze-dried product from cooked (Ckd) and raw minced samples of the lean portion of beef and lamb cuts and offal items.

BEEF			LAMB		
Cut or offal item	**Ckd**	**Raw**	**Cut or offal item**	**Ckd**	**Raw**
FOREQUARTER ITEMS:					
Bolar Blade	39.9	27.3	Boneless, Rolled, Netted Shoulder	36.27	27.54
Brisket Navel End	45.4	32.5	Breast	45.67	28.77
Brisket Point End	42.0	26.8	Fore-Shank	41.45	25.96
Chuck Eye Roll	41.5	26.9	Ground lamb	33.76	31.13
Cube Roll	43.8	31.3	Neck Chops	46.12	28.08
Manufacturing Beef	28.7	26.6	Rack – Fully Frenched	33.69	28.77
Oyster Blade	38.3	28.8	Rack – Partly Frenched	35.85	30.26
Ribs Prepared	38.9	29.3	Square-cut Shoulder	35.61	27.93
			Square-cut Shoulder Chops	45.26	28.40
HINDQUARTER ITEMS:					
Eye Round	35.3	26.5	Bone-in Leg Chop/Steak	33.30	26.34
Flank	39.0	26.9	Boneless Chump	30.01	26.02
Flat	44.1	29.7	Boneless Flap	41.27	31.20
Hind Shin	36.0	25.9	Boneless Loin	34.13	25.94
Inside	42.6	28.2	Hind-Shank	40.09	25.95
Knuckle	35.9	28.1	Loin Chop	40.31	29.17
Rump Centre	38.8	29.0	Loin Saddle	33.18	27.79
Striploin	41.0	30.3	Tenderloin	34.34	26.26
Tenderloin	41.0	28.8	Tunnel-Boned Leg, Chump off, Shank off	32.92	26.04
All-cuts average	**39.5**	**28.4**		**37.40**	**27.86**
OFFAL ITEMS:					
Heart	41.0	22.3	Brains	27.23	21.78
Kidney	33.9	19.9	Heart	33.83	22.66
Liver	35.2	31.2	Kidney	25.61	19.92
Sweetbread	44.0	42.7	Liver	37.30	30.94
Tongue	35.5	43.4	Sweetbread	28.06	21.23
Tripe Uncooked	22.6	18.5	Testes	26.48	15.30
			Tongue – Swiss Cut	41.31	33.83
Offals average	**35.4**	**29.6**		**31.40**	**23.67**

Appendix 2: The Density of Selected New Zealand Beef and Lamb Cuts and Offal Items

1. Introduction

Measures of the density of food items (including meat) are required by some nutrient databases to enable users of the information to assess the nutrient content of foods either on a weight basis or a volume (eg 1 cup) basis. Density as the weight per unit volume permits the calculation of the volume associated with any weight.

Because published values for lean meat density in the scientific literature suggest that it shows little variation between different types of meat or between meat from different animals, it was decided to conduct a pilot trial to evaluate the variation in density of a selection of lean meat items and offal items before and after cooking, in order to determine whether or not it was necessary to assess the density of all items in the overall trial. The proposal was that, if the variation in density proved to be low, then the values obtained on the samples evaluated could also be used for all other items involved.

2. Material and Methods

The items chosen for analysis are listed in Table A2-1.

Table A2-1: Items to be evaluated for density within the pilot trial

Lamb items		**Beef Items**	
Item	**Cooking**	**Item**	**Cooking**
Tunnel-boned leg (chump+shank off)	*Slow roast*	Eye round	*Slow roast*
Fully-Frenched rack	*Fast roast*	Cube roll	*Fast roast*
Loin chops	*Fast fry*	Striploin	*Fast fry*
Square-cut shoulder chops	*Braise*	Inside	*Braise*
Testes	*Simmer & fry*	Hearts (cap-off)	*Simmer*
		Kidneys	*Simmer*
Hearts	*Simmer*	Uncooked tripe	*Simmer*
Kidneys	*Fry*	Liver	*Fry*
Sweetbreads	*Simmer*		
Liver	*Fry*		

The overall procedure is shown as a flow diagram in Figure A2-1, and illustrations of the equipment used are shown at the end of this report in Figure A2-2.

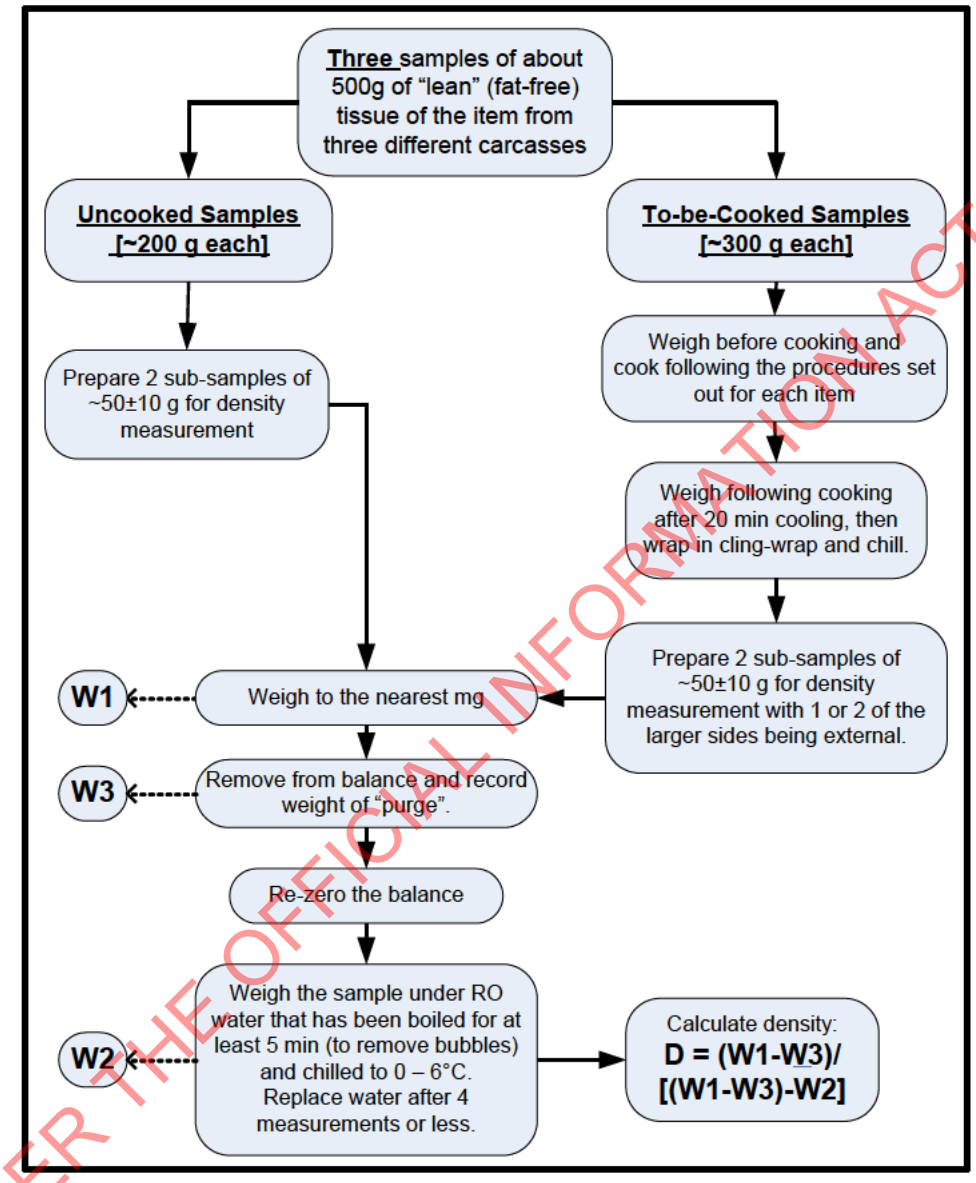

Figure A2-1: The density measuring procedure for cooked and uncooked samples of lean meat and offal items.

Points to note about density-measuring protocol set out in Figure A2-1 are as follows:

1. Density was measured on samples with all visible fat (except intramuscular marbling fat) removed because this is the nature of the samples that are being evaluated in the laboratory for nutrient content.
2. The procedure was based on that described by Jarvis (1971).
3. Weights were measured to the nearest milligram as this was found to be adequate for samples weighing between 45 and 55 g if density is to be measured to the third decimal place.
4. Jarvis (1971) showed that temperature had a small but consistent effect on density, so care was taken to ensure that the water temperature did not exceed 6°C. According to the results presented by Jarvis the decrease in density from about 2°C to 6°C was less than 0.001 $g \cdot mL^{-1}$.
5. RO water (water purified by reverse osmosis) was boiled prior to being chilled in order to remove small bubbles of gas.

6. All measurements were made with the same setup with a cage suspended under an electronic balance so that it was under water in a container that always contained 3 litres of the chilled, de-bubbled water.
7. For each new lot of chilled water two metal "standards" were tested in order to standardise procedures over time. One consisted of stainless steel weighing 41.463 g with a density of 7.956 $g \cdot mL^{-1}$, and the other was aluminium weighing 50.484 g with a density of 2.840 $g \cdot mL^{-1}$.

3. Results

Results of density determinations are given in Table A2-2.

Table A2-2: Means (±SD) for estimates of sample density ($g \cdot mL^{-1}$) for the lean meat from a range of beef cuts and lamb cuts as well as for a selection of beef and lamb offal items.

Item	Raw sample		Cooked sample	
	n	Mean ± SD	n	Mean ± SD
Lamb cuts:				
Tunnel-boned leg	6	1.061 ± 0.007	6	1.082 ± 0.005
Loin chop	7	1.067 ± 0.007	7	1.071 ± 0.007
Square-cut shoulder chop	6	1.057 ± 0.004	5	1.076 ± 0.006
Fully Frenched rack	5	1.064 ± 0.009	6	1.065 ± 0.008
Lamb offal:				
Heart	6	1.059 ± 0.002	6	1.072 ± 0.016
Kidney	6	1.054 ± 0.004	5	1.070 ± 0.002
Sweetbread	6	1.059 ± 0.004	6	1.070 ± 0.002
Liver	6	1.070 ± 0.005	6	1.079 ± 0.005
Brain	6	1.041 ± 0.001	6	1.041 ± 0.001
Testes	-	-	6	1.058 ± 0.003
Fat (adipose tissue)	9	0.961 ± 0.010	4	0.950 ± 0.005
Beef cuts:				
Eye round	6	1.075 ± 0.003	6	1.098 ± 0.006
Striploin	6	1.066 ± 0.003	6	1.073 ± 0.006
Inside	6	1.077 ± 0.002	6	1.116 ± 0.002
Cube roll	6	1.063 ± 0.003	6	1.071 ± 0.007
Beef offal:				
Heart	6	1.062 ± 0.003	6	1.090 ± 0.003
Kidney	6	1.053 ± 0.001	6	1.084 ± 0.002
Tripe	6	1.006 ± 0.025	6	1.058 ± 0.004
Liver	6	1.079 ± 0.001	6	1.093 ± 0.004
Fat (adipose tissue)	8	0.956 ± 0.011	-	-

Points to note about density estimates shown in Table A2-2 are as follows:

1. Within the raw beef and lamb cuts the density of the lean tissue was very consistent with low standard deviations. Coefficients of variation were generally less than 1% (for example, for a CV% of 1% at a density of 1.07, the SD would be 0.0107; most of those shown in Table 2 are less than that).

2. Overall for lean meat samples the mean density for lamb was 1.062 (±0.007), and for beef was 1.070 (±0.006).
3. For the lean meat samples of beef and lamb the density after cooking increased slightly and was often more variable. This was to be expected as the loss of water would mean that the remainder contained a higher proportion of the more dense components. The variation between cuts in the size of the increase in density with cooking was probably mainly attributable to the different cooking methods rather than to specific cut effects. The cooking methods used were the same as those specified for the main parts of the trials.
4. The largest cooking effect on density was shown by lean tissue from the beef inside cut. This was probably due to the braising cooking method that involved cutting the meat into cubes with 20-25 mm edges, browning it in a frying pan, and then cooking in water in a casserole in an oven at 160°C.
5. Density values for the beef and lamb offal items were more variable. The lowest and most variable value was for uncooked tripe. This was probably a reflection of the variation in the fat content of the samples measured, and possibly to the fact that it was difficult to ensure that no bubbles were present in amongst the papillae. The lamb brain samples had the next lowest density, presumably due to their relatively high lipid content. However, apart from the tripe, the range in average densities for all raw beef and lamb offal items assessed extended only from 1.041 to 1.079.
6. As with lean meat items, the densities of the offal items increased with cooking in all cases except for lamb brains. The variation in the extent of these increases is likely to be mainly a reflection of the different cooking procedures used.
7. Density for adipose tissue was measured on raw samples for lamb (n = 9) and beef (n = 8), and for cooked samples of lamb only (n = 4). Average values were very similar for raw lamb and beef (0.961 & 0.956, respectively).

The density values given in Table A2-2 for raw lean muscle tissue are in general agreement with values in the scientific literature, but no published values were found for cooked lean meat or for either raw or cooked offal items. Some of the values from the literature are summarised below.

Jarvis (1971) reported the density of lean from beef thick flank cuts in three experiments, with the average values at a temperature of 5°C being 1.0784, 1.0772, and 1.0765 $g \cdot mL^{-1}$. He also showed that density decreased with increasing temperature, but this was a very small effect over the range from 2 to 6°C, and only about 0.010 $g \cdot mL^{-1}$ over the range from 2 to 30°C.

In the same study Jarvis (1971) measured the density of beef adipose tissue from beef thick flank cuts and in three experiments reported values at 5°C of 0.9660, 0.9580, and 0.9460 $g \cdot mL^{-1}$. The density of lipid extracted from mammalian adipose tissue at 10°C has been reported to be approximately 0.92 (Fidanza et al. 1953) so the expected density of adipose tissue will decrease as the proportion of lipid in the tissue increases. This is known to occur as an animal grows and develops, as illustrated by the results reported by Robelin (1981) where the lipid in subcutaneous adipose tissue of cattle at 15% of their mature weight (5.4% body fat) was 25% by weight, but this increased to 61% lipid in subcutaneous adipose tissue for cattle at 55% of their mature weight (15.7% body fat).

Bieber et al. (1961) measured the density (reported as specific gravity) of 50 beef rib eye cuts containing 3.25% lipid at 3°C and obtained an average value of 1.0694 $g \cdot mL^{-1}$ with a range from lowest to highest value of 0.0110.

Brown et al (2003) measured the density of 11 distal forelimb muscles from each of 7 horses and reported average values of either 1.07 or 1.08 $g \cdot mL^{-1}$ for each muscle. Muscles in this part of the forelimb of horses would be expected to have very low levels of fat and quite high levels of connective tissue as they included the tendons. These two characteristics could explain why the density values are slightly higher than most of the lean muscle values in Table A2-2.

Rahman and Driscoll (1994) reported density values for 44 seafoods, which presumably would consist primarily of muscle or muscle-like tissues. The values ranged from 1.042 to 1.093.

Generally these published values for both lean muscle tissue as well as adipose tissue are in good agreement with the values shown in Table A2-2.

4. Conclusions and Recommendations

a. Density values for raw and cooked samples of the lean muscle tissue from several cuts of lamb and beef plus that of several offal items were measured using under-water weighing at < 6°C.

b. The values for uncooked muscle and adipose tissue were similar to published values for those tissues.

c. Because of the low variation in the density of raw muscle tissue shown here and elsewhere, it is recommended that a value of 1.07 be used for all lamb and beef lean muscle samples. This means, for example, that a 100 mL volume of lean will weigh 100 g and a "cup" of 250 mL will weigh 267.5 g.

d. The density of cooked forms of the same lean muscle samples varied more than the raw values because of the different cooking methods involved. Usually the cooked product was slightly more dense and it is suggested that a standard value of 1.08 be used.

e. Density values for both raw and cooked offal items showed more between-item variation than for lean meat items, but, with the possible exception of brain and tripe, it is suggested that standard values of 1.07 and 1.08 for raw and cooked samples, respectively, be used.

f. It is recommended that the density of adipose tissue, should this be needed, be taken as being 0.96. Thus, 100 mL of fat is estimated to weigh 96 g, and a "cup" of 250 mL will weigh 240 g.

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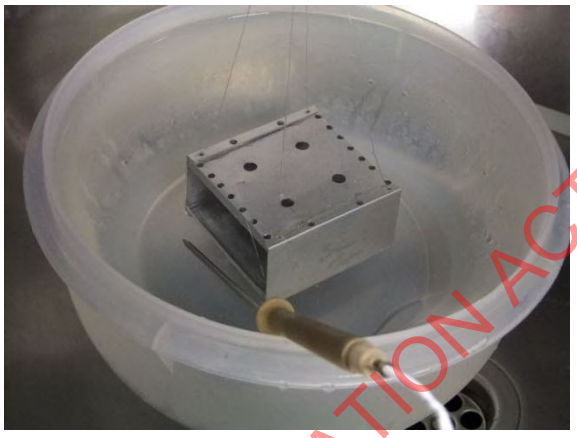
Figure A2-2: Photographs of the equipment used for the measurement of density. The balance on the left was used to measure the weight of a sample in air and the cage shown in the photograph on the right was slung from below this scale and used to weigh the sample underwater at < 6°C. The bowl was filled with 3 litres of chilled, de-bubbled (by boiling), RO water.



Appendix 3: Beef and Lamb Cut and Offal Names for Export and the Equivalent Names for the Domestic Market

NZ Export Description and Number for Beef Cuts	*Domestic description*
Inside; cap-off [1224]	Topside
Knuckle [1410]	Thick flank
Eye round (fully skinned) [1330]	Often part of the silverside
Tenderloin side muscle off [1710]	Fillet
Cube roll/rib eye (ribs 6 to 12) [2240]	Scotch
Oyster Blade [2330]	Oyster blade
Bolar blade (trim fat to 5 mm) [2320]	Bolar
Manufacturing beef (95% CL) [2715]	Mince
Chuck Eye roll (ribs 1 to 5) [2430]	Chuck Steak
Flank steak [1820]	Skirt Steak
Flat (trim fat to 5 mm) [1320]	Silverside (excluding the eye)
Ribs prepared (ribs 6 to 12) [2211]	-
Striploin (trim fat to 5 mm) [1640]	Porterhouse/sirloin
Rump centre (fully skinned) [1555]	Rump
Brisket Point End – deckle off (trim to 5 mm) [2520]	Brisket point End
Navel end brisket (trim fat to 5 mm) [2540]	Brisket naval End
Hind Shin [1100]	Shank
Tongue Swiss cut [0112]	Ox Tongue
Heart cap off [0121]	Ox heart
Liver [0130]	Ox liver
Kidneys [0140]	Kidneys
Sweetbread [0117]	Sweetbreads
Uncooked Tripe (excluding honeycomb) [0173]	Uncooked Tripe

NZ Export Description and Number for Lamb Cuts	*Domestic description or alternative names*
Boneless, rolled, netted shoulder [3620]	Same
Breast [3801]	Same
Fore-shank [3711]	Same
Ground lamb [3299]	Mince
Neck chops [3675]	Round neck chops
Rack – fully frenched [3552]	Same
Rack – partly frenched	Same
Square-cut shoulder [3361]	Same or shoulder shank-off
Square-cut shoulder chops [3666]	Shoulder chops
Bone-in leg chop or steak [3015]	Leg chop/steak
Boneless chump [3270]	Rump
Boneless flap [3820]	Same
Boneless loin [3434]	Striploin or Backstrap
Hind-shank [3701]	Knuckle
Loin chop [3436]	Middle-loin chop
Loin saddle [3321]	Same or Double-loin
Tenderloin [3450]	Fillet
Tunnel-boned leg, chump off, shank off [3110]	Boned leg
Brains [0280]	Same
Heart [0220]	Same
Kidney [0240]	Same
Liver [0230]	Lambs' fry
Sweetbread [0217]	Same
Testes	Same
Tongue – Swiss cut [0212]	Tongue

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Assure Quality, Auckland, for measuring concentrations of cholesterol, and vitamin B5.

New Zealand Laboratory Services Limited, Auckland, for measuring concentrations of all the minerals that are reported (except iodine and selenium), vitamin D3, and vitamins B1, B2, B3, and B6.

AgResearch Grasslands, Palmerston North, for measuring the concentration of tryptophan.

Gribbles, Dunedin, for measuring concentration of vitamin B12.

A large number of skilled technicians for conducting the many assays and procedures involved in this project.

Document 4

Proceedings of

The International Meat Secretariat's Symposium on Protein Requirements

for optimal health throughout all life stages

September 16, 2013 • Granada, Spain



"As the world's population increases rapidly and against the constraints of limiting land, water and food resources, it is more important than ever to be able to define accurately the amount and quality of protein required to meet human nutritional needs and describe appropriately the protein supplied."

(Dietary protein quality evaluation in human nutrition: Report of an FAO Expert Consultation 2013)




Given protein's critical role in current and future dietary requirements for an increasing world population and the emerging science suggesting the potential inadequacies of the current protein recommendations, the International Meat Secretariat (IMS) hosted a symposium on protein requirements for optimal health throughout the lifecycle during the International Union of Nutritional Sciences (IUNS) International Congress of Nutrition in Granada, Spain, September 2013. The agenda included four renowned protein scientists who provided evidence-based information about the nutritional qualities of meat and its role in a healthful, sustainable diet. The session was coordinated by the chair of the International Meat Secretariat's Human Nutrition and Health Committee.

Document 4

Symposium Summary

Leading protein scientists presented strong evidence supporting a beneficial effect to increasing high-quality protein intake during all life stages. The International Meat Secretariat Human Nutrition and Health Committee hosted this important global event during the IUNS International Congress of Nutrition in Granada Spain, September 16, 2013. Two speakers, Professors Paul Moughan and Rajavel Elango, explained why the method for establishing the Recommended Dietary Allowance (RDA) for all life stages may not be taking into consideration all relevant factors and offered new solutions for determining a more precise RDA. Professors Nancy Rodriguez and Caryl Nowson addressed the need to consider functional outcomes when evaluating protein needs throughout the lifecycle.

Professor Moughan reported on the United Nations Food & Agriculture Organization (FAO) Expert Consultation to review recommendations on the characterization of dietary protein quality in humans. A significant finding of the Expert Consultation was the need to assess each individual dietary indispensable amino acid as a nutrient in its own right, since a large body of research shows that the various amino acids have differing physiological and regulatory roles. To more accurately reflect protein digestion in humans, the recommendation is that true ileal amino-acid digestibility be assessed for each dietary indispensable amino acid, rather than a value for a single, faecal, crude-protein digestibility. Additional research is needed to fully implement the digestible indispensable amino acid score (DIAAS).

Professor Elango also addressed a new method for calculating protein requirements for adults and children. Several drawbacks are associated with the calculation of RDAs from nitrogen (N) balance studies. The indicator amino acid oxidation (IAAO) technique has emerged as a viable alternative to determine essential amino acid requirements in adults. IAAO is based on the concept that all amino acids in the body are in excess and therefore oxidized when one essential amino acid is deficient for protein synthesis. Professor Elango explained how to determine protein requirements in adults and children using the IAAO system. The data derived from using the IAAO method of calculation suggests the RDA for adults and children may be underestimated by at least 50 percent.

Professor Rodriguez focused on the importance of adequate protein intake complemented with an active lifestyle to promote healthy aging, bone health, and the prevention of sarcopenia. Recent research shows that consumption of approximately 25-30 g of high-quality protein maximally stimulates muscle protein synthesis in old, as well as young, persons. An extension of these findings suggests that a protein intake of 25-30 g at three intervals throughout the day may provide older adults with the greatest opportunity to sustain muscle mass. This translates to a daily intake of 1.1-1.5 g protein/kg/d. An increase in protein intake also has shown benefits to bone health by increasing calcium absorption, negating previous evidence to the contrary. In addition, high-quality proteins are a nutrient-dense source of many essential micronutrients which contribute to the nutritional status of older adults.

Professor Nowson's presentation focused on the protein needs of older people. An early study found that older people who consumed the U.S. RDA for 10 days were in negative N- balance. It appears the body will lose lean mass when necessary to maintain N-balance. Additionally, older people tend to have lower rates of protein synthesis and whole-body protein breakdown in response to an anabolic stimulus. Evidence is emerging from randomized controlled trials that a diet including at least 1.3 g/kg/d combined with twice-weekly progressive resistance exercise clearly benefits older adults by enhancing lean muscle mass and leg strength. For this reason, food- and meal-based strategies rather than supplemental drinks are likely to be more sustainable and are recommended as the initial approach to optimising protein intake in older people.

Experts estimate that higher protein intakes in the approximate range of 1.1 to 1.5 g/kg/d may contribute to better muscle and bone maintenance and improve quality of life. Children have even higher protein needs for growth; for example, school age children (6-10 y) may require protein intakes of at least 1.55 g/kg/d. Researchers recommend that at least two meals (ideally three) a day should contain 25 to 30 grams of high-quality protein from naturally nutrient-rich foods for optimal health.

In closing the symposium, Mary Ann Binnie, the chair of the International Meat Secretariat's Human Nutrition and Health Committee, reiterated that increasing dietary protein intake throughout the lifecycle may be beneficial. She supported the new FAO-proposed methodology for determining protein quality as it will allow a more precise characterization of the true quality of protein. Ms. Binnie thanked the symposium speakers on behalf of the International Meat Secretariat for sharing recent research which marks a significant step forward in understanding what foods might best provide protein needs for optimal health throughout all life stages.

Document 4

Dietary Protein Quality: *New Perspectives*

Summary of the proposed recommended approach to scoring the quality of proteins

- Considering amino acids as individual nutrients (digestible/bioavailable) gives maximum information
- Digestible indispensable amino acid score (DIAAS) incorporates recent scientific advances, and is an improvement over the protein digestibility-corrected amino acid score (PDCAAS)
- Before DIAAS can be fully implemented, more comprehensive data on the true ileal-amino-acid digestibility of foods is needed
- Establishment of such a world food dataset is urgent
- This is an important step in the fight against malnutrition

Paul J. Moughan BAgrSc (Hons), PhD, DSc, FRSNZ, FRSC

Professor Paul J Moughan holds the position of Distinguished Professor, Massey University, New Zealand and is Director of the Riddet Institute. His research has encompassed the fields of human and animal nutrition, food chemistry, functional foods, mammalian growth biology and digestive physiology. He has published in excess of 350 scientific works. In 1995 he was awarded Doctor of Science and in 1997 was awarded a Personal Chair at Massey University and was elected a Fellow of the Royal Society of New Zealand. He is a Fellow of the Royal Society of Chemistry, Cambridge, England. In 2011 he was appointed Chair of the FAO Expert Consultation to review recommendations on the characterisation of dietary protein quality in humans.

Background

Foods are digested in the alimentary canal and their constituent proteins are broken down to amino acids and small peptides. During absorption by the enterocyte, the peptides are themselves hydrolysed mainly to free amino acids. Most of the absorbed amino acids are either used by body cells for protein synthesis or they are oxidised. The amounts of dietary indispensable amino acids present in a protein and the extent to which they may be used for protein synthesis is referred to loosely, as "protein quality." Protein quality evaluation aims to determine the capacity of a food protein or diet to meet the protein and indispensable amino acid requirements of an individual. The protein and amino acid requirement values reflect the amounts of absorbed amino acids and nitrogen required to support particular metabolic states (e.g. maintenance of body protein in adults, growth in children, lactation) or to underpin optimal function. Adequate dietary protein and amino acid intakes are needed for supporting optimal growth in children and for various health outcomes such as body weight management in adults or muscle mass retention in the elderly.

Food proteins are derived from a wide variety of sources and are not of equal quality. It is important, therefore, to be able to describe dietary protein quality accurately. An accurate description of dietary protein quality is of fundamental importance for dietary assessment and nutritional planning, for ensuring food security, for the food regulatory environment, and for trade purposes. Many methods for assessing dietary protein quality have different relevance for different applications and objectives, but a commonly applied method has been the protein digestibility-corrected amino acid score, PDCAAS.

FAO Expert Consultation Recommendations

Several perceived shortcomings of the PDCAAS method, however, have led to its revision. The findings of a recently held FAO Expert Consultation have been published (FAO 2013) and herald significant changes in the proposed recommended approach to scoring the "quality" of proteins. Firstly, it is recommended that each individual dietary indispensable amino acid be considered as a nutrient in its own right. This recognises a large body of research, demonstrating specific physiological and regulatory roles for individual amino acids (Jonker et al. 2012). The amino acid contents of foods in tables and databases should be given as true ileal-digestible amino acids. For foods whereby the protein may have been damaged during processing, true ileal-digestible reactive lysine (Moughan and Rutherfurd 1996) contents should also be given. Where an overall score for a protein source, whole food, or diet is required, calculation of digestible indispensable amino acid score (DIAAS) is recommended. DIAAS is a ratio:

DIAAS = [(mg of digestible dietary indispensable amino acid in 1 g of the dietary protein) / (mg of the same dietary indispensable amino acid in 1 g of the reference protein)].

The ratio is calculated for each dietary indispensable amino acid and the lowest value is designated as the score, DIAAS. DIAAS can be less than or more than 1.0. Values above 1.0 are not to be truncated, as was done for PDCAAS, except when calculating DIAAS to determine protein or amino acid intakes for mixed diets or sole source foods, where truncated values must be used. The non-truncation of DIAAS for protein sources used as food ingredients, means that the score provides information about the protein's potency as a complementary protein source. The recommended (FAO 2013) amino acid scoring patterns (i.e. amino acid pattern of the reference protein) to be used for calculating DIAAS are:

- infants (birth to 6 months), the amino acid pattern of breast milk;
- young children (6 months to 3 years), the pattern for the 6-month-old infant;
- older children, adolescents and adults, the pattern for the 3 to 10 year old.

For regulatory purposes, two scoring patterns are given (FAO 2013): the amino acid composition of human milk for infant formulas; and for all other foods and population groups the pattern for young children (6 months to 3 years old).

The key differences between DIAAS and the former PDCAAS are the amended rules around truncation of the score and that true ileal amino-acid digestibility is used for each dietary indispensable amino acid, rather than a single, faecal, crude-protein-digestibility value. The latter change is a significant step forward in accurately describing the absorbed amount of each of the dietary indispensable amino acids. The true ileal amino-acid digestibility (the disappearance of dietary amino acids by

the end of the small intestine) would preferably be determined in humans but, when not possible, a workable solution would be in the growing pig (the preferred model) or the growing rat. For proteins whereby lysine may have undergone structural changes (e.g. processed foods, or foods that have been stored for prolonged periods of time), the true ileal digestibility of reactive lysine should be determined in addition to the true ileal digestibility of the other dietary indispensable amino acids. There is an important distinction between amino-acid digestibility and availability. Digestibility refers to the disappearance of the amino acid during transit through the gut (assumed to be absorption), while availability refers to the uptake of an amino acid in a structural form that can be used for body protein synthesis (Fuller 2012). The amino acid lysine is particularly susceptible to undergoing chemical reactions with other food constituents during processing, some types of cooking, and storage. As a result lysine molecules may be altered structurally and thus rendered "unavailable." These altered molecules may be absorbed but cannot be used for protein synthesis and are excreted from the body. Thus, for some foods, determination of the digestibility of reactive (i.e. structurally unaltered or available) lysine is very important. The term "reactive" means that the lysine is in an unaltered form, whereby it can react with certain reagents.

How should ileal amino-acid digestibility be determined?

Ideally, amino-acid digestibility would be determined in human subjects, but this is not practical for routine food evaluation purposes. Ileal amino-acid digestibility can be determined in adult humans, either with the cooperation of ileostomates or by using the naso-ileal intubation method. Both approaches have shortcomings and limitations, and are really restricted to experimental situations and to validating the application to humans of digestibility data obtained using animal models. The growing pig is considered to be a satisfactory animal model for protein digestion in humans, and ileal digesta can be sampled routinely (Deglaire and Moughan 2012). Correction of the ileal-digesta amino-acid flows for endogenous amino acids must be made (Moughan and Rutherfurd 2012) to obtain "true" as opposed to "apparent" digestibility coefficients.

One of the conclusions of the FAO Expert Consultation was that before true ileal amino-acid-digestibility data can be applied in practice for the determination of DIAAS, more work needs to be undertaken to develop a robust inter-species regression relationship to allow the prediction of ileal amino-acid digestibility in humans based on data from the growing pig. Also, although published data on the true ileal amino-acid digestibility of human foods and protein sources exists, the Consultation concluded that research needs to be conducted to provide a more complete data set. Research is now needed urgently to generate the inter-species prediction equations and to provide a contemporary digestibility data set for human foods. Once such information is available, the new DIAAS system can become fully operational. Currently, available data for the true ileal-digestible amino-acid contents of selected protein sources is shown in Table 1, and some DIAAS and PDCAAS values are given in Table 2.

Table 1. True ileal-digestible amino acids (g/kg dry matter) in several protein sources

	WPI[2]	MPC[3]	SPI[4]	Meat	Myofibrillar protein
Lysine	147[1]	89[1]	54[1]	82	99
Threonine	58	43	33	41	49
Tryptophan	30	16	14	12	12
Isoleucine	73	51	42	42	51
Total branched chain	301	212	159	163	193
Glutamic acid	231	227	201	142	172
Methionine	26	22	13	24	31

[1] Available lysine based on reactive lysine determined using o-methylisourea; [2] Whey Protein Isolate; [3] Milk Protein Concentrate; [4] Soya Protein Isolate

Data courtesy of Fonterra and Riddet Institute and from Cui et al. 2013.

Table 2. DIAAS and PDCAAS for selected protein sources

	WPI[1]	MPC[2]	WPC[3]	SPI[4]	Pearl Barley	Meat	Muscle hydrolysate
DIAAS[5]	1.25	1.31	1.10	1.00	0.58	1.1	0.93
PDCAAS[5]	1.00	1.00	1.00	1.00	0.52[6]		

[1] Whey Protein Isolate; [2] Milk Protein Concentrate; [3] Whey Protein Concentrate; [4] Soya Protein Isolate; [5] Reference amino acid pattern for young child, 6 months to 3 years (FAO 2013); [6] NB a more poorly digested protein

Data courtesy of Fonterra and Riddet Institute.

Conclusions

In 2013, the FAO Expert Consultation published its review of recommendations on the characterisation of dietary protein quality in humans. Recommendations included the urgent need to consider amino acids as individual nutrients and to adopt DIAAS to score protein quality. Before DIASS can be fully implemented, more comprehensive data on the true ileal amino-acid digestibility of foods must be developed.

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Document 4

Protein Needs of Children: *Are Current Dietary Recommendations Appropriate?*

Summary of need for new protein intake recommendations

- Current protein intake recommendations for children are inadequate
- 'Optimal' protein and amino acid intakes could have health benefits
- Protein requirements must be considered in the context of:
  - Amino acid composition
  - Dietary energy
  - Parasite infestation
  - Global implications

Rajavel Elango, PhD

Dr. Rajavel Elango is an Assistant Professor of Pediatrics at the Faculty of Medicine, School of Population and Public Health, University of British Columbia. He is also a Scientist Level 1 at the Child & Family Research Institute, BC Children's Hospital, and an associate member in the Human Nutrition Program at the Faculty of Land and Food Systems, University of British Columbia. Dr. Elango's current research program at the University of British Columbia is focused on the identification of the dietary requirements for protein and amino acids during critical life stages including pregnancy and childhood malnutrition.

Background

The current recommendations for protein requirements in children (6-10 y) are based on the recent Dietary Reference Intakes (DRI 2005) and WHO/FAO/UNU Expert Consultation Report (2007). The mean (estimated average requirement, EAR) and population-safe (recommended dietary allowance, RDA) recommendation for good quality protein were set at 0.76 and 0.95 g/kg/day, respectively. These recommendations were derived using a factorial calculation where the mean requirement is the maintenance needs plus an additional component for growth, which was estimated from the rate of protein deposition and the efficiency of protein utilization. The maintenance needs were based on adult protein requirements derived from nitrogen (N) balance studies. N balance has various methodological drawbacks, including overestimation of nitrogen intakes, underestimation of nitrogen excretion and hence an overall underestimation of N balance. Furthermore, N balance studies require a minimum 7-day test diet adaptation for the dietary change to be reflected in urinary nitrogen excretion (DRI 2005). Due to ethical reasons, such prolonged periods of adaptation to deficient protein intakes is not possible in young children. Hence, the development of valid and minimally invasive techniques to directly determine protein requirements in children is needed.

Recent Advances in Methods to Determine Protein and Amino Acid Requirements

Using stable isotope tracers, the Indicator Amino Acid Oxidation (IAAO) technique has emerged as a viable alternative to determine essential amino acid requirements in human adults (DRI 2005; Elango et al. 2008).

Indicator Amino Acid Oxidation

The IAAO technique is based on the concept that when one essential amino acid is deficient for protein synthesis, then all other amino acids, including the indicator amino acid (another essential amino acid, usually L-[1-13C]phenylalanine), are in excess and therefore will be oxidized. This is primarily because excess amino acids cannot be stored and therefore must be partitioned between incorporation into protein or oxidation. With increasing intake of the limiting amino acid, oxidation of the indicator amino acid will decrease, reflecting increasing incorporation into protein (Elango et al. 2012). Once the requirement is met for the limiting amino acid, there will be no further change in the oxidation of the indicator amino acid with increasing intake of the test amino acid (Figure 1). The inflection point where the oxidation of the indicator amino acid stops decreasing and reaches a plateau is referred to as the 'breakpoint.' The breakpoint, identified with the use of two-phase linear regression analysis, indicates the EAR of the limiting (test) amino acid. The 95% confidence interval (CI) represents the RDA, which is the safe amount of protein or amino acid consumption by populations. This minimally invasive IAAO method has been systematically applied to determine most essential amino acid requirements in adult humans, healthy children, and in patients with disease. The requirement values obtained using the IAAO method were used to derive amino acid intake recommendations in the DRI (2005) and FAO (2007) reports.

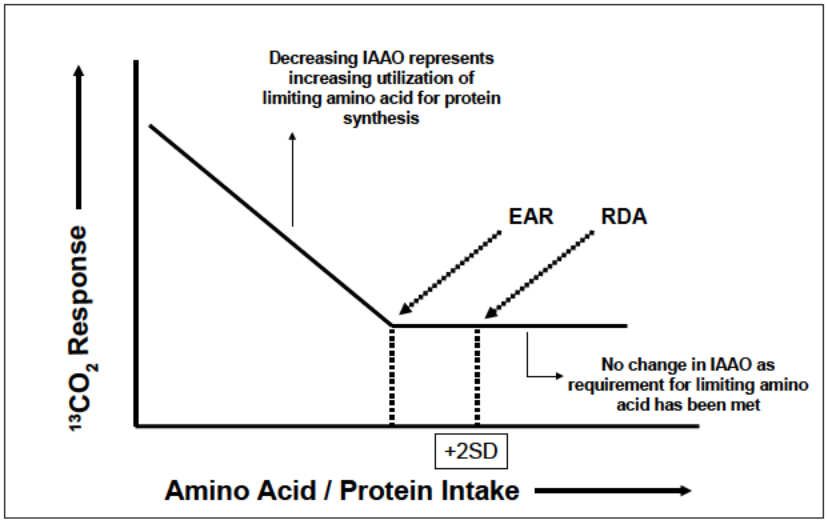

Figure 1. Concept of the indicator amino acid oxidation technique (adapted from Elango et al. 2012)

Application of IAAO to Determine Protein Requirements in Adult Humans

Due to the minimally invasive procedures involved (single study day, oral stable isotope dose and sampling of breath), the IAAO method was applied to determine the total protein requirement in adult humans (Humayun et al. 2007). Eight young adult subjects participated in seven studies each, in which they received graded intakes of protein ranging from 0.1 to 1.8 g/kg/day, and indicator amino acid (L-[1-13C]phenylalanine) oxidation was measured on each day. The diets provided energy at 1.5 × resting energy expenditure, with 33% of energy from fat, and variable energy from carbohydrate (48-66%) and protein (1-19%), based on the amino acid composition of egg protein. The intake of phenylalanine (indicator amino acid) was maintained at a constant level, with excess tyrosine, to ensure that with increasing intakes of total protein nitrogen the indicator amino acid was partitioned between oxidation and protein synthesis. With increasing protein intakes, oxidation of phenylalanine decreased until a breakpoint was reached (between an intake of 0.9 and 1.2 g/kg/day). There was no further decrease in phenylalanine oxidation with increasing protein intake, suggesting no further incorporation of the indicator amino acid into protein. Application of the two-phase linear regression analysis to the data identified a breakpoint (mean requirement) and the upper 95% CI, population-safe requirement. The mean and population-safe requirements were determined to be 0.93 and 1.2 g/kg/day and are 41% and 50%, respectively higher than the current DRI recommendations (Table 1). To confirm the validity of the results, a re-analysis of pre-existing nitrogen balance studies (with intakes above Zero-N balance) was conducted using two-phase linear regression analysis. The EAR and RDA were estimated to be 0.91 and 0.99 g/kg/day, respectively, and the results support each other (Humayun et al. 2007).

Table 1. Protein requirements in humans

	DRI 2005/FAO 2007 Adults/Children g/kg/d	N Balance (re-analyzed)‡ g/kg/d	IAAO§ Adults/Children g/kg/d
Estimated Average Requirement (EAR)	0.66/0.76	0.91	0.93/1.3
Recommended Dietary Allowance (RDA)	0.80/0.95	0.99	1.2/1.55

‡Reanalysis of existing nitrogen balance studies using two-phase linear regression analysis
§IAAO, indicator amino acid oxidation

Application of IAAO to Determine Protein Requirements in Children

Most recently, the IAAO method has been used to determine protein requirements in 6- to 10-year-old children and the mean and safe protein requirements were determined to be 1.3 and 1.55 g/kg/day, respectively (Elango et al. 2011). The current DRI and FAO recommendations are set at 0.76 and 0.95 g/kg/day. The new values are significantly higher than current recommendations (Table 1).

Gattas et al. (1990) conducted the only other direct study to estimate protein requirements in children of similar age (8-10 y), using N balance. Eight healthy children in Chile each received 0.6, 0.8, 1.0 and 1.2 g/kg/day as a mixed diet for 10 days. A mean intake of 0.94 g/kg/day for satisfactory nitrogen retention using single linear regression analysis, and a population-safe intake of 1.2 g/kg/day, was determined. These N balance estimates are 38% and 29% lower than the mean and population-safe IAAO requirements of 1.3 and 1.55 g/kg/day, respectively. However we believe that some of the differences can be explained by the choice of test protein intakes, as well as the method of data analysis. The highest intake tested was 1.2 g protein/kg/day, thus making it impossible to test for a response to greater protein intake. Also, the choice of fitting a linear regression analysis model to determine zero N balance is not appropriate because the physiologic response relationship between N intake and balance is not linear; a decreased efficiency of protein utilization occurs as zero balance approaches (DRI 2005). A two-phase linear regression analysis is more appropriate, as shown earlier in our re-analysis of existing adult N balance data (Humayun et al. 2007). N balance data analyzed using linear regression results in an overestimate of Zero-N balance by at least 10%, which leads to a 20% underestimation of protein requirements. Applying a 20% increase to the N balance based requirement estimates derived by Gattas et al. (1990) in school-age children yields a mean and population-safe protein requirement of 1.13 and 1.44 g/kg/day, which, although are 15% and 8% lower than the results from the current study (Table 1), are nonetheless much greater than the current DRI (2005) and FAO recommendations (2007).

Conclusions

Newer stable isotope-based techniques to determine protein requirements need to be developed and applied in vulnerable populations such as children, pregnant women, elderly etc. Based on the minimally invasive IAAO method to determine protein requirements in adult humans and children, current recommendations appear significantly underestimated. A re-assessment of recommendations for protein intake in children is an urgent need.

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Document 4

Getting older, getting better!
Eating and exercising for healthy aging

Summary of eating and exercising for healthy aging

- Protein intake ranging from 1.1 to 1.3 g/kg/d distributed in meals throughout the day will maximize muscle protein synthesis and contribute to better bone health when consumed with adequate calcium
- The type, content and timing of protein meals can be used along with regular exercise to optimize dietary protein efficiency in healthy older adults
- Routine consumption of good quality protein throughout the day can assist in optimizing nutritional status in older men and women

Nancy Rodriguez
PhD, RD, CSSD, FGACSM

Nancy Rodriguez is a Professor of Nutritional Sciences in the College of Agriculture and Natural Resources (CANR) with joint appointments in Departments of Kinesiology and Allied Health Sciences at the University of Connecticut. She directs the Sports Nutrition program at the University and for the Department of Sports Medicine in the Division of Athletics. Dr. Rodriguez is an Associate Editor for Medicine and Science in Sports and Exercise and she serves on Editorial Boards for ACSM's Health & Fitness Journal, the Journal of Nutrition, the Journal of Applied Physiology, and the International Journal of Nutrition and Exercise Metabolism. She shares her expertise in the courses she teaches at UConn where she is a University of Connecticut Teaching Fellow.

Background

Aging well is an eminent challenge. As men and women live longer, they are engaged in a lifestyle that includes sustained employment and substantial opportunities for varied recreation and retreat. Aging does not discriminate and regardless of cultural preferences and socioeconomic status, today's baby boomer generation is health conscious and motivated to embrace recommendations aimed at vibrant longevity. A contemporary approach to diet design for healthy aging is consuming protein in amounts that exceed the Recommended Dietary Allowance (0.8 g/kg) but rest well within the Acceptable Macronutrient Distribution Range (10-35% of energy intake). When combined with an active lifestyle, this level of protein intake may thwart muscle loss, improve bone health, and enhance nutritional status in individuals as they grow older.

Protein Recommendations and Aging

Sarcopenia

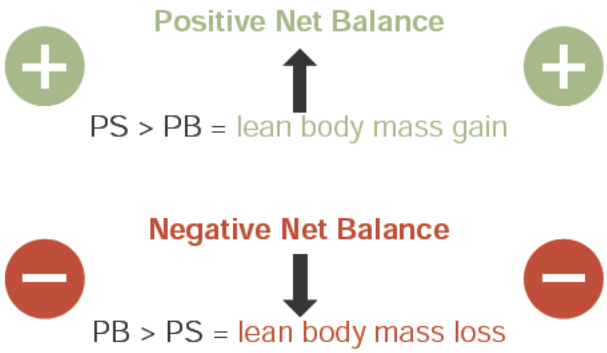
The loss of muscle tissue as a natural part of the aging process defines sarcopenia. As a term, sarcopenia is not common to most people's vocabulary although the muscle wasting that occurs as men and women progress into later life is readily acknowledged. Noted changes in body composition that occur with age are the reduction in lean body mass with a simultaneous increase in fat mass that becomes apparent in early middle-age at approximately 40-50 years. The loss of lean body mass is paralleled by reductions in muscle strength. This specific outcome is cause for most concern because loss of muscle strength is a prequel to loss of muscle function which predisposes older men and women to falls and fractures that can significantly affect quality of life and be potentially fatal.

The mechanisms of sarcopenia are progressive and evolve from the cellular level and eventually translate into behaviors characterized by inactivity. Changes at the cellular level include a reduction in the number of neurons, satellite cell activation and proliferation, contractile protein gene expression and muscle-specific mRNA translation. Modifications in muscle metabolism follow and changes in the endocrine environment coupled with reduced tissue responsiveness to hormones and nutrients may eventually lead to various degrees of malnutrition. Ultimately, a range of physical inactivity ensues and the loss of muscle mass is perpetuated.

Whether this process is an absolute in the physiology of aging has been challenged in recent years as researchers have focused efforts on the relationship between level of dietary protein and routine exercise (Dickinson et al. 2013; Volpi et al. 2012). With specific regard to dietary protein consumption, studies have documented that the acute mixed muscle protein synthetic response to protein consumption is actually similar between young and old individuals (Paddon-Jones and Rasmussen 2009). While the combined effects of exercise and protein consumption on protein utilization by older individuals have not been clearly delineated, there does appear to be a combined synergistic benefit (Dickinson et al. 2013). Further studies to identify specific mechanisms that mediate these responses are needed since aging remains linked to a blunted muscle-protein synthetic response to feeding, insulin, and exercise.

In an effort to overcome these physiological factors, recent research has evaluated whether a practical and balanced approach to higher protein intakes may be beneficial to protein utilization in older men and women and delay the onset of, or slow, muscle loss with aging (Paddon-Jones and Rasmussen 2009). This approach takes advantage of the fact that consumption of approximately 25-30 g of high quality protein maximally stimulates muscle protein synthesis in old, as well as young, persons. The proposed relationship between protein intake and muscle protein synthetic response is shown in figure 1. An extended application of these scientific findings is to distribute daily protein intake throughout the day in amounts that approximate 25-30 g per meal to optimize muscle protein utilization in a manner that might contribute to sustenance of muscle mass in older men and women. Because high quality protein sources such as beef, chicken, eggs, and fish are nutrient dense, routine incorporation of these whole foods in the diet can assist older adults in meeting recommended protein intake while simultaneously keeping calorie intake sensible.

Figure 1. Proposed Relationship Between Protein Intake and Muscle Protein Synthetic Response



Protein Synthesis (PS) – Protein Breakdown (PB) = Protein Balance

Bone Health

The relationship between dietary protein consumption and bone health has changed over the last decade as evidence showing a favorable effect of protein on bone has mounted (Gaffney-Stromberg et al. 2009). The common misconception that increased protein intake causes calcium losses from the body that can ultimately weaken bone has been disproven. Like muscle protein, the skeleton and its constituent proteins are dynamic – constantly being broken down and synthesized. For bone mass and quality to be sustained, calcium intake must be adequate. As methods for assessing calcium absorption and bone turnover became more sophisticated, investigations focused on the possible mechanism by which higher protein intakes might affect calcium utilization. This work demonstrated that higher protein intakes combined with recommended calcium consumption actually enhanced calcium absorption that contributed to the noted increase in urinary calcium excretion with increased dietary protein. Therefore, dietary protein was not 'pulling' calcium from the bone for eventual excretion by the kidney but improving calcium uptake by the body (Gaffney-Stromberg et al. 2009).

Contrary to popular belief, lower protein diets (< 0.8 g/kg/day) actually compromise bone's ability to repair and recover from fractures, whereas diets moderate in protein (1-1.5 g/kg/d) are associated with normal calcium metabolism, greater bone mass, and fewer fractures when calcium intakes are adequate (Gaffney-Stromberg et al. 2009). This relationship is significant in the context of the musculoskeletal system and reinforces the integration of muscle and bone for healthy aging. An appreciation for the parallel that exists between osteoporosis and sarcopenia is important when considering lifestyle interventions such as protein intake and routine physical activity for healthy aging.

Nutritional Status

In the context of longevity, living well, and staying healthy, the role of high-quality protein foods as nutrient-dense sources of essential micronutrients cannot be overstated (Asp et al. 2012; Meydani 2001). Iron, calcium, zinc, the B-complex vitamins, and antioxidants such as Vitamin E are found in animal products like meat, dairy, poultry, and seafood which are both protein and nutrient dense. That is, the calories provided by a standard serving of these whole foods in a meal, are packed with essential amino acids along with these micronutrients making their incorporation into daily menus a wise choice given their contribution to improved nutritional status in older adults (Asp et al. 2012).

Conclusion

In conclusion, it is important to note that the RDA sets the minimal amount of dietary protein for most adults, and is based on nitrogen balance, not functional outcomes. This is particularly relevant to dietary directives for healthy aging. Current evidence suggests that most healthy people require dietary protein intake ≥1.0 g/kg/d to prevent muscle loss. Given that maximal stimulation of muscle protein synthesis is achieved with an approximate 30-gram protein meal, consuming 3 meals daily, a typical 70-80 kg person would consume 1.1-1.5 g protein/kg/d. Protein intake at this level will contribute to better bone health when consumed with a calcium-adequate diet. The type, content and timing of protein-centric meals can be used, along with exercise, to optimize dietary protein efficiency in healthy older adults. Finally, routine consumption of good quality protein throughout the day can assist in optimizing nutritional status in older men and women. From a practical perspective, innovative diet design based on whole foods, complemented with an active lifestyle respective to the individual, provides a feasible and reasonable approach to aging well.

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Document 4

Protein for long life: *Do Older Adults Need More Protein to Live Longer?*

Caryl Nowson
PhD, BSc, Dip.Nut.Diet
Professor Caryl Nowson holds the chair of Professor of Nutrition and Ageing, School of Exercise and Nutrition Sciences, Deakin University, Burwood, Melbourne Australia, and is team leader of Food, Lifestyle and Health group within the Centre for Physical Activity and Nutrition Research. She has a research program spanning 30 years that has focused on two major diseases of ageing: nutrition related to hypertension, and nutrition related to bone health. She has a particular interest in the relationship of dietary factors to health outcomes for the elderly, particularly falls and fractures.

Summary of protein recommendations for optimal health and function

- A protein intake of at least 1.3 g/kg/day, utilising high-quality protein sources, is beneficial
- Consume at least 3 meals per day with a significant amount of protein (25-30 g) consumed in at least two meals per day
- Perform progressive resistance exercise at least twice per week

Background

Recently, debate among nutrition experts regarding the recommended dietary protein intake for older people has increased. It has been proposed that dietary protein intakes for optimal health should be considerably higher than the current minimum protein requirements. A leading cause of disability and reduced quality of life in older people is osteoporosis with one in three women and one in six men experiencing an osteoporotic fracture in their life time. In Australia, the incidence of osteoporotic fractures is also predicted to increase, from one every 8.1 minutes in 2001 to one every 3.7 minutes in 2021 (Sambrook et al. 2002). Fracture risk is increased when bone density is low, and loss of muscle mass is associated with loss of bone mass. Muscle weakness predicts falls and subsequent fractures. Muscle weakness is associated with age-related muscle loss which in turn is related to osteoporosis and leads to a life of restricted mobility, loss of independence, and reduced life expectancy (Cederholm et al. 2013). Frailty and accelerated age-related muscle loss (sarcopenia) are closely related, and frail older people are by definition sarcopenic (Morley et al. 2011). Sarcopenia is a complex process involving a range of age-related physiological changes combined with the adoption of a sedentary lifestyle and a sub-optimal dietary pattern (Paddon-Jones et al. 2008). Frailty significantly increases the risk of adverse health outcomes, such as falls, hospitalization, disability, loss of independent living and death (Fried et al. 2001). Frailty is difficult to define but a common definition, the Fried Frailty Index (FFI), requires the presence of three or more of five components: weight loss, exhaustion, weakness, slowness and low physical activity (Fried et al. 2001). Between 6% and 25% of free-living individuals aged 65 years and older may be considered frail and this percentage increases to between 25% and 40% in those aged 80 years and above (Strandberg et al. 2007). Two key effective interventions to reduce sacropenia include a dietary strategy to address nutrient deficiencies, specifically protein, and an exercise regime, particular resistance exercise (Gillespie et al. 2009).

Recommended Dietary Intakes for Protein for Older People

Traditionally, protein requirements have been derived on the basis of sufficient dietary protein to ensure nitrogen balance. The most recent meta-analysis included studies which assessed a total of 235 individuals, though only 16 individuals were older (68-84 y) (Rand et al. 2003). An early study found that older healthy subjects were in negative nitrogen balance after consuming the U.S. protein recommended dietary allowance (RDA) for 10 days (Campbell et al. 1994). It appears that the body adapts to a lower protein intake to maintain nitrogen balance by breaking down lean mass, which will ultimately result in rapid progression to sarcopenia, frailty and reduced quality of life in older people. Older people appear to have lower rates of protein synthesis and lower rates of whole-body proteolysis in response to an anabolic stimulus (consuming food or performing resistance exercise), which is consistent with overall slower tissue remodelling (Kumar et al. 2009).

Evidence is emerging that this "anabolic resistance" in older people can be overcome by ingesting protein supplements or foods that are rich in the essential amino acid leucine (Bell et al. 2005; Symons et al. 2009). This increase in protein synthesis appears to be further enhanced by resistance exercise (Drummond et al. 2009). Recent evidence suggests that optimal health for older people, particularly optimal muscle retention, may require dietary protein intakes greater than the RDA. The need to assess dietary protein requirements in terms of functional outcomes associated with morbidity and predictive of mortality is increasingly recognized. These predictive functional outcomes are related to the ability to perform simple physical tasks, such as the ability to get up out of a chair and walk a short distance at a reasonable speed. Optimal levels of dietary protein need to be assessed in the context of the range of physical activity levels present in the older population, from those who are relatively inactive to those who are performing the recommended regular weight-bearing activities. Consistent with approaches to reduce chronic disease in younger people, dietary recommendations to reduce health risk and optimise quality of life in the later years must be combined with recommendations for physical activity.

Evidence of Higher Protein Requirements for Older People

Evidence is accumulating to suggest older people intake an optimal protein level of approximately 1.3 g/kg/d which would support increased muscle mass with emerging evidence for a benefit on function/physical performance. Evidence from randomised controlled trials shows a higher-protein diet of at least 1.3 g/kg/d combined with twice-weekly progressive resistance provides a clear benefit by enhancing lean muscle mass gain and leg strength in older people (Tieland, Borgonjen-Van den Berg et al. 2012; Tieland, Dirks et al. 2012). These studies were conducted in frail, older community-dwelling participants of average body weight who ingested twice-daily protein supplements consisting of two 15 g milk-based protein drinks (250 ml each) which raised total daily protein intake from 1.0 to 1.3-1.4 g/kg/d.

A dietary plan that includes 25-30 g of high-quality protein per meal (60 g/day) has been proposed to maximize muscle protein synthesis. It has been shown that ingestion of approximately 25-30 g of protein per meal maximally stimulates muscle protein synthesis in both young and older individuals (Paddon-Jones et al. 2004; Cuthbertson et al. 2005; Katsanos et al. 2005). Many older people may be consuming only minimal amounts of protein at each meal throughout the day and may not reach the threshold intake of 25-30 g protein to stimulate protein synthesis. Two recent protein-supplement studies have demonstrated an improvement in physical performance with a protein supplement. One study showed an increase in lean mass with a protein supplement combined with resistance exercise (Tieland, Borgonjen-Van den Berg et al. 2012). The second study demonstrated that a modest 30-40% increase in total dietary protein has some clear benefits on muscle mass (Tieland, Dirks et al. 2012). A recent study found that a protein-enriched diet equivalent to ~1.3 g/kg/d achieved through twice daily consumption of 80 g of cooked beef, veal, or lamb on most days during a period of 14 weeks was safe and effective for enhancing the effects of progressive resistant training on lean mass in elderly women (Daly et al. 2013, submitted). On the basis of this accumulating evidence, older people would be advised to consume protein intakes up to 1.3 g/kg/d.

Conclusions

Any intervention or strategy to assist in maintaining muscle strength needs to be readily achievable and acceptable to older people in the long-term. A strategy is more likely to be sustainable if it can be incorporated into a food-based dietary approach meeting all their dietary requirements while enhancing their enjoyment in life. For this reason, food- and meal-based strategies rather than supplemental drinks are likely to be more sustainable and are recommended as the initial approach to optimising protein intake in older people.

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INTERNATIONAL MEAT SECRETARIAT

Oficina Permanente Office International Internacional de la Viande de la Carne

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The Symposium was hosted and sponsored by the International Meat Secretariat.

BEEF

The Symposium Proceedings were funded by the Beef Checkoff.

Document 5

Minutes of the First Meeting of the Technical Advisory Group for the Eating and Activity Guidelines

11 November 2013

11.00 to 16.45
Held in room 2.12, the Boardroom
Ministry of Health
1 The Terrace
WELLINGTON

In Attendance

Members of the TAG

Professor Jim Mann	Chair
Delvina Gorton	
Dr Clare Wall	
Dr Ofa Dewes	
Dr Pamela von Hurst	
Dr Sandy Mandic	
Dr Scott Duncan	
Professor Murray Skeaff	

Louise McIntyre	Secretariat, Ministry of Health
Martin Dutton	Secretariat, Ministry of Health
Dr Harriette Carr	Ministry of Health
Elizabeth Aitken	Ministry of Health
Maria Turley	Ministry of Health
Mary-Ann Carter	Health Promotion Agency

Welcome

Elizabeth opened the meeting with a short introduction as to who she was and her role within the Ministry.

Elizabeth welcomed the Technical Advisory Group (TAG) members and thanked them for agreeing to be on the TAG. Special thanks were given to Jim Mann for agreeing to Chair the group.

A one minute silence was observed at 11.00am in commemoration of Armistice Day.

Elizabeth outlined the importance of the input from this group, including how it will potentially shape the work programme of the Nutrition and Physical Activity Team, and wished the members an interesting and productive day.

Apologies

There were no apologies for this meeting.

Introductions

The group gave a one minute introduction as to who they are, where they work, what their role is, and what their speciality interest is.

Declaration of interests

Jim noted that the Terms of Reference outlined the process and importance of declaring any conflict, or potential conflict of interest. If anyone had any queries they could raise them with the Ministry for advice.

Elizabeth reiterated that members should err on the side of caution and declare any perceived conflicts of interest.

Several TAG members declared specific conflicts of interest, and it was suggested that the Secretariat sends out a form to the group on which they can formally declare any conflicts of interest.

Actions

The Secretariat should:

- circulate a form by 1 December 2013 for TAG/Internal Steering Group members to record any conflicts of interest within the last five years
- note that a high proportion of researchers will have some form of conflict of interest due to how research in New Zealand is funded.

Terms of Reference

Martin gave an overview of the Terms of Reference, and Jim noted that they appeared straight forward and un-contentious. Jim invited any feedback or questions on the Terms of Reference.

One member asked if there was any consideration given to including Māori representation on the group. The Secretariat responded that the Ministry tried to include a Māori member on the group, but an appropriate person was not available. The Ministry will continue to consult with Māori to ensure cultural needs and expectations are met, and may be able to include a Māori member on the TAG at a later date.

Guideline evaluation

Currently the food and nutrition guidelines are published in five separate population specific background papers. In 2013 the first physical activity specific guidelines were published by the Ministry. Prior to that, physical activity recommendations and advice from Sport and Recreation New Zealand (SPARC, now Sport NZ) were included in the Food and Nutrition Guidelines.

In 2011, the Ministry contracted an independent evaluation of the Food and Nutrition Guidelines series.

Why were the Food and Nutrition Guidelines evaluated?

- No formal comprehensive evaluation had been conducted on the Food and Nutrition Guidelines.
- The Ministry had no objective/representative data on who used the Guidelines, how they were used and whether they met the needs of health practitioners.
- Evaluation is considered good practice.

The evaluation focused on who used the guidelines, how they used them, what did they find useful about them, what could be done to improve them, what processes or models might work better than the current one?

- Dietitians and nutritionists were the highest users of the Guidelines.
- Health promoters and community health workers tended to use health education resources instead.
- Evaluation participants were unanimous in their view that the Guidelines need to be retained, albeit in a form that is more accessible to a wider range of health practitioners and others, and updated more frequently.

The key suggestions from stakeholders and health practitioners to strengthen the current Guidelines included:

1. Increased clarity and communication specifically on their purpose and target audiences.
2. Faster process of development.
3. Wider cultural relevance.
4. More robust evidence base (specifically a graded systematic evidence base where possible).
5. Combined information on nutrition and physical activity.
6. Improved accessibility for the non-nutrition specific workforce.
7. Better promotion.

The evaluation recommended the use of a technical advisory group to advise the Ministry on the appropriate evidence to use for any guideline review. As a result, the Technical Advisory Group for the Eating and Activity Guidelines was set up.

The Ministry will use the information from the evaluation to shape a new direction for the guidelines including a concise core document written using plain English and with a family/whānau focus.

New Guidelines direction

The TAG reviewed this agenda item and discussed:

- the concept of one core document supported by issues based documents
- the benefits of having a concise document
- the pros and cons of having the core document online only
- that a family focus would be a broad scope and that we should potentially concentrate our efforts on guideline statements for adults in the first instance
- whether the core document should include 0 to 2 year olds
- there is not much evidence to inform the recommendations for Pacific Peoples
- food versus nutrient based recommendations and background information
- the importance of TAG advising on the evidence base, then handing over to experts with other skills to tailor messages for the target populations
- whether we should include sustainability. Can people achieve and sustain the recommendations, and can the world sustain the foods recommended?
- the inclusion of sedentary behaviour in the guideline statements
- the importance of stakeholder consultation.

Actions

The Secretariat should:

- take TAG discussions into consideration when producing the Eating and Activity Guidelines

Guideline statements and evidence base discussion (nutrition)

The TAG split into expert working groups on nutrition and physical activity.

The nutrition group reviewed this agenda item and discussed:

- that the four potential evidence bases were not easily compared with each other as they arose from projects with differing foci:
    - Australian Dietary Guidelines 2007 – are food based dietary guidelines. The evidence base for the statements was a literature review to answer targeted questions on food, diet and disease/health relationships (2002 to 2009)
    - American Dietary Guidelines 2010 – are food and nutrient based dietary guidelines. Their evidence base looks at food/dietary patterns and nutrients and disease/health outcomes
    - Canadian Food Guide 2007 – is a visual food guide based on the Institute of Medicine's (IOM) Dietary Reference Intakes (DRIs) (1998-2004) which is nutrient focused
    - Nordic Nutrition Recommendations 2012 – is a set of nutrient reference values (NRVs) for the Nordic region countries which also includes some food/dietary pattern based advice
- the Ministry's preference is to adopt the Australian evidence base because New Zealand and Australia have:
    - a similar food supply
    - shared Nutrient Reference Values (NRVs)
    - shared food regulatory body, ie Food Standards Australia New Zealand (FSANZ) and food code
- Australia is planning to review their dietary guidelines every five years
- a number of shortcomings with the Australian evidence in regard its adoption to support New Zealand guidelines
    - the evidence base for the statements looks at literature published up to April 2009 so is missing evidence from May 2009 onwards
    - from the evidence presented, not all TAG members agree with the conclusions reached in the Australian guidelines
- that any evidence base used would be 'old', including the most recent Nordic Nutrition Recommendations 2012 which is a common issue with guidelines
- that the Australian evidence base would be the default evidence base for the reviewed and updated New Zealand statements initially
    - where this evidence base was not considered adequate in regard to a specific statement, other evidence bases would be considered
- the intention of each of the current statement in turn
    - the intention of each statement was clarified and a potential evidence base to support it identified during the discussions
    - final guideline statement wording would be provided to the TAG to ensure the intention remained intact
- the draft statements should be pre-tested with consumers/end users.

Actions for guideline statements and evidence bases (nutrition)

The Secretariat will:

- distribute a summary of discussions to the nutrition group for comment and/or confirmation within five working days of the meeting (see appendix 1)
- propose new draft guideline statements based on the summary of discussions
- draw together relevant statements with graded evidence and distribute to the group for comment/confirmation
- confirm the intention of the statements and their specific graded evidence base with the TAG via email by 31 January 2014
- begin work on the core document in February 2014.

Guideline statements and evidence base discussion (physical activity)

The TAG split into expert working groups on nutrition and physical activity.

The physical activity group reviewed this agenda item and discussed:

- that the Eating and Activity Guidelines title needs amending as "activity" may refer to sedentary or physically inactive activities
    - the Eating and Activity Guidelines could potentially be renamed the Eating and **Physical** Activity Guidelines
- the concept of each proposed guideline statement
- the pros and cons of international guideline statements and evidence bases including:
    - Australia 1999 – based on the same evidence as the current NZ guidelines for adults, which is now outdated
    - United States 2008 – very comprehensive; considered the gold standard; considerable consultation and input; missing emerging evidence since 2008
    - United Kingdom 2010 – based on the US scientific review with an extensive update; includes a separate comprehensive report on sedentary behaviour; comprehensive guideline statements standardised for all four home nations
    - Canada 2011 – guided by the AGREE II instrument; simple guideline statements; potential gaps in the guideline statements
    - Australia (draft) – based on the US scientific report; also informed by the UK and Canadian updates; updated information included; graded evidence statements using NHMRC criteria for assessing evidence for the development of guidelines; not guaranteed to be released
        - The expert working group did not have access to the Australian draft guidelines on physical activity as they are yet to be publicly released
- the pros and cons for moving to a guideline statement using the duration of 150 minutes per week, rather than 30 minutes on 5 days per week:
    - whether it has consequences on the reporting of information for surveys such as the New Zealand Health Survey
    - whether people easily equate how much regular activity is required to meet 150 minutes per week?
    - whether physiologically spreading 150 minutes of physical activity through the week equates to the same as doing 30 minutes activity on five days per week
    - that the UK guideline statements give both the 150 minute figure and an example of how this may be achieved (eg through 30 minutes activity on five days per week)
    - extensive consideration was given to this in the UK guidelines (p43 to 46).

- the inclusion of a guideline statement on sedentary behaviour:
  - the evidence on the importance of reducing sedentary behaviour is clear
  - that evidence on how often and by how much sedentary behaviour should be broken up by is still emerging
  - that it is highly unlikely that recommending a duration for reducing sedentary behaviour will cause harm or injury to the person, so the Ministry could add this into the guideline statements
  - that it is not possible to define a time and duration for reducing sedentary behaviour at present but this may come as the evidence emerges and practical advice provided in the meantime
- the definition of certain terminology (eg physical inactivity)
- the distinction between sedentary behaviour, physical inactivity, sleeping and television time
- whether, given levels of overweight and obesity, we should recommend 300 minutes of moderate- or 150 minutes of vigorous-intensity activity per week
- whether to include a guideline statement on the importance of restorative sleep
- whether the evidence supports including a separate guideline on vigorous-intensity physical activity
- consideration of trend data in NZHS and how this could be managed - recommendation was to continue to measure 30 minutes on five days per week as the survey definition of regular moderate activity
- whether a recommended duration (time) should be added to the statement on muscle-strengthening.

Summary for guideline statements and evidence bases (physical activity)

Summary of the discussions by the expert working group on physical activity:

- a consensus to replace the current physical activity guidelines for adults was reached
- New Zealand should adopt international statements as a base and modify them to meet the needs of the target populations
- guideline statements should use positive and encouraging terminology
- guideline statements limited to five so they are easy to remember. The importance of vigorous activity still remains relevant though
- an overarching title or tagline for the Guidelines should be “Sit Less, Move More” (but we need to check for association with NZ Heart Foundation)
- the guideline statements on physical activity for adults (Sit Less, Move More) should be:
  - Reduce sedentary behaviour and break up long periods (60 minutes) of sitting
  - Accumulate at least 150 minutes of moderate-intensity (or 75 minutes of vigorous-intensity) physical activity spread throughout the week
  - Aim to double the amount of physical activity for extra health benefits and to manage your weight
  - Do muscle-strengthening activities on at least two days per week
  - If you currently do no physical activity, start by doing some activity, and then build up to the recommended amount
- the Guideline statements need to be reviewed by a communications expert to consider how we can make them consumer friendly
  - this may occur at the level of developing supporting resources
  - the expectation is that some messages may have to change slightly or have examples added to be understood by the general public.

Action points for guideline statements and evidence bases (physical activity)

The Secretariat will include the following in the core document[1]:

- a paragraph after each guideline statement which includes:
  - which jurisdiction the statement has come from
  - a link to the guidelines that the statement came from
  - a summary of the scientific evidence to support the statement in Plain English
  - the level of graded evidence available to support the statement
- an example of sustainability in the subtext (eg, by using active transport)
- a paragraph or footnote that "these guideline statements may require tailoring for individuals based on their needs and abilities, particularly for people with physical disabilities or health conditions"
- a glossary of technical terms, similar to the one in the Guidelines on Physical Activity for Older People (aged 65 years and over).

Round up and conclusion

Following discussion with the TAG, the expert group on physical activity removed the words "(60 minutes)" from guideline statement 1. It is thought adding a time into the statement may dilute it because of the lack of evidence on the amount of time required to break up sitting. It was suggested that we move the 60 minute recommendation into a "how to achieve this" paragraph.

The TAG recommended the inclusion of the words "and bone-strengthening" to statement 4 in the guideline statements. It was discussed that certain resistance training can improve muscle-strength **and** bone-strength. The Canadian physical activity guidelines are the only other guidelines that mention bone-strengthening.

The TAG agreed that the guideline statements for physical activity should be:

- Reduce sedentary behaviour and break up long periods of sitting.
- Accumulate at least 150 minutes of moderate-intensity (or 75 minutes of vigorous-intensity) physical activity spread throughout the week.
- Aim to double the amount of physical activity for extra health benefits and to manage your weight[2].
- Do muscle- and/or bone-strengthening activities on at least two days per week.
- If you currently do no physical activity, start by doing some activity, and then build up to the recommended amount.

Meeting close

The meeting closed at 16.45pm.

[1] It is recommended that the draft Guideline statements for physical activity are reviewed by Sport New Zealand, the Health Promotion Agency and other government organisations with an interest in physical activity

[2] Following the meeting it was suggested that we clarify that doubling the amount of physical activity means aiming for 300 minutes of moderate- or 150 minutes of vigorous- intensity the physical activity for extra health benefits and to manage weight. We aim to give this example within the subtext.

Appendix 1 - Technical Advisory Group Meeting 11 November 2013
Feedback on current nutrition guideline statements

Current Ministry of Health nutrition guideline statements:

1. Maintain a healthy body weight by eating well and by daily physical activity.
2. Eat well by including a variety of nutritious foods from each of the four major food groups each day:
    - Eat plenty of vegetables and fruit.
    - Eat plenty of breads and cereals, preferably wholegrain.
    - Have milk and milk products in your diet, preferably reduced or low fat options.
    - Include lean meat, poultry, seafood, eggs or alternatives (From 2006, "alternatives" was replaced with, for example, "nuts, seeds and legumes").
3. Prepare foods or choose pre-prepared foods, drinks and snacks:
    - With minimal added fat, especially saturated fat.
    - Low in salt; if using salt, choose iodised salt.
    - With little added sugar; limit your intake of high sugar foods.
4. Drink plenty of liquids each day, especially water.
5. Purchase, prepare, cook and store food to ensure food safety.
6. If choosing to drink alcohol, limit your intake.

Others

- Eat together ie take opportunities to eat meals with other people. (Older people GLs)
- Eat meals with family or whānau as often as possible. (2-18yrs GLs)

Proposed updated Ministry of Health guideline statement:

1. To achieve and maintain a healthy weight, be physically active and choose amounts of nutritious food and drinks to meet your energy needs. (Australia 2013)

    OR

    Balance your food intake and activity levels to achieve and sustain a healthy weight. (Based on American GLs 2010)

2. Eat a variety of nutritious foods from each of the four major food groups each day:
    - Eat a variety of different coloured seasonal vegetables and fruit.
      OR
    - Eat plenty of different coloured seasonal vegetables and fruit.
    - Eat a variety of grains and cereals that are naturally high in fibre.
    - Eat low fat milk products such as milk and yoghurt or calcium enriched milk alternatives.
    - Include legumes, nuts, seeds, fish, eggs, lean poultry and lean red meat.
      OR
    - Include a variety of protein foods such as legumes, nuts, seeds, fish, eggs, lean poultry and lean red meat.

3. Prepare foods or choose pre-prepared foods, drinks and snacks
    a) With minimal added fat, especially saturated fat.
       If you choose to add fat use plant based fats, for example plant based oils and plant based spreads.
    b) Low in salt (sodium); if using salt, choose iodised salt.
    c) With little or no added sugar.
4. Satisfy your thirst with water.

5. Purchase, prepare, cook and store food to ensure food safety.

6. If choosing to drink alcohol, limit your intake. This means having no more than two standard drinks per day for women or three standard drinks for men, with at least two alcohol-free days per week.

   Pregnant women or those planning to get pregnant are advised **not** to drink alcohol.

Related discussion notes

1 Maintain a healthy body weight by eating well and by daily physical activity.

- Doesn't reflect energy balance
- Eating well – can mean eat 'lots' to some
- Incorporate consideration of growth into statement by adding "Achieve and maintain.."
- Consider 'positive health' (strength based) perspective when talking about body weight.
- Because of change in physical activity statements use "regular physical activity", instead of "daily"

Proposed options:

i) To achieve and maintain a healthy weight, be physically active and choose amounts of nutritious food and drinks to meet your energy needs. (Australia 2013)

OR

ii) Balance your food intake and activity levels to achieve and sustain a healthy weight. (Based on American GLs 2010)

2 Eat well by including a variety of nutritious foods from each of the four major food groups each day:

- Disliked 'Eat well', as above.
- 'Enjoy' suggested but not thought specific enough to eating.
- Liked 'variety', 'each day'
- Query use of 'nutritious' to describe foods – what does it mean? Couldn't think of anything better to replace it with at this point.
- Queries related to possible changes to current food groups – changes possible following review of current serving size advice and development of food model but for the next year at least food groups will remain as they are. When/if changes made wording of guideline statements will be reviewed to match.

Proposed option:

i) Eat a variety of nutritious foods from each of the four major food groups each day:

2a) Eat plenty of vegetables and fruit.

a) Concern about potato in vegetable and fruit food group, as warm potato physiologically becomes almost straight glucose on digestion. Eating 'plenty' of potato is not recommended. No change to food groups at present as above (2), so statement needs to include recommendation to limit intake of potato if possible.
b) Australian, US and Canada all specifically recommend eating different coloured vegetables. Nordic recommendations (NNR 2012) summary does not state this but cover of NNR 2012 document includes dramatic picture of range of multi-coloured vegetables and fruit (including purple, blue, green, yellow, orange and red ones), emphasising concept of eating a range of colours.
c) Query regarding strength of evidence to support specific colour vegetable recommendation.
d) Including focus on eating different colours could downplay role of potato as vegetable option.
e) Liked word 'variety'.
f) Include 'seasonal' to include consideration of sustainability issue.

Proposed option:

i) Eat a variety of different coloured seasonal vegetables and fruit.
ii) Eat plenty of different coloured seasonal vegetables and fruit.

2b) Eat plenty of breads and cereals, preferably wholegrain.

- Remove 'plenty' as overemphasising proportion of this food group recommended for diet.
- Remove 'breads' from name of food group, replacing with 'grains'. Not all bread is of the same nutritional value, with most readily available bread being highly refined. Need to be encouraging consumption of wholegrain products, moving away from more refined foods like white rice, white or non-grainy 'brown' bread.
- Many, including some Pacific people, choose high sugar cereals, rather than healthier options. 'Cereal' means 'Coco Pops' or similar high sugar product.
- No appropriate or useful definition of 'wholegrain' available currently.
- Foods Standards Code includes inappropriate definition for wholegrain, which means food labels using this word can be misleading.
- 'Naturally rich in fibre' was considered a useful description.
- Term 'dense' used to describe wholegrain breads could be considered.

Proposed option:

i) Eat a variety of grains and cereals that are naturally high in fibre.

2c) Have milk and milk products in your diet, preferably reduced or low fat options.

- Milk and milk products food group provides primarily calcium, but also protein to the diet.
- Recommendation need to be strong on low fat options.
- Need to include milk alternatives ie calcium enriched soy or rice milk.
- Some recommended not listing cheese as no calcium rich, low fat cheeses available in NZ. Keep focus to milk and yoghurt.
- Query whether this recommendation could encourage consumption of high sugar yogurts/dairy desserts.

Proposed option:

i) Eat low fat milk products such as milk and yoghurt or calcium enriched milk alternatives every day.

2d) Include lean meat, poultry, seafood, eggs or alternatives (From 2006, "alternatives" was replaced with, for example, "nuts, seeds and legumes").

- Association between red meat and colorectal cancer not looking as strong as previously thought. No specific reason re cancer to strongly limit intake.
- Processed meats still strong association with colorectal cancer, but currently no useful definition of term to aid accurate identification of problematic products (?)
- Positive evidence related to fish, rather than seafood.
- Recommendations related to fish need to consider sustainability issue.
- Animal products less sustainable than plant products. Consider reversing order of list of foods in this group placing plant based foods at the beginning.
- Nuts and seeds high in fat, but considered good fats so not seen as a significant issue having them higher up on the food list.
- Any recommendations regarding meat need to be prefaced by term 'lean'.

Proposed options:

i) Include legumes, nuts, seeds, fish, eggs, poultry and lean red meat.
ii) Include a variety of protein foods such as legumes, nuts, seeds, fish, eggs, poultry and lean red meat.

3 Prepare foods or choose pre-prepared foods, drinks and snacks:

- TAG liked current wording and recommended keeping it.

3a) With minimal added fat, especially saturated fat.

- Agreement that still a need to recommend limiting total fat in relation to excess energy in diet and obesity.
- Decreasing saturated fat in the diet still considered a key piece of advice.
- Also include some advice re better fats to choose if fat is being used eg plant based oils, spreads.
- Some keen to mention seeds and nuts in this list as well as best source of fats.

Proposed option:

i) With minimal added fat, especially saturated fat.
If you choose to add fat use plant based fats, for example plant based oils and plant based spreads.

3b) Low in salt; if using salt, choose iodised salt.

- Decreasing salt in the diet still considered a key piece of advice.
- Include term 'sodium' in statement so consumers can identify salt on food labels where there term is used.

Proposed option:

i) Low in salt (sodium); if using salt, choose iodised salt.

3c) With little added sugar; limit your intake of high sugar foods.

- 'Free sugars' is the correct term but without meaning for consumers so need to continue with 'added sugar'.
- Discussion around misunderstanding related to term 'high sugar foods', where some consumers believe fruit, being full of fructose, is then not a healthy option.
- Second part of sentence not thought to be needed

Proposed option:

i) With little or no added sugar

4 Drink plenty of liquids each day, especially water.

- Important to include, without re-enforcing the incorrect '8 glasses a day' recommendation.
- TAG keen on the Canadian words: 'Satisfy your thirst with water.'

Proposed option:

i) Satisfy your thirst with water.

5 Purchase, prepare, cook and store food to ensure food safety.

- Considered relevant to include in as key guidelines statements.
- TAG happy with current wording.
- Do the public know what 'food safety' is? American wording is longer but explains better? 'Follow food safety recommendations when preparing and eating foods to reduce the risk of foodborne illnesses.'
- We will talk to Ministry for Primary Industries (MPI) regarding this statement.

6 If choosing to drink alcohol, limit your intake.

- ALAC/HPA recommended levels need to be included in statement.
- Although first iteration of core document will not include specific advice for pregnant women, adding advice to this statement considered important as it is a key public health message.

Proposed option:

i) If choosing to drink alcohol, limit your intake. This means having no more than two standard drinks per day for women or three standard drinks for men, with at least two alcohol-free days per week.

Pregnant women or those planning to get pregnant are advised **not** to drink alcohol.

Others

- Eat together ie take opportunities to eat meals with other people. (Older people GLs)
- Eat meals with family or whānau as often as possible. (2-18yrs GLs)
- Considered important messages but not a key guideline statement.
- Some concern about not including single people or possibly showing single status in slightly negative light.

Document 6

10 March 2014

Louise McIntyre & Elizabeth Aitken
Ministry of Health
PO Box 5013
WELLINGTON

Dear Louise and Elizabeth,

RE: FEEDBACK ON THE DRAFT EATING AND ACTIVITY GUIDELINES STATEMENTS (EAGS) FOR NEW ZEALAND ADULTS

The current draft document *Eating and Activity Guidelines Statements for New Zealand Adults* currently advises to limit processed meat intake based on international systematic graded evidence.

As stated in the tracked document and with supporting references, the current WCRF recommendation for processed meat was based on a meta-analysis of a limited number of selected cohort studies. As the Alexander et al (2009) paper highlights, epidemiological evidence shows no independent association between animal fat intake or animal protein intake with colorectal cancer. In addition when using global recommendations, New Zealand consumption of processed meat needs to be considered, particularly when it is been compared to Nordic countries of which some evidence has been drawn.

Whilst the New Zealand Meat Processors Association recognises its products do provide a source of sodium, much work has been achieved in collaboration with the Heart Foundation's HeartSAFE project which has achieved 37 tonnes of sodium removed from the processed meat supply to date.

If you have any questions on the comments, documents or references provided to support my response, please get in touch any time, DDI 09 489 0877 or S9(2)(a) [redacted]

For your consideration.

Fiona Greig
Enc.

New Zealand Meat Processors Association Incorporated
ADDRESS Ground Floor, Air New Zealand Building, Smales Farm Park, Cnr Taharoto and Northcote Roads, Takapuna, North Shore City 0622, Auckland
PO Box 33 648, Takapuna, North Shore City 0740, Auckland
PHONE 09 489 0877 **EMAIL** megan@nzmpa.co.nz

Document 7

Draft Eating and Activity Guidelines Statements 2014

Draft Eating and Activity Guidelines Statements	
Draft eating guideline statements	Draft activity guideline statements
1. To be a healthy weight, balance your intake of food and drinks with your activity levels. 2. Enjoy a variety of nutritious foods every day including: • plenty of different coloured vegetables and fruit • a range of grains and cereals that are naturally high in fibre • some low fat milk products and/or calcium-fortified milk alternatives • some legumes*, nuts, seeds, fish, eggs, lean poultry or lean red meat. *Legumes include cooked dried beans (eg baked beans), split peas, lentils and chickpeas. 3. Choose and prepare foods and drinks: • with minimal fat, especially saturated fat; if you choose to add fat use plant based oils and spreads • low in salt (sodium); if using salt, choose iodised salt • with little or no added sugar 4. Make water your first choice for drinks. 5. Buy, prepare, cook and store food to ensure food safety. 6. If you drink alcohol, keep your intake low. Don't drink if you are pregnant or planning to become pregnant.	1. Sit less, move more! Reduce sedentary behaviour and break up long periods of sitting. 2. Do at least 150 minutes (2 ½ hours) of moderate-intensity or 75 minutes (1¼ hours) of vigorous-intensity physical activity spread throughout the week. 3. For weight management and extra health benefits, aim to do at least 300 minutes (5 hours) of moderate- or 150 minutes (2 ½ hours) of vigorous-intensity physical activity spread throughout the week. 4. Include some muscle- and bone-strengthening activities on at least two days per week. 5. If you currently do no physical activity, start by doing some activity, and then build up to the recommended amount.

Document 8

Dear Colleagues

Feedback on the Eating and Activity Guidelines statements

Later this year, the Ministry intends to publish a concise document based on revised key healthy eating and physical activity messages (guidelines statements) for adult New Zealanders. **As part of the next stage of revision, the Ministry invites your organisation to provide feedback on the draft guideline statements.** These statements will also be included in the Ministry's health education resources written for the public.

Background

The concise document will be for health practitioners and others who provide advice on nutrition and physical activity to the general public. The revised statements which the document is based on have been updated to i) bring them in line with the current published international graded evidence base and ii) consider health literacy and communication perspectives. The first part of the revision involved seeking feedback on the current statements from an external technical advisory group comprising of academics and experts from other non-government agencies, and the second part involved revision following feedback from communications specialists. The resulting statements (attached) are currently undergoing focus group testing with members of the public, with emphasis on their meaning and relevance to key population groups including Māori, Pacific, South Asian and European/other.

We are aware that considering different factors ie evidence base, health literacy and communication will require careful balancing of word choice and phrasing. To retain integrity the statements ultimately need to accurately reflect the evidence base. Further work can be done by the Ministry to develop consumer friendly key messages and by the sector to make the statements understandable.

As well as the key messages (guidelines statements) the concise document (and related webpages) will include examples of foods and activities, as well as advice and links to other information sources for the practical application of the statements will be included.

What we need from your organisation

We are interested in your feedback on the draft guidelines statements attached below. The first document below provides the basic eating and activity messages. The second document contains an extended version of the activity statements which includes the 'why' and some ideas on 'how'. We are interested in your feedback on this additional version of the statements. If positively received we may develop a similar version for the eating statements.

Please note these two documents are draft and not for further dissemination.

Basic guidelines statements 26 March 2014.doc

Long activity statements 26 Mar 2014.doc

When do we need your feedback by?

The Ministry would be grateful if you could provide feedback including any alternate wording or examples of any points you make to maximise our understanding of them by midday Tues 22 April.

How do we want feedback?

Please email to. If you wish to discuss this consultation further you can contact me by email or phone on the details below.

Yours sincerely

Louise McIntyre
Advisor - (Nutrition)
Nutrition & Physical Activity Policy
Public Health
Clinical Leadership, Protection & Regulation
Ministry of Health
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Document 9

Draft Eating and Activity Statements as at 17 July 2014

Overarching statement for Eating and Activity Statements:

- Three options are proposed:
  - i) 'Eating, drinking and physical activity are key determinants of health'.
  - ii) 'The amount and type of food and physical activity are key determinants of health'.
  - iii) 'What and how much you eat and drink, and your level of physical activity strongly effect (or shape or impact) your health'.

Eating Statements

1. Enjoy a variety of nutritious foods every day

- Eating a range of foods helps you get all the nutrients you need from food to be healthy.
- Include:
  - **plenty of different coloured vegetables and fruit**
    - *e.g. broccoli, kumara, cabbage, fresh or canned tomatoes, carrots, green leafy vegetables, frozen green peas or beans, lettuce, apples, oranges, plums, feijoas, bananas.*
  - **a range of grains and cereals that are naturally high in fibre** – go for wholegrain options as much as possible
    - *e.g. wholegrain bread; wholemeal pasta, brown rice, wholegrain cereals like porridge and whole wheat biscuits*

    or as per Australian GLs:
    Grains (cereal) foods, mostly wholegrain and/or high cereal fibre varieties, such as breads, cereals rice, pasta, noodles, polenta, couscous, oats, quinoa and barley
  - **some low fat milk products** *e.g. green or yellow top milk, low fat yoghurt;* or calcium-added milk alternatives (non-dairy milks*) e.g. calcium added soy or rice milk*

Activity Statements

1. Sit less, move more! Break up long periods of sitting

- Standing up more often can help your health, even if you are already physically active.
  - Break up the time you are sitting throughout the day for at least a few minutes every hour, preferably more.
  - See standing and moving as an opportunity.

2. Do at least 2 ½ hours of moderate-intensity or 1 ¼ hour of vigorous-intensity aerobic physical activity spread throughout the week.

- Aerobic activities are great for the heart, lungs, and overall fitness and wellbeing.
  - You can achieve this guideline by doing at least 30 minutes of moderate-intensity or 15 minutes of vigorous-intensity aerobic activity on 5 days a week.
    - Moderate-intensity activities make you breathe harder but you should still be able to enjoy a chat while doing them e.g. brisk walking on flat ground, playing with tamariki (children), and dancing.
    - Vigorous-intensity activities make you breathe a lot harder and you won't be able to chat while doing them e.g. by walking fast or walking uphill, running, swimming or doing kapa haka.

- **some legumes*, nuts, seeds, fish, eggs, and/or poultry and red meat** with the fat removed.

  **Legumes include cooked dried beans (e.g. baked beans), split peas (e.g. dahl), lentils and chickpeas (e.g. hummus).*

2. Choose and prepare foods and drinks:

- **With unsaturated fats instead of saturated fats.**
  - The body needs some fat, and the best type of fat is unsaturated which comes mainly from plants.
    - *Examples of healthy plant based fats include canola and olive oil and plant based margarines.*
    - *Other sources of healthy fats include seeds, nuts, avocados.*

- High saturated fat intakes increase your risk of heart disease.
  - *Fat from animals as well as coconut oil and palm oil have a lot of saturated fat.*

Or Australian Guidelines wording:

Limit intake of foods containing saturated fat, added salt, added sugars and alcohol

- Limit intake of foods high in saturated fat such as many biscuits, cakes, pastries, pies, processed meats, commercial burgers, pizza, fried foods, potato chips, crisps and other savoury snacks.
- Replace high fat foods which contain predominantly saturated fats such as butter, cream, cooking margarine, coconut and palm oil with foods which contain predominantly polyunsaturated and monounsaturated fats such as oils, spreads, nut butters/pastes and avocado.

Choose and prepare foods and drinks:

- **That are low in salt (sodium);** if using salt, choose iodised salt.
  - High intakes of salt may increase your risk of heart disease, stroke, kidney disease and some cancers.

- It is important that the physical activity is spread throughout the week.
  - ➢ Physical activity doesn't have to be done all at once – break it into smaller more manageable chunks.

3. For extra health benefits, aim for 5 hours of moderate-intensity activity; 2 ½ hours of vigorous-intensity activity per week or an equivalent combination of both.

- More time spent being active or increasing the intensity of the activity will provide extra health benefits such as increased fitness and reduced risk of some cancers.
- You can achieve this guideline by doing at least 60 minutes of moderate-intensity or 30 minutes of vigorous-intensity aerobic activity on 5 days a week.
  - ➢ High-intensity intermittent training (short periods of intense anaerobic activity with less recovery in between) is also time efficient and good for your weight.

4: Doing some activity is better than doing no activity.

- Make sure what you do is fun and build it into your daily routine.
  - ➢ Walk or cycle to places you might normally drive to, play actively with the tamariki, take the stairs instead of using the lift, do active jobs around the house, go fishing or gathering kai for dinner.
- Being physically active with whānau and friends is good for your overall wellbeing (and theirs) and can motivate you to stay active.
- If you have a health condition you may wish to consult your doctor or physical activity specialist before starting physical activity.
  - ➢ Talk to your doctor or practice nurse about a Green Prescription (GRx). A GRx is advice to you to be physically active, as part of your overall health management. It includes a written referral to a GRx coordinator who will support you to become more active.

5: Include some muscle and bone strengthening activities at least two days each week

- **With little or no added sugar.**
  - Adding sugar increases the energy (calorie) content of food and drinks
  - A high or regular intake of foods and drinks with added sugar can lead to tooth decay

3. Make water your first choice over other drinks

- The body needs water to survive and work well.
- Town supplied tap water in New Zealand is safe to drink and widely available. If you are not on a town supply check the safety of your water with your local council.
- Plain water contains no energy (calories) so won't cause you to put on weight and is the best way to satisfy thirst.
  - *Limit high sugar drinks like fizzy drinks.*

4. Buy, prepare, cook and store food to ensure food safety.

- Food can easily grow bugs that cause sickness/food poisoning so careful preparing, cooking and storing of food is important to reduce the risk of it happening.
  - *Don't buy food past its use-by date (check the label)*
  - *Follow storage advice on labels*
  - *Always wash your hands before handling food*
  - *Keep raw meat away from cooked meat and other food – the bugs on raw meat can transfer to other foods*
  - *Keep leftovers covered and in the fridge, reheat well before use and don't keep longer than 2 days*
  - *Be aware of food that is at higher risk of growing bugs and store and cook it safely, eg, meat, chicken, fish, milk products, rice and legumes.*

5. If you drink alcohol, keep your intake low.

- Alcohol can cause weight gain
- Alcohol can increase the risk of some diseases including breast cancer

- Muscle and bone strengthening helps to keep your body strong and reduce the risk of injury.
  - Muscle strengthening requires pushing or pulling against a heavy object or weight which provides a force to stop you.
    - Strengthen your muscles with resistance activities such as walking up hills or stairs, digging in the garden, carrying the shopping or weight lifting.
  - Bone strengthening requires doing activities that place impact on your bones.
    - Strengthen your bones with impact activities such as walking, running, jumping, active sports.
  - These activities can be done around the home, outside, in the community, or under the supervision of a trained professional at a gym or sports club.

▪ *Keeping your intake low means having no more than 2 standard drinks per day for women and 3 standard drinks for men, with at least two alcohol free days per week*[k] **Don't drink if you are pregnant or planning to become pregnant**. o Alcohol can harm your unborn baby o No amount of alcohol is safe for your unborn baby	

Single weight-related statement for eating and activity statements:

Food, drinks and physical activity are key to achieving a healthy body weight:

- A healthy weight:
  - o Increases your chances of staying well and active
  - o Decreases your risk of getting diabetes, heart disease and some cancer.

- To prevent excess weight gain and to lose weight:
  - o choose nutritious foods which are low in energy (minimal fat and no added sugar)
  - o drink water instead of sugary drinks and/or alcoholic drinks
  - o reduce your portion sizes
  - o sit less and reduce screen time
  - o be as active as you can

Document 11

Draft Eating and Activity Statements as at 17 July 2014

Overarching statement for Eating and Activity Statements:

- Three options are proposed:
  - iv) 'Eating, drinking and physical activity are key determinants of health'.
  - v) 'The amount and type of food and physical activity are key determinants of health'.
  - vi) 'What and how much you eat and drink, and your level of physical activity strongly effect (or shape or impact) your health'.

Eating Statements	Activity Statements
1. Enjoy a variety of nutritious foods every day • **Include**: ▪ **plenty of different coloured vegetables and fruit** ▪ **a range of grains and cereals that are naturally high in fibre** – go for wholegrain options as much as possible **(or** as per Australian GLs: ▪ **Grains (cereal) foods, mostly wholegrain and/or high cereal fibre varieties)** ▪ **some low fat milk products or calcium-added milk alternatives** ▪ **some legumes*, nuts, seeds, fish, eggs, and/or poultry and red meat** with the fat removed. **Legumes include cooked dried beans (e.g. baked beans), split peas (e.g. dahl), lentils and chickpeas (e.g. hummus).* **2. Choose and prepare foods and drinks:** • **With unsaturated fats instead of saturated fats.** **(Or** Australian Guidelines wording: • **Limit intake of foods containing saturated fat, added salt, added sugars and alcohol)**	**1. Sit less, move more! Break up long periods of sitting** **2. Do at least 2 ½ hours of moderate-intensity or 1 ¼ hour of vigorous-intensity aerobic physical activity spread throughout the week.** **3. For extra health benefits, aim for 5 hours of moderate-intensity activity; 2 ½ hours of vigorous-intensity activity per week or an equivalent combination of both.** **4. Doing some activity is better than doing no activity.** **5. Include some muscle and bone strengthening activities at least two days each week**

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That are low in salt (sodium); if using salt, choose iodised salt.
With little or no added sugar.

3. Make water your first choice over other drinks

4. Buy, prepare, cook and store food to ensure food safety.

5. If you drink alcohol, keep your intake low.
Don’t drink if you are pregnant or planning to become pregnant.</td>
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<tr>
<td colspan="2">Single weight-related statement for eating and activity statements:

Food, drinks and physical activity are key to achieving a healthy body weight:

A healthy weight:

Increases your chances of staying well and active
Decreases your risk of getting diabetes, heart disease and some cancer.

To prevent excess weight gain and to lose weight:

choose nutritious foods which are low in energy (minimal fat and no added sugar)
drink water instead of sugary drinks and/or alcoholic drinks
reduce your portion sizes
sit less and reduce screen time
be as active as you can

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Document 10

Draft Eating and Activity Statements as at 24 July 2014

Overarching statement for Eating and Activity Statements:

- Three options are proposed:
  - i) 'Eating, drinking and physical activity are key determinants of health'.
  - ii) 'The amount and type of food and physical activity are key determinants of health'.
  - iii) 'What and how much you eat and drink, and your level of physical activity strongly effect (or shape or impact) your health'.

Eating Statements

1. **Enjoy a variety of nutritious foods every day**
   - Eating a range of foods helps you get all the nutrients you need from food to be healthy.
   - Include:
     - **plenty of different coloured vegetables and fruit**
       - *e.g. broccoli, kumara, cabbage, fresh or canned tomatoes, carrots, green leafy vegetables, frozen green peas or beans, lettuce, apples, oranges, plums, feijoas, bananas.*
     - **a range of grains and cereals that are naturally high in fibre – go for wholegrain options as much as possible**
       - *e.g. wholegrain bread; wholegrain cereals like oats (porridge) and whole wheat biscuits, brown rice, wholemeal pasta and noodles, polenta, couscous, quinoa and barley.*
     - some low fat milk products *e.g. green or yellow top milk, low fat yoghurt;* or calcium-added milk alternatives (non-dairy milks*) e.g. calcium added soy or rice milk*
     - some legumes*, nuts, seeds, fish, eggs, and/or poultry and red meat with the fat removed.

       **Legumes include cooked dried beans (e.g. baked beans), split peas (e.g. dahl), lentils and chickpeas (e.g. hummus).*

Activity Statements

1. **Sit less, move more! Break up long periods of sitting.**
   - Standing up more often can help your health, even if you are already physically active.
     - *Break up the time you are sitting throughout the day for at least a few minutes every hour, preferably more.*
   - The benefits for your health begin as soon as you start moving.
     - *Stand up for your health - see standing and moving as an opportunity.*
     - *Replace sitting down with gentle activity.*
2. **Do at least 2 ½ hours of moderate, or 1 ¼ hour of vigorous physical activity spread throughout the week.**
   - Aerobic activities are great for the heart, lungs, overall fitness and overall wellbeing.
     - *Moderate intensity activities make you breathe harder but you should still be able to enjoy a chat while doing them e.g. brisk walking on flat ground, playing with tamariki (children), and dancing.*
     - *Vigorous intensity activities make you breathe a lot harder and you won't be able to chat while doing them e.g. by brisk walking uphill, running, swimming or doing kapa haka.*
   - More health benefits are gained from spreading your physical activity throughout the week, than doing it all at once.

2. Choose and prepare fresh and minimally processed foods and drinks:

- **With unsaturated fats instead of saturated fats.**
  - The body needs some fat, and the best type of fat is unsaturated which comes mainly from plants.
    - *Examples of healthy plant based fats include canola and olive oil and plant based margarines.*
    - *Other sources of healthy fats include seeds, nuts, avocados.*
  - High saturated fat intakes increase your risk of heart disease.
    - *Fat from animals as well as coconut oil and palm oil have a lot of saturated fat.*
    - *Limit intake of foods high in saturated fat such as many biscuits, cakes, pastries, pies, processed meats, commercial burgers, pizza, fried foods, potato chips, crisps and other savoury snacks.*
    - *Remove fat from meat or poultry before cooking and cook in a way that removes fat rather than adds it eg grilling, steaming, boiling.*
- **That are low in salt (sodium);** if using salt, choose iodised salt.
  - High intakes of salt may increase your risk of heart disease, stroke, kidney disease and some cancers.
    - *Choose foods with the lowest amount of salt (sodium) by comparing the food labels.*
    - *If you like adding salt to your food, decrease how much you add over time to let get used to the taste.*
- **With little or no added sugar.**
  - Adding sugar increases the energy (calorie) content of food and drinks
  - A high or regular intake of foods and drinks with added sugar can lead to tooth decay
    - *Choose foods with the lowest amount of added sugar by comparing the food labels*
    - *Being active regularly through the week helps your body to regulate and manage the energy it receives much better than doing one longer period of activity.*
    - *You can achieve this by doing at least 30 minutes of moderate or 15 minutes of vigorous intensity physical activity on five days a week, or an equivalent combination of both.*
    - *Break your activity up into smaller more frequent chunks by doing it in regular 10 minute episodes.*

3. For extra health benefits, aim for 5 hours of moderate, or 2 ½ hours of vigorous physical activity spread throughout the week.

- More time spent being active or increasing the intensity of the activity will provide extra health benefits such as increased fitness and reduced risk of some cancers including colon and post-menopausal breast cancer.
  - *You can achieve this by doing at least 60 minutes of moderate or 30 minutes of vigorous intensity physical activity on five days a week, or an equivalent combination of both.*
  - *You can also do short periods of intense activity with a brief recovery period in between which is time efficient and good for your health.*

4. Doing some physical activity is better for you than doing none.

- Make sure what you do is fun and build it into your daily routine.
  - *Walk or cycle to places where you might normally drive to, take the stairs instead of using the lift, or do active jobs around the house.*
- Being physically active with friends or whānau is good for your overall wellbeing (and theirs) and can motivate you to stay active.
  - *Go for a walk with friends or whānau, play actively with tamariki, go fishing or gathering kai for dinner.*
- If you have a health condition you may wish to consult your doctor or physical activity specialist before starting physical activity.
  - *Talk to your doctor or practice nurse about a Green Prescription. A Green Prescription coordinator will provide you*

- *Add little or no sugar to foods and drinks*

3. Make water your first choice over other drinks

- The body needs water to survive and work well.
- Town supplied tap water in New Zealand is safe to drink and widely available. If you are not on a town supply check the safety of your water with your local council.
- Plain water contains no energy (calories) so won't cause you to put on weight and is the best way to satisfy thirst.
  - *Limit high sugar drinks like fizzy drinks.*

4. Buy, prepare, cook and store food to ensure food safety.

- Food can easily grow bugs that cause sickness/food poisoning so careful preparing, cooking and storing of food is important to reduce the risk of it happening.
  - *Don't buy food past its use-by date (check the label)*
  - *Follow storage advice on labels*
  - *Always wash your hands before handling food*
  - *Keep raw meat away from cooked meat and other food – the bugs on raw meat can transfer to other foods*
  - *Keep leftovers covered and in the fridge, reheat well before use and don't keep longer than 2 days*
  - *Be aware of food that is at higher risk of growing bugs and store and cook it safely, eg, meat, chicken, fish, milk products, rice and legumes.*

5. If you drink alcohol, keep your intake low.

- Alcohol can cause weight gain
- Alcohol can increase the risk of some diseases including breast cancer.
  - *Keeping your intake low means having no more than 2 standard drinks per day for women and 3 standard drinks for men, with at least two alcohol free days per week*

Don't drink if you are pregnant or planning to become pregnant.

- Alcohol can harm your unborn baby.
- No amount of alcohol is safe for your unborn baby.

with personal advice and support on becoming more physically active, as part of your overall health management.

5. Do some muscle strengthening activities on at least two days each week.

- Muscle strengthening activities help to keep your body strong for doing everyday activities, and reducing the risk of injury.
  - *Muscle strengthening requires pushing or pulling against your own body weight, a heavy object or a machine.*
  - *Strengthen your muscles with resistance activities such as weight lifting or push ups, or alternatively walking up hills or stairs, digging in the garden, or carrying tamariki or shopping.*
  - *These activities can be done around the home, outside, in the community, or under the supervision of a trained professional at a gym or sports club.*

Single weight-related statement for eating and activity statements: Food, drinks and physical activity are key to achieving a healthy body weight: • A healthy weight: o increases your chances of staying well and active o decreases your risk of getting diabetes, heart disease and certain cancers. • To prevent excess weight gain and to lose weight: o choose nutritious foods which are low in energy (minimal fat and no added sugar) o drink water instead of sugary drinks and/or alcoholic drinks o reduce your portion sizes o sit less and reduce screen time o be as active as you can.	

Document 12

Draft Eating and Activity Statements as at 17 July 2014

Overarching statement for Eating and Activity Statements:

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  - vi) 'What and how much you eat and drink, and your level of physical activity strongly effect (or shape or impact) your health'.

Eating Statements	Activity Statements
1. Enjoy a variety of nutritious foods every day o **Include**: ▪ **plenty of different coloured vegetables and fruit** ▪ **a range of grains and cereals that are naturally high in fibre** – go for wholegrain options as much as possible ▪ **some low fat milk products or calcium-added milk alternatives** ▪ **some legumes*, nuts, seeds, fish, eggs, and/or poultry and red meat** with the fat removed. **Legumes include cooked dried beans (e.g. baked beans), split peas (e.g. dahl), lentils and chickpeas (e.g. hummus).* **2. Choose and prepare fresh and minimally processed foods and drinks:** • **With unsaturated fats instead of saturated fats.** • **That are low in salt (sodium); if using salt, choose iodised salt.** • **With little or no added sugar.** **3. Make water your first choice over other drinks** **4. Buy, prepare, cook and store food to ensure food safety.** **5. If you drink alcohol, keep your intake low.**	**1. Sit less, move more! Break up long periods of sitting.** **2. Do at least 2 ½ hours of moderate or 1 ¼ hour of vigorous physical activity spread throughout the week.** **3. For extra health benefits, aim for 5 hours of moderate, or 2 ½ hours of vigorous physical activity spread throughout the week.** **4. Doing some physical activity is better for you than doing none.** **5. Do some muscle and bone strengthening activities at least two days each week.**

Don’t drink if you are pregnant or planning to become pregnant.	

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Food, drinks and physical activity are key to achieving a healthy body weight:

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  - choose nutritious foods which are low in energy (minimal fat and no added sugar)
  - drink water instead of sugary drinks and/or alcoholic drinks
  - reduce your portion sizes
  - sit less and reduce screen time
  - be as active as you can

The Role of Red Meat in a Healthy New Zealand Diet

Written by Amanda Johnson BSc(hons), MSc, PG Dip Diet

February 2015

Contents

Acknowledgement to the following for reviewing sections of The Role of Red Meat in a Healthy New Zealand Diet report:

Dr Tatjana Buklijas, Liggins Institute Centre for Human Evolution, Adaptation & Disease
Dr Laurence Eyres, FoodInc
Delvina Gorton, New Zealand Heart Foundation
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Professor Jim Mann CNZM, University of Otago
Associate Professor Winsome Parnell, University of Otago
Professor Elaine Rush MNZM, Auckland University of Technology
Professor Christine Thompson, University of Otago
Dr Pam von Hurst, Massey University

Summary

Historically, red meat has played a central role in the human diet.

Around 4 to 5 million years ago, it is believed the ancestral hominid line emerged from the receding forests to become bipedal open grassland dwellers, evolving to require higher-quality foods based around meat protein and fat.

This was accompanied by subsequent physiological and metabolic adaptations involving the development of a larger brain and a smaller gastro-intestinal tract.

Evidence from fossil stable isotope analysis demonstrates a growing reliance on consumption of meat as humans evolved.

Red meat continues to play an important role in the human diet today; it is an excellent source of protein and, trimmed of visible fat, is low in total fat and saturated fatty acids. It also makes a significant contribution to the monounsaturated and omega 3 fatty acids in our diet.

In addition, meat from ruminant animals, such as beef and lamb, provides conjugated linoleic acid (CLA), which has been found to have cancer preventive and immunomodulatory properties in animal models.

In terms of micronutrients, red meat (particularly beef and lamb) is an excellent source of bioavailable iron and zinc, and also provides selenium, vitamin D, and B vitamins, with red meat being one of our major sources of vitamin B_{12}. Red meat also contains bioactive compounds such as taurine, carnitine, creatine and some endogenous antioxidants.

Lean meat has an important role to play in the diets of all age groups in New Zealand, providing nutrients that enable optimal growth and development in childhood as well as maintenance of health and wellbeing throughout adulthood and well into old age.

For those who exclude meat, careful consideration needs to be given to the nutritional adequacy of the diet as more restrictive diets are associated with a greater risk of deficiencies. In particular, vegans (who exclude all animal products) need to take extra care to ensure their nutritional needs are met.

The low fat and saturated fatty acid content of lean red meat makes it an ideal food to include as part of a heart-healthy, balanced diet.

The protein content may play a useful role in weight management due to its effect on appetite control, satiety and food craving. There is also emerging evidence that as dietary protein intake falls, energy intake increases. Due to the impact protein has on the glyacemic index of a meal, there is an important role in diabetic blood sugar control.

With respect to cancer, epidemiological and mechanistic data on associations between red meat and cancer are weak in magnitude and are inconsistent. Current average

intakes of red meat in New Zealand are below the amount recommended by the World Cancer Research Fund (WCRF, 2007) of up to 500g cooked red meat per week.

Lean red meat had a central role in the diet of early man and continues to do so in modern times (Ruxton et al., 2013). It is consumed by nine out of ten New Zealanders once or more a week. Red meat provides a unique package of nutrients that make an important contribution to optimal health as part of a balanced diet and active lifestyle.

1. Introduction

In New Zealand, 94.5% of the adult population consumes red meat (University of Otago & Ministry of Health, 2011). Among children, 95% consume an omnivorous diet (Parnell et al., 2003).

As the majority of New Zealanders consume meat, consideration of its contribution to nutritional intakes and its role in health and disease is important.

This report provides background information on human evolution and the increasing importance of meat consumption as humans evolved. It reviews current scientific knowledge in terms of the nutritional content of red meat, its contribution to the diets of New Zealanders and its role in health and disease.

Some of the myths and misconceptions about meat are discussed in Appendix 1 and information about current farming practices in New Zealand, sustainability, and risk management at processor level are covered in Appendix 2.

The term 'red meat' in this report refers to beef, veal, lamb and mutton. For the purpose of this report, where meat is mentioned it refers to red meat flesh, which is defined as the skeletal muscle of beef, lamb, veal and mutton which includes any attached fat, connective tissue, rind, nerve, blood and blood vessels (FSANZ, 2012).

2. Human evolution and meat consumption

Meat has played a central role in our diets throughout evolution and there is good evidence that over the last 2 million years the human ancestral line has been consuming increasing quantities of meat (Mann, 2000). The earliest evidence for scavenged meat goes back to the late Australopithecines after early hominins were herbivores. In fact, it has been suggested that even mild and intermittent shortages of meat can have adverse consequences for energy and micronutrient-sensitive tissues such as the brain (Williams and Dunbar, 2013).

Not only have there been changes in cranio-dental features to enhance our ability to bite and tear animal flesh, but comparative gut morphology shows humans are truly omnivorous (Mann, 2007). In addition, fossil isotope ratios indicate consumption of a high-meat diet in early hominids, as early as 1.8 million years ago (Mann, 2000).

More recent human history, from archaeological records of around 40,000 years ago, shows the use of bone and antler tools such as spear tips and harpoons.

There is also evidence to suggest animal traps and bows and arrows were used subsequent to this time (Ulijaszek, 2002). Around 9,000 years ago the settling and growth of populations and the domestication of both plants and animals began (Biegert, 1975).

Primates in general and humans in particular, have larger brain sizes than would be expected for their body size, a phenomenon described as encephalisation. In humans, there has been a dramatic increase in brain size over the last 2-3 million years (Aiello & Wheeler, 1995).

The consumption of meat rich in fats (particularly the unsaturated fats) is one theory to be the factor responsible for the threefold increase in brain size over the last 4.5 million years (Chamberlain, 1996; Mann, 1998). It has been estimated that whenever it was ecologically possible, hunter-gatherers consumed 45-65% of their energy from animal foods, with protein providing 19-35% of energy at the expense of carbohydrates, which provided 22-40% of energy (Cordain et al., 2000). Another theory, the social brain hypothesis suggests brain size in primates is linked to the size of groups of which they live (Dunbar, 2009).

It has been suggested diets high in meat can be associated with high cholesterol levels and elevated risk of heart disease (Snowdon et al., 1984; Huijbregts et al., 1995; Menotti et al., 1999). However, a diet high in animal foods does not necessarily elicit unfavourable blood lipid profiles. An analysis of a type of hunter-gatherer diet by Cordain et al. in 2002 found that although 65% of energy was provided by animal foods, many hunter-gatherer societies are relatively free of the signs and symptoms of cardiovascular disease (CVD). More intense exercise and work patterns are likely to have provided pre-agricultural people with protection against CVD. In addition, qualitative differences in fat intake, including a higher intake of monounsaturates and polyunsaturates and a lower *n*-6:*n*-3 ratio, would have served to inhibit the development of cardiovascular disease among these populations.

Other dietary factors, such as a high intake of antioxidants, fibre, vitamins and phytochemicals and a low intake of salt and sugar, along with low levels of stress and no smoking, would further deter the development of cardiovascular disease.

Reverting to the diet and lifestyle of the hunter-gatherer has been shown to result in health benefits. A study of middle-aged, overweight, diabetic Aborigines in Australia, who reverted to their traditional hunter-gatherer diet for seven weeks, found improvements in all aspects of carbohydrate and lipid metabolism linked with insulin resistance (O'Dea, 1984). Despite the high contribution of animal foods to energy intake in this study (64%), the diet was low in total fat (13%) due to the very low fat content of the wild animals.

While there is no consensus on what the Palaeolithic diet is exactly, it is generally characterised by higher protein, less total fat, more essential fatty acids, lower sodium and higher fibre (Turner & Thompson, 2013).

It has been proposed that the relatively recent deviation from the Palaeolithic diet and lifestyle may be the basis of many, if not all, current diseases of civilisation (Kuipers et al., 2012), yet in some cases positive selection was so strong that in the 10,000

years since the beginning of Neolithic age, populations in Europe and East Africa evolved to use dairy beyond infancy (Tishkoff et al., 2006). A recent randomised controlled trial of one Palaeolithic diet among 70 post-menopausal women (mean age 60 years) found strong effects on fat mass, body weight and abdominal obesity after 6 months, although there were no significant differences at 24 months (Mellberg et al, 2014). In this study, the Palaeolithic diet provided 30% of energy from protein, 40% from fat and 30% from carbohydrate; the diet was based on lean meat, fish, eggs, vegetables, fruits, berries, nuts, avocado, rapeseed oil and olive oil; the diet was high in monounsaturated and polyunsaturated fats.

In summary, meat has been a significant part of our diet for millions of years and still makes an important contribution today. A diet high in lean red meat has been shown to lower plasma cholesterol, contribute significantly to tissue *n*-3 fatty acids, and provides a good source of iron, zinc and vitamin B_{12} (Mann, 2000).

A Palaeolithic dietary pattern may be beneficial in terms of aiding weight loss, but further research is needed into the longer-term effects of this type of diet before firm recommendations can be made (Mellberg et al, 2014).

3. Key nutrients in beef and lamb

The primary components of meat are water, fat and protein. The proportions of these constituents can be highly variable, depending on the species and breed of animal, the age of the animal at slaughter, the season, and the types of grass and feed used. The amount of trimming of fat both before and after purchase, and the cooking method used will also influence the nutritional composition of the meat as eaten (BNF, 1999).

There are a number of valuable vitamins, minerals and trace elements in lean meat. In particular, red meat is an excellent source of iron and zinc, which are present in a highly bioavailable form. Red meat also provides a number of B vitamins, along with vitamin D, and offal is a good source of vitamin A.

A summary of the nutrients in selected cuts of lean beef and lamb can be found in Table 1.

Table 1: Nutritional composition of selected cuts of lean, meat (per 100g)

Nutrient	Beef* (composite cuts)	Lamb* (composite cuts)	Adult NZ RDI**
Energy (kJ)	841	792	5,600-18,600
Protein (g)	30.7	27.4	46-81
Fat (g)	8.6	8.9g	-
Thiamine (mg)	trace	trace	1.1-1.4
Riboflavin (mg)	trace	trace	1.1-1.6
Niacin (mg)	9.0	11.0	14-18
Vitamin B_6 (mg)	0.22	0.18	1.3-2.0
Vitamin B_{12} (µg)	1.6	1.8	2.4-2.8
Total folate (µg)	6.8	0	400-600
Sodium (mg)	40	68	460-920^{+}

Potassium (mg)	280	320	2800-3800[+]
Calcium (mg)	6.1	15	1000-1300
Iron (mg)	2.6	1.8	8-27
Zinc (mg)	5.1	4.0	8-14
Selenium (µg)	3.3	6.3	60-75

Sources: *Sivakumaran et al., 2014; **NHMRC, 2006

RDI is the Recommended Dietary Intake (the average daily dietary intake level sufficient to meet the nutrient requirements of nearly all (97-98%) healthy individuals in a particular life stage and gender group).
[+]Adequate Intake (AI), used when an RDI cannot be determined.

Detailed background information on different nutrients and their role in the prevention of deficiency can be found in the National Health and Medical Research Council report *Nutrient Reference Values for Australia and New Zealand including Recommended Dietary Intakes* (NHMRC, 2006). This report also provides information on optimising diets to reduce chronic disease risk.

3.1. Fat

A small amount of fat can contribute to the palatability and flavour of meat. However, it is advisable to remove the visible fat from meat before eating to reduce overall fat content. Red meat cuts as sold have undoubtedly become leaner in recent years (Laugesen, 2005).

Since 1997, the red meat industry's Quality Mark has required the trimming of beef and lamb cuts to no more than 5mm external fat (see Appendix 2 for further information). This has ensured leaner cuts have become the norm for those buying meat as steaks or chops.

A study into the impact of this initiative found the trimming of fat from red meat before sale (supported by virtually all butchers) resulted in 30% less fat and 65% less saturated fat than 20 years ago (Laugesen, 2005).

Data from the 2008/09 New Zealand Adult Nutrition Survey revealed that intake of total fat was 33.7% and 33.8% for men and women respectively (University of Otago & Ministry of Health, 2011), down from 40% in 1977 and 35% in the 1997 survey (Russell et al., 1999).

The same survey showed beef and veal contributed 4.8% to total fat intake and lamb and mutton contributed 2%, down from the previous survey of 8% of total fat intake from beef and lamb. Sausages and processed meats contributed 4%,and pies and pasties contributed 3.5% to fat intake.

The total fat and fatty acid content of selected meats is shown in Table 2, where it is to be noted the saturated fat content is about 33% of total fat of lean cuts compared to over 50% in the fat trimmed from the meat.

3.1.1. Saturated fatty acids (SFA)

Saturated fatty acids (SFA) are fully saturated with hydrogen and contain no double bond. They are the main types of fatty acids found in foods such as milk, cream, cheese, meat from most land animals, palm oil and coconut oil as well as in pies, biscuits, cakes and pastries (NHMRC, 2006).

Only around half the fat in meat is saturated (see Table 2). The rest is mainly monounsaturated fats, with small amounts of polyunsaturated fats, including some *n*-3 fatty acids. The main saturated fatty acids in meat are palmitic and stearic acid (Higgs, 1999); and stearic acid has almost no effect on blood cholesterol (FAO, 2010).

The density of saturated fatty acids in a 100g portion of lean meat is quite low (see Table 2). For example, one tablespoon of olive oil contains more saturated fat (2.3g) than two slices of lean roast silverside of beef (1.7g) (Sivakumaran et al., 2014). In the 2008/09 New Zealand Adult Nutrition Survey, the contribution to intake of saturated fat from beef and veal was 5% and 2.3% from lamb and mutton. (University of Otago & Ministry of Health, 2011). For more information on saturated fats and coronary heart disease, see section 8.1.1.

3.1.2. Monounsaturated fatty acids (MUFA)

Monounsaturated fatty acids (MUFA) have one double bond; the main MUFA is oleic acid (NHMRC, 2006).

Monounsaturates have been found to help lower the amount of LDL cholesterol in the blood, while maintaining HDL blood cholesterol levels. This is likely to be a factor in the ability of Mediterranean diets, which are rich in monounsaturates, to protect against cardiovascular disease (BNF, 2005).

A significant proportion of the fatty acids in meat are monounsaturates (see Table 2), principally oleic acid (Higgs, 1999). In New Zealand, the contribution to intake of monounsaturated fat from beef and veal is 5.8% and 2.1% from lamb and mutton (University of Otago & Ministry of Health, 2011).

3.1.3. Polyunsaturated fatty acids (PUFA)

Polyunsaturated fatty acids (PUFA) contain two or more double bonds. There are two main types of PUFA: omega-3 and omega-6 (abbreviated as *n*-3 and *n*-6). The balance of *n*-3 and *n*-6 in the diet is thought to be important for health. High intakes of *n*-6 PUFA have been linked with a lower risk of coronary heart disease (CHD) and lower LDL-cholesterol levels (NHMRC, 2006; BNF, 2005). The *n*-3 PUFA have little effect on blood cholesterol, but reduce triglyceride levels and have a beneficial effect on blood clotting. In addition, experimental studies have shown *n*-3 PUFA modify inflammatory and immune reactions (Simopoulus, 2002).

Fish and seafood are the richest dietary sources of *n*-3 PUFA, with concentrations 5-15 times higher than meat (Howe et al., 2006); however meat is also likely to make a significant contribution to intakes of *n*-3 PUFA when the relative amounts eaten are considered. Australian data show meat, poultry and game contribute 43% to overall intakes of *n*-3 PUFA, with beef contributing 22.3% and lamb contributing 5.9%

(Howe et al., 2006). Whilst this is high in percentage terms, it is still relatively low in absolute long chain *n*-3 amounts.
Meat from animals raised on grass, as in New Zealand, contains higher levels of *n*-3 PUFA than meat from animals raised on grain. One study found, for example, there was 2-4 times the amount of *n*-3 PUFA in beef from grass-fed animals (including 18:3) than in meat from concentrate-fed animals, except for 20:4 *n*-3 where there was 10 times the amount in the grass group (Enser et al., 1998). The same study found similar results for lamb from animals grazed on grass. Enser (1995) also showed lean grass-fed beef has a much higher amount of phospholipids, which are rich in *n*-3, particularly docosapentaenoic acid (22:5) and a source of choline.

A more recent study compared the effects of consuming red meat from either grass-fed or concentrate-fed animals, and found that dietary intakes, as well as plasma and platelet concentrations of long chain *n-3* PUFA were significantly higher in those subjects who consumed the grass-fed animals (McAfee et al., 2011). The difference in intake of long chain *n-3* PUFA between the groups that was attributable to the red meat consumed was estimated at 18mg/day.

A significant amount of the *n*-3 PUFA in meat are from docosapentaenoic acid (DPA), which is an intermediate in the production of docosahexaenoic acid (DHA) from eicosapentaenoic acid (EPA). DPA has been shown to be a more potent inhibitor of platelet aggregation than EPA or DHA (Akiba et al., 2000), and in the Kuopio Ischaemic Heart Disease Risk Factor Study, reduction in risk of acute coronary events correlated significantly with serum concentrations of DPA and DHA in individuals whose mercury status was low (Rissanen et al., 2000). Epidemiological data on DPA are, however, limited and more information is needed on the nutritional and health benefits of consumption of DPA (Howe et al., 2006).

Given the evidence linking EPA, DHA and DPA to health, it would seem prudent to encourage increased consumption of these fatty acids in the diet. An intake in the region of 0.4g/day for women and 0.6g/day for men is recommended (NHMRC, 2006). Overall, red meat in New Zealand could make an important contribution to intakes of *n*-3 PUFA, particularly in those who don't eat much fish (Knowles et al., 2004).

Table 2: Fat and fatty acid content of lean cooked meat (per average 100g serving)

Meat Cut	Total fat (g)	SFA (g)	MUFA (g)	PUFA (g)
Lean beef, cooked, composite cuts	8.6	2.9	3.1	0.4
Beef mince, premium, simmered	3.3	1.2	0.9	0.2
Beef silverside, lean, roasted	5.0	1.7	1.8	0.3
Beef topside, lean, braised	7.3	2.5	2.6	0.4
Lean lamb, cooked, composite cuts	8.9	3.2	2.3	0.5
Lamb leg, lean, roasted,	6.4	2.1	1.8	0.4
Lamb, rump, lean, roasted	5.3	1.8	1.3	0.3

Source: Sivakumaran et al., 2014

3.1.4. *Trans* fatty acids

Trans fatty acids (TFAs) are unsaturated fatty acids that have at least one double bond in the *trans* configuration. There is good evidence TFAs have a more adverse effect on cardiovascular disease risk than saturated fatty acids (FAO, 2010), although, quantitatively TFAs constitute a much smaller proportion of the diet than saturated fatty acids (NHMRC, 2006). Most of the *trans* fat in the diet is found in margarines and products such as cakes, biscuits and pastrie. Some *trans* fats can also occur naturally at low levels in ruminant animal foods, formed as a result of biohydrogenation by rumen bacteria. However, the predominant ruminant TFA is vaccenic acid (Turpeinen et al., 2002), which has not been associated with coronary heart disease (Willett et al., 1993). There is an average of 0.2g *trans* fat in lean cuts of beef and lamb (New Zealand FOODfiles, 2013).

The World Health Organisation has recommended TFAs contribute no more than 1% of total dietary energy (WHO, 2003). In New Zealand, current intakes are around 0.6% of total dietary energy (FSANZ, 2014) which is due to the removal of partially hydrogenated fat from margarines by manufacturers a decade ago. It is recommended saturated fatty acids and TFAs together contribute no more than 8-10% of total energy (NHMRC, 2006).

3.1.5. Conjugated linoleic acid

The term conjugated linoleic acid (CLA) generally refers to mixtures of positional and geometric conjugated isomers of linoleic acid. The principle dietary form of CLA is the cis-9, *trans*-11 isomer (Pariza et al., 2000), which provides over 90% of our intake (Nakamura et al., 2008). CLA has been shown in animal studies to inhibit carcinogenesis and atherosclerosis, enhance immunologic function, affect body composition change (reducing fat gain and enhancing lean body mass gain), and stimulate growth (Pariza et al., 2000). More recently, CLA has been found to modulate immune function in humans (O'Shea et al., 2004). However, studies in humans into the effects of CLA are generally less conclusive than animal studies, with conflicting and inconsistent findings (Plourde et al., 2008; Nakamura et al., 2008) as dosages of around 3g/day were required.

The highest levels of dietary CLA are found in the meat and milk from ruminant animals (Nakamura et al., 2008). The method of feeding may affect the levels of CLA present in the meat. For example, beef from pasture-fed cattle may have a higher CLA content than beef from silage- or grain-fed cattle (Mir et al., 2004). CLA in meat is located in the interstitial, non-visible fat, evenly distributed along the muscle fibres, as well as in the subcutaneous deposits (Eynard & Lopez, 2003), whereas visible fats are often, and easily discarded, interstitial fats will be eaten. Thus, lean meat could potentially make an important contribution to the human intake of CLA.

The current dietary intake of CLA in Western populations is too low to provide the beneficial effects seen in animal studies (Turpeinen et al., 2002) and further research is needed into the potential benefits of dietary sources of CLA. In particular,

investigations are needed to develop an understanding of the molecular action of CLA isomers and their potential use in chronic disease therapy (Nakamura et al., 2008).

In addition, a significant portion of the lipids in lean meat are in the form of phosopholipids which are a source of choline, which contributes to normal homocysteine and fat metabolism.

3.2 Protein

Red meat is an excellent source of high biological value protein; the protein is highly digestible and provides all essential amino acids (lysine, threonine, methionine, phenylalanine, tryptophan, leucine, isoleucine and valine) with no limiting amino acids (Williams, 2007). A 100g portion of cooked lean beef or lamb provides around 25-30g of protein (see Table 1).

On average, beef and veal contribute 7.8% to protein intakes in New Zealand, lamb and mutton contribute 2% (University of Otago & Ministry of Health, 2011).

Diets with as little as 10% energy from protein are adequate to meet basic protein requirements, but intakes above 15% energy from protein appear to be required for ensuring adequate intakes of micronutrients.

Evidence is accumulating that increasing intake of high quality protein to a level above the recommended intake may be beneficial during weight loss (see section 8.3). However, an upper limit of 25% energy from protein has been suggested until more is known about the long-term effects of a high-protein diet (NHMRC, 2006).

3.3. Micronutrients

3.3.1. Iron

Iron is needed for the production of a number of proteins in the body, including haemoglobin, myoglobin, cytochromes and enzymes involved in redox reactions. Iron is also important for early brain development and for supporting a healthy immune system.

Iron is present in food in two forms – haem and non-haem. Haem iron (found in meat and fish) is more bioavailable than non-haem iron, with conservative estimates that 25% is absorbed (Hallberg & Rossander-Hulthen, 1991). Non-haem iron (found in meat, legumes, nuts, cereals, some fruits and dark green vegetables such as spinach) is less bioavailable and absorption is influenced by other dietary components. For example, foods containing vitamin C can increase absorption of non-haem iron. In contrast, foods containing phytates (found in legumes and wholegrain cereals) can inhibit non-haem iron absorption. Absorption of iron from vegetarian diets has been estimated to be around 10% (Institute of Medicine Panel on Micronutrients, 2001) and it has been suggested there can be a 10-fold difference in the absorption of iron from different meals with a similar iron content (Hallberg & Hulthen, 2000). Absorption of iron is about 18% from a mixed diet, so iron requirements for vegetarians, who rely on non-haem sources, will be about 80% higher than for those who eat meat (NHMRC, 2006).

Beef and lamb are among the richest sources of bioavailable iron in the diet and, in addition, meat enhances the absorption of non-haem iron from foods eaten at the same time. The nature of the enhancing effect is thought to be related primarily to the muscle proteins (Hurrell et al., 2006). In New Zealand, beef and veal have been found to contribute 7% to our total iron intake and lamb and mutton provide a further 1.5% (University of Otago & Ministry of Health, 2011). The actual contribution of meat to iron intake is much greater, however, owing to the higher proportion of iron absorbed.

Inadequate intakes of iron can lead to varying degrees of deficiency; from low iron stores (indicated by low serum ferritin and reduced iron-binding capacity) to iron-deficiency anaemia (low haemoglobin and haematocrit as well as reduced mean corpuscular haemoglobin and volume) (NHMRC, 2006). The recommended intake of iron in different population groups is shown in Table 3.

Iron deficiency is the most common and widespread nutritional disorder in the world. As well as affecting a large number of children and women in developing countries, it is one of only a few nutrient deficiencies which are also significantly prevalent in developed countries such as New Zealand. The numbers are staggering: 2 billion people – over 30% of the world's population – are anaemic (WHO, 2012), with a substantial proportion of these anaemias resulting from iron deficiency.

The adverse effects of iron deficiency anaemia include poor cognitive development, fatigue, reduced tolerance to work, and decreased aerobic capacity. Iron deficiency anaemia can also have an impact on behaviour. In infants, iron deficiency anaemia has been associated with maintaining closer contact with caregivers, showing less pleasure and delight, being more wary, hesitant and easily tired, being less attentive to instructions and being less playful (Lozoff et al., 1998). Severe, chronic iron deficiency anaemia in infancy has also been associated with reduced mental and motor functioning, and continued developmental and behavioural risk more than 10 years after iron treatment (Lozoff et al., 2000).

Approximately 4% (Soh et al., 2004) to 6% (Grant et al., 2007b) of infants and toddlers in New Zealand have iron deficiency anaemia. However, non-anaemic iron deficiency is considerably more common than iron deficiency anaemia in New Zealand infants and young children (Soh et al., 2004), and may be associated with subtle negative effects on cognitive function and fatigue, as well as an increased risk of developing iron deficiency anaemia if the infant is exposed to a physiological challenge such as rapid growth, infection, or injury.

A study in Auckland children aged 6-24 months found 14% were iron deficient, with the occurrence among Māori and Pacific Island children even higher at 20% and 17% respectively (Grant et al., 2007b). Iron intake was less than the estimated average requirement (EAR) for 25% of the infants. Not meeting the EAR increased the risk of iron deficiency for children aged 6-11 months (relative risk (RR) = 18.45, 95% confidence interval [CI]: 3.24-100.00) and 12-23 months (RR = 4.95, 95% CI: 1.59-15.41). In comparison with New Zealand Europeans, Pacific children had a greater daily iron intake ($p = 0.04$) and obtained a larger proportion of iron from meat and meat dishes ($p = 0.02$) (Wall et al., 2008).

Iron requirements in the first year of life are greater than at any other time due to rapid growth and blood volume expansion (Grant et al., 2007a). The depletion of iron stores accrued in utero, and increased demands for growth, mean that after six months of age infants depend on complementary foods to provide iron (Ministry of Health, 2008a). Meat has been found to play an important role as a complementary food. For example, the addition of powdered red meat to a weaning gruel has been shown to markedly increase total iron absorption (Hallberg et al., 2003). Puréed meat can be introduced once an infant is 6 months of age. Given the risk of iron deficiency in infants and young children, it has been suggested public health campaigns should encourage adequate meat intake to help reduce the problem (Mira et al., 1996).

The importance of both meat and fortified milk for providing iron in the diets of toddlers was demonstrated in a New Zealand trial. The trial assessed the effect of increased red meat consumption, or the use of iron-fortified milk, for improving iron status in healthy non-anaemic toddlers aged 12-20 months (Szymlek-Gay et al., 2009). In this 20 week randomised placebo-controlled trial, toddlers were assigned to either a red meat group (encouraged to consume approximately 2.6mg iron from red meat dishes daily), a fortified milk group (toddlers' regular milk was replaced with iron-fortified milk containing 1.5mg iron per 100mls) or a control group (toddlers' regular milk was replaced with a non-iron-fortified milk containing 0.01mg iron per 100mls). Whereas serum ferritin tended to decrease in the control group, it increased by 44% in the fortified milk group, and did not change in the red meat group. The authors concluded that iron-fortified milk can increase iron stores in healthy non-anaemic toddlers and red meat can prevent their decline (Szymlek-Gay, 2009).

Iron deficiency is also prevalent in Auckland high school students (Schaaf et al., 2000), particularly in girls, where iron deficiency and anaemia were each ten times more common (9.6% and 8.7% respectively) than in boys (0.8% and 0.7%). In females, iron deficiency was two to three times more common and anaemia was three to four times more common in Māori, Pacific Island and Asian adolescents compared with Europeans. Iron deficiency in this study was defined as any two or more of the following: serum ferritin less than 12 µg/L, iron saturation less than 14%, or red cell distribution width greater than 14.5%. Anaemia was defined as haemoglobin less than 120g/L for females and less than 130g/L for males. The level of iron deficiency and anaemia in this study was higher than that reported in an earlier Dunedin longitudinal survey (Fawcett et al., 1998), which found the prevalence of iron deficiency (ferritin less than 12 µg/L) at age 21 was 0.24% in men and 6.7% in women. The higher prevalence in the Auckland study is likely to be due to the different age group studied; adolescent girls have higher requirements for iron due to growth super-imposed on menstrual losses.

Concern has also been expressed in relation to the sub-optimal iron status of women of childbearing age in New Zealand. One study (Ferguson et al., 2001) estimated that the prevalence of sub-optimal iron status among 15-49 year old women was between 7% (serum ferritin less than 12 µg/L) and 13% (serum ferritin less than 16 µg/L). The authors stated that this situation is unacceptable given the negative consequences of even mild iron deficiency. The latest New Zealand Adult Nutrition Survey found that from 1997 to 2008/09 the prevalence of iron deficiency in females had increased from 2.9% to 7.2%. After adjusting for age and ethnicity, there was also an increase in the prevalence of low iron stores in females (University of Otago & Ministry of Health,

2011). For certain high-risk sub-groups (for example vegetarians, athletes, pregnant women, Pacific people and Māori), the prevalence of iron deficiency and iron deficiency anaemia is often much higher (Gibson et al., 2002).

A further study in premenopausal women in Auckland showed that, for women who had children, following a dietary pattern that was higher in meat and vegetables was associated with a 25% lower risk of sub-optimal iron status (Beck et al., 2014).

Pregnant women in particular are vulnerable to iron deficiency, as requirements are significantly increased to meet the needs of the growing foetus as well as increased maternal blood volume. An iron-rich diet, which includes the regular consumption of red meat, chicken and fish, has been recommended (Grant et al., 2007a). Non-haem sources of iron such as grains, cereals, legumes and eggs should also be encouraged along with foods containing vitamin C to enhance absorption.

Table 3: Recommended daily intakes for iron in New Zealand

Population Group	RDI* (mg/day)
Infants (0-6 months)[+]	0.2 (AI**)
Infants (7-12 months)	11
Children (1-3 years)	9
Children (4-8)	10
Children (9-13)	8
Boys (14-18 years)	11
Girls (14-18 years)	15
Women (19-50 years)	18
Pregnant women	27
Breastfeeding women[++]	9-10
Women over 50 years	8
Men over 19 years	8

*RDI is the Recommended Dietary Intake (the average daily dietary intake level sufficient to meet the nutrient requirements of nearly all (97-98%) healthy individuals in a particular life stage and gender group).
**AI is the Adequate Intake, used when an RDI cannot be determined.
[+] Amount normally received from breast milk.
[++] Assumes menstruation does not resume until after 6 months of breastfeeding.

Source: NHMRC, 2006

In cases of iron deficiency anaemia, iron supplementation is accepted as the most appropriate method of treatment. However, a New Zealand study investigated whether dietary treatment of non-anaemic iron deficiency could improve iron status in pre-menopausal Dunedin women. The study found that dietary intervention involving increased intakes of both haem iron (from flesh food) and enhancers of iron absorption (such as vitamin C), along with a decrease in intake of inhibitors of iron absorption (such as phytic acid), may improve the iron status of pre-menopausal women with low iron stores (Heath et al., 2001). Although the changes in iron status were less with dietary intervention than with supplements, in motivated women with low iron stores, dietary intervention may be an appropriate first-line treatment as long as they are monitored to ensure the treatment has been effective.

Prevention and treatment of iron deficiency among vulnerable groups within New Zealand is an important public health issue. In particular, we need to ensure optimal

intakes of iron among groups such as infants, children, adolescents and pregnant women.

3.3.2. Zinc

Zinc is a component of various enzymes that help maintain the structural integrity of proteins and regulate gene expression (NHMRC, 2006). It is also known to play a central role in the immune system, with zinc deprivation leading to an increased susceptibility to pathogens because of impaired immune response (Shankar & Prasad, 1998). Zinc deficiency can also lead to impaired growth and adverse pregnancy outcomes (NHMRC, 2006).

Those at increased risk of zinc deficiency include older people, vegetarians and people with renal insufficiency (Ibs & Rink, 2003). Zinc deficiency has also been found among New Zealand school children; the 2002 Children's Nutrition Survey (Parnell et al, 2003) found 16% of children had low serum zinc concentrations (21% of males and 10% of females).

Further analysis of data from the 2002 Children's Nutrition Survey by Gibson et al. (2011) found that among Pacific children aged 5-15 years, the prevalence of low serum zinc concentrations was 21%, compared with 16% of Māori children and 15% of European children. In this study, children derived 23% of their zinc intakes from meat, poultry and fish.

It has been suggested that pre-school children may be at even higher risk of zinc deficiency. A recent intervention study found that at baseline 38% of toddlers (12-20 months of age) had low serum zinc concentrations despite seemingly adequate zinc intakes (Morgan et al., 2010). However, researchers in this study found that providing either red meat or fortified milk did not improve zinc status despite increasing zinc intakes.

New Zealand women have also been found to be at risk of zinc deficiency. A study into the zinc status of pre-menopausal Dunedin women found zinc status was lower than had been found in earlier studies (Gibson et al., 2001). It is suggested that changes over time in food selection patterns may account for this change. An example would be the decline in consumption of flesh foods – specifically beef and lamb, which are rich sources of bioavailable zinc. Certainly, in this study, the women who included red meat in their diet had a superior biochemical zinc status to that of those who avoided eating red meat.

The recent New Zealand Adult Nutrition Survey 2008/09 estimated that the prevalence of inadequate zinc intake was 24.7% (males 39.1%, females 11.2%). The highest prevalence was among older males aged 71+ years (89.7%) although these data should be interpreted with caution as the EAR may be set too high, and biochemical zinc status was not determined (University of Otago & Ministry of Health, 2011). An earlier study into the zinc status of Dunedin women aged 70 to 80 years old found 12% had low serum zinc levels (de Jong et al., 2001) and the authors concluded that promotion of nutrient-dense foods or trace element supplements for New Zealand seniors should be considered.

Although zinc is widely distributed in foods, meat, fish and poultry are major contributors, with cereals and dairy foods also providing substantial amounts (NHMRC, 2006). Beef and lamb in particular are among the richest dietary sources of zinc, with a 100g portion providing at least a quarter of adult requirements (see Table 1).

3.3.3. Selenium

Selenium is an integral part of glutathione peroxidase, an enzyme that protects against oxidative damage (NHMRC, 2006). Selenium is also important for the production of other key selenoproteins such as iodothyronine deiodinase (Arthur et al., 1999). Dietary selenium is essential for the efficient operation of many aspects of the immune system (Arthur et al., 2003; Broome et al., 2004) and for optimal thyroid hormone metabolism (Arthur et al., 1999). It may also be anti-carcinogenic (Combs, 2005). Intakes of selenium higher than the recommended intake may be required for protection against cancer and may have other health benefits. However, there is an urgent need for more large scale trials to assess any such beneficial effects and to estimate the level of selenium intake that is protective (Thomson, 2004a).

Overt deficiency of selenium in humans is rare but is seen as Keshan disease, an endemic cardiomyopathy in adolescent or pre-adolescent years in low selenium areas of China (Yang et al., 1988). More marginal deficiency may contribute to reduced immune function, some cancers and viral diseases (Broome et al., 2004).

The New Zealand Adult Nutrition Survey 2008/09 (University of Otago & Ministry of Health, 2011) found that among adults, selenium is provided by fish and seafood (11.6%), bread (15.1%), poultry (9.6%) and meat and meat products (15.1%). Analysis of data from the 2002 Children's Nutrition Survey showed that among children aged 5-14 years, selenium was provided by bread and grains (33%), meat (14.8%), poultry (11.2%), and fish and seafood (8.6%) (Thomson et al., 2007).

Regional differences in selenium intake in New Zealand were observed in the Children's National Nutrition Survey (Thomson et al., 2007). Analysis of the selenium status of children aged 5-14 years showed children in the upper North Island had mean serum selenium concentrations higher than those in the lower North Island and South Island. Younger children had lower selenium intakes than older children (Thomson et al., 2007). These differences have been partly attributed to the different levels of selenium found in bread, since the selenium content of bread is lower in the South Island than the North Island where higher selenium wheat from Australia is used. Another reason for the differences is the high fish and poultry intakes of Pacific children, of whom there was a higher proportion in the north of the North Island (60%) compared with the lower North Island (18%) and the South Island (11%). As a whole, our children fall in the middle of the range of international serum selenium concentrations. However, the selenium status of South Island children is among the lowest values reported internationally (Thomson et al., 2007).

Pregnant and breastfeeding women may be at risk of low selenium concentrations due to the increased selenium demands of the growing foetus and the increased demands of lactation. In addition, infancy is a vulnerable time, with rapid growth and development also leading to increased selenium requirements. A study of South Island

children, aged 6-24 months, and their mothers, found dietary selenium intakes were below recommended levels (McLachlan et al., 2004) with intakes of 7.9 ± 6.2 µg/d in infants; 13.7 ± 8.4 µg/d in toddlers and 38 ± 25 µg/d in mothers. The low intakes were reflected in blood selenium concentrations, which were at the lower end of international levels. The authors recommend dietary strategies to improve selenium intakes are implemented, for example, the inclusion of selenium-rich foods such as fish, meat and unrefined cereals.

The last New Zealand Adult Nutrition Survey 2008/09 estimated that the prevalence of inadequate selenium intake was 45% (males 32%, females 58%). Females aged 15-18 years had a consistently high prevalence of inadequate intakes (over 70%) across all ethnic groups (University of Otago & Ministry of Health, 2011).

Overall, the selenium status of the New Zealand population has been increasing and continues to do so. This is due in part to some extent to the increase in selenium concentration of meat, but also to the increase in contribution of imported foods to our diet (Thomson, 2004).

3.3.4. Vitamin A

Vitamin A is a fat-soluble vitamin, which helps maintain normal reproduction, vision and immune function (NHMRC, 2006). The term vitamin A includes retinol from animal sources, and pro-vitamin A carotenoids, such as beta-carotene, which are precursors of vitamin A.

In New Zealand, 17.2% of the population have been found to have inadequate intakes of Vitamin A, with a higher prevalence among younger people aged 15-18 years; 37.5% of males and 27.4% of females (University of Otago & Ministry of Health, 2011). Lower intakes of beta-carotene among younger people contributed to their inadequate intakes.

Carcass meat contains little vitamin A, but liver is a particularly good source of this vitamin in the form of retinol. Chronic intake of large amounts of retinol over time can be toxic and pregnant women should limit their intake of liver as vitamin A can be teratogenic (ie can cause defects in the growing foetus). In some countries, pregnant women are advised to avoid liver altogether; however, in New Zealand, animal feeding practices are different and levels of vitamin A in liver are likely to be lower. The Ministry of Health in New Zealand advises up to 100g of liver may be consumed per week during pregnancy, although liver pâté is not recommended as there is a risk of food-borne illness such as listeriosis (Ministry of Health, 2006a). No more than 10g of liver or pâté per week should be offered to infants and toddlers (Ministry of Health, 2008).

3.3.5. B Vitamins

Red meat is an excellent source of vitamin B_{12}, which is only found naturally in foods of animal and microbial origin. Throughout life, the dietary supply of vitamin B_{12} and other methyl donors are essential for normal growth, development and function and is an essential nutrient for one carbon metabolic pathways. It is key for protein, fat and carbohydrate metabolism including the synthesis of fatty acids in myelin in the

nervous system, and the synthesis and stability of deoxyribose nucleic acid conjunction with folate, for DNA synthesis (Stabler et al., 2013; Rush et al., 2014). Ensuring an adequate intake of vitamin B_{12} particularly in pregnancy and lactation is essential for optimising health of the offspring. A 100g portion of cooked beef or lamb provides almost the entire daily requirement for vitamin B_{12} (see Table 1). For vegans, who avoid all animal products, fortified foods or supplements will be necessary to provide adequate B_{12} (see section 4).

A 100g serving of beef or lamb also provides around half the daily requirement for niacin, along with some thiamine, riboflavin and vitamin B_6, as shown in Table 1. These B vitamins are important for numerous metabolic functions in the body, particularly, as their respective co-enzyme forms, in energy metabolism.

3.3.6. Vitamin D

The main function of vitamin D is to help maintain plasma calcium concentrations by enhancing the absorption of calcium in the small intestine and controlling urinary losses. Over the past decade, deficiency of this vitamin has been associated with higher risk of multiple sclerosis and poorer immune function (Harandi et al, 2014) and prevention of diabetes (Harinarayan, 2014) and some cancers (Ananthakrishnan et al, 2014).

Vitamin D status is generally maintained by the exposure of skin to sunlight. Where exposure to sunlight is inadequate, dietary sources of vitamin D become important. Sub-optimal vitamin D status is associated with low bone mineral density and the risk of osteoporosis later in life (Holick & Chen, 2008).

A high prevalence of vitamin D insufficiency was found in an analysis of the 2002 National Children's Nutrition Survey; with 4% of New Zealand children aged 5-14 years vitamin D deficient (<17.5nmol/L) and 31% vitamin D insufficient (<37.5nmol/L) (Rockell et al., 2005). The children studied had a mean serum 25-hydroxyvitamin D concentration of 50nmol/L, with mean concentrations in sub-groups ranging from 32nmol/L in Pacific girls aged 11-14 years, to 62nmol/L in New Zealand European and other boys aged 5-6 years. Children of Māori and Pacific ethnicity may be at particular risk of low vitamin D status because of low vitamin D intakes, New Zealand's high latitude (35-47ºS) and skin colour (Rockell et al., 2005).

New Zealand adolescents and adults have also been found to be at risk of vitamin D insufficiency (Rockell et al., 2006). Analysis of serum 25-hydroxyvitamin D levels using data from the 2008/09 New Zealand Adult Nutrition Survey found 4.9% were vitamin D deficient (<25nmol/L) including 0.2% with severe deficiency (<12.5nmol/L), and one in four adults (27.1%) were below the recommended level of vitamin D, but did not have vitamin D deficiency. The prevalence of vitamin D insufficiency was higher among Pacific adults who were 2.3 times as likely to have vitamin D deficiency as non-Pacific adults.

A study of elderly Dunedin women also found vitamin D deficiency was common, particularly in women over 70 years of age, who had a high bone fracture risk (McAuley et al., 1997). Deficiency was most marked in winter months.

Red meat provides vitamin D. A study into the vitamin D content of beef and lamb found them to be a source of both vitamin D_3 and its active metabolite 25-hydroxyvitamin D_3 (Purchas et al., 2007). 25-hydroxyvitamin D_3 is suggested to have 1.5 to 5 times the activity of vitamin D_3, and the authors of this study estimate (assuming 1µg of 25-hydroxyvitamin D_3 is equivalent to 3µg of vitamin D_3) that, on average, 100g of beef strip loin would contain 1.2µg of total vitamin D_3 and 100g of cooked lamb leg steak would contain 2.6µg.

Current FoodFILES data shows an average of 0.14ug/100g vitamin D3 for lean, raw beef cuts and 0.04ug/100g vitamin D3 for lean, raw lamb cuts (Sivakumaran et al; 2014).

Although this is a small amount compared to the amount needed (adequate intake of 5-10ug/day in adults under 70 years) to improve the vitamin D status of New Zealanders to optimal levels, there is some interest in determining whether meat has a role to play in providing vitamin D. A study by Crowe et al (2011) for example, found that plasma 25 (OH) D_3 concentrations were lower in vegetarians and vegans than in meat and fish eaters. These results do need confirmation through further research (Glossmann, 2011), particularly as the vitamin D content of meat may be variable and dependant on the animal feed and exposure of the animal to sunlight.

3.3 Bioactive substances

In addition to the essential nutrients, meat also provides a number of bioactive substances (Williams, 2007). Meat is a rich source of taurine, an amino acid that may be important during lactation and times of immune challenge, and may offer protection against oxidative stress. Meat also provides carnitine, which transports long chain fatty acids across the inner mitochondrial membranes to produce energy during exercise; requirements for carnitine may be increased in pregnancy and after strenuous exercise. Red meat is the principle human dietary source of creatine, which plays a role in energy metabolism. Meat is also a source of a number of endogenous antioxidants, for example ubiquinone, glutathione, lipoic acid, spermine, carnosine and anserine.

4. Nutritional implications of a meatless diet

A diet that excludes meat can be nutritionally adequate, but if an increasing number of foods are excluded it becomes important to plan the diet carefully to ensure nutrient needs are met. Intakes of iron, zinc and vitamin B_{12} need careful consideration – especially for vegans.

Vitamin B_{12} is of notable concern as it is only found naturally in foods of animal origin (see section 3.3.5). South Asian vegetarian women living in New Zealand have been found to have low serum B_{12} status (Gammon et al., 2012) and research into pre-adolescent Indian migrant girls in New Zealand has shown asymptomatic B_{12} deficiency (Rush et al., 2009).

Vegans are at particular risk of deficiency (Mann et al., 1999) as all animal foods are excluded from the diet. Among adults, a diet devoid of vitamin B_{12} may not lead to symptoms of deficiency for many years as most of us have significant body stores. In contrast, newborn infants have only small body stores and breastfed infants of unsupplemented vegan mothers may be at particular risk. One case study, for example, found a 14-month old boy who was exclusively breastfeed until 9 months of age had severe vitamin B_{12} deficiency caused by his mother's, presumably unsupplemented, vegan diet. Supplemental B_{12} rapidly improved haematological and neurological symptoms, although cognitive and language development remained seriously delayed at the age of two years (von Schenck, 1997).

Vegan mothers who are breastfeeding need to ensure an adequate intake of vitamin B_{12} and it is advised they supplement their diet to the recommended level during pregnancy and lactation (NHMRC, 2006). For vegan infants who are not breastfed, an appropriate soy-based infant formula should be used. Once a vegan infant has started to consume complementary foods, it is important to ensure a daily intake of vitamin B_{12}, with fortified foods or a supplement (Ministry of Health, 2008a).

Diets that exclude animal foods also have the potential to have low iron and zinc bioavailability. Eliminating meat, along with increasing intake of phytate-containing legumes and whole grains, reduces the absorption of both iron and zinc (Hunt, 2003) and a higher intake of these nutrients will be required in order to meet nutritional requirements. Vegetarians need iron intakes about 80% higher than non-vegetarians (NHMRC, 2006), and zinc intakes about 50% higher – particularly vegans (Hunt, 2003; NHMRC, 2006).

5. Food and Nutrition Guidelines in New Zealand

The majority of New Zealanders consume meat, and as meat is such a nutrient-dense food it can be particularly useful in the diets of population groups with high nutrient needs. It is recommended we include 1-2 servings a day of iron-containing foods in our diet. For recommended serving sizes, see Table 4.

5.1. Infants and toddlers

Lean meat can make an important contribution to the diets of infants and toddlers, providing protein, vitamins and minerals, in particular iron and zinc, which are present in a highly bioavailable form (see sections 3.3.1 and 3.3.2). Once an infant is around six months of age, puréed meat can be added to the diet with finely chopped, tender meat being introduced as swallowing develops (Ministry of Health, 2008a). Iron-fortified infant cereals can be introduced from 6 months and foods containing vitamin C (eg fruits and vegetables) should be offered with meals and snacks, to assist in non-haem iron absorption. If an infant is not breast-fed, it is important to use an iron-fortified infant formula until 12 months of age. Foods containing iron inhibitors such as tea and coffee should be avoided by young children. Overall, it is important to offer a wide variety of foods from the different food groups to ensure nutritional needs are met during this period of rapid growth and development.

5.2 Children and young people (2-18 years old)

Nutritional needs are highest during rapid growth, for example during early childhood and during the adolescent growth spurt; iron needs are particularly high in menstruating girls (Ministry of Health, 2012).

Ensuring optimal iron and zinc intake remains important among children and young people. New Zealand adolescent girls, especially those of Māori or Pacific ethnicity are at greatest risk of iron deficiency anaemia; young children may also be at risk.

To ensure adequate iron intakes, it is recommended animal foods should be included in the diet, for example meat, poultry, fish and seafood along with plant foods such as breads, cereals vegetables, legumes, nuts and fruit which provide non-haem iron. Eating foods rich in vitamin C will help to enhance absorption of non-haem iron; children and young people should also avoid drinking tea with meals. At least 1-2 servings a day of iron-containing foods should be provided in the diets of children and young people. Lean meat, poultry, fish and shellfish are also good bioavailable sources of zinc (Ministry of Health, 2012).

5.3. Healthy adults

The Ministry of Health's *Food and Nutrition Guidelines for Healthy Adults* recommends maintaining a healthy weight, eating well, and being physically active every day. A variety of foods from the four main food groups should also be included daily (vegetables and fruits; breads and cereals; milk and milk products; and lean meat, poultry, seafood, eggs or alternatives). In addition, we are advised to choose foods with minimal fat, sugar and salt, to drink plenty of liquids (especially water) and to limit alcohol intake (Ministry of Health, 2003b). At least one serving a day is recommended from the meat and alternatives group to provide protein, B vitamins, iron, zinc, magnesium, copper, potassium, phosphorus and selenium.

5.4. Pregnant and breastfeeding women

Iron requirements increase significantly during pregnancy (see Table 3). However, routine iron supplements are not recommended in New Zealand as the proportion of iron absorbed from food increases in response to the increased need. They should only be given after diagnosis of iron deficiency anaemia. Iron requirements during breastfeeding are substantially lower than in pregnancy while women are not menstruating.

To ensure adequate iron intake among pregnant and breastfeeding women, dietary strategies should include consumption of at least two servings of iron-containing foods a day (Ministry of Health, 2006a). Beef and lamb can make a particularly useful contribution to intakes of iron as they are rich sources of bioavailable iron. Other sources of iron are poultry, seafood, eggs, nuts and seeds, and legumes. Monitoring of iron status throughout pregnancy is important to identify current or potential iron deficiency and all women should receive advice on dietary sources of iron and factors affecting iron absorption, in order to avoid iron deficiency. Pregnant vegetarian and vegan women may find it difficult to meet iron requirements and should be encouraged to consume plenty of iron-containing plant-based foods along with foods rich in vitamin C and to have blood levels of iron checked regularly.

Pregnant and breastfeeding women should be advised to consume a variety of nutritious foods from the main food groups to ensure adequate nutritional status.

5.5. Older people

Among older people in New Zealand (aged 65 years and older) nutrition deserves special attention as good nutrition is essential for good health and can prevent malnutrition, support physical function, reduce the risk of chronic disease, support mental health and prevent disability.

Older people should include a variety of foods in the diet from the main food groups and should drink plenty of fluids each day; in addition, at least 30 minutes of physical activity is recommended on most days of the week (Ministry of Health, 2013a). It is recommended older people have at least one serving a day of iron-containing foods, such as lean meat, skinless chicken, seafood, eggs and legumes.

There is a growing area of New Zealand research to address the issue of the difficulty of chewing meat in older adults, and subsequent reduced energy intake.

Table 4: Recommended serving sizes for meat and alternatives

Serving size for lean meat, chicken, seafood, eggs, legumes
2 slices (100g) cooked meat
¾ cup (195g) mince or casserole
1 egg (50g)
1 medium fillet of cooked fish (100g)
1 medium steak (120g)
¾ cup (135g) cooked dried beans
2 drumsticks or 1 chicken leg (110g)

Source: Ministry of Health, 2003b

6. Eating patterns of New Zealanders

Two significant national nutrition surveys carried out in New Zealand provide a comprehensive picture of New Zealanders' eating patterns. The 2008/09 New Zealand Adult Nutrition Survey, *A Focus on Nutrition* (University of Otago & Ministry of Health, 2011), studied New Zealanders aged 15 years and older. This survey updates the 1997 survey *NZ Food: NZ People* (Russell et al., 1999). The 2002 survey, *NZ Food NZ Children* (Parnell et al., 2003) looked at New Zealand children aged 5 to 14 years.

In the Adult Nutrition Survey (2008/09), most of the population (94.5%) reported eating red meat in the previous four weeks, with red meat eaten 1-2 times per week by 30.1% and 3-4 times per week by 45.4%. More than half the population trimmed the excess fat from meat regularly or always (University of Otago & Ministry of Health, 2011).

Among children, 95% consume an omnivorous diet, with just 3.6% avoiding red meat and 0.7% avoiding all meat (Parnell et al., 2003). Meat makes a valuable contribution to the intake of a range of nutrients for many New Zealanders (see section 3).

7. Are current recommendations for meat intake adequate?

Overall, the Ministry of Health's food and nutrition guidelines suggest 1-2 portions per day should be eaten from the meat and alternatives food group. However, in order to optimise health and prevent chronic disease, recommendations on the number of servings consumed from the meat and alternatives food group may need to be reviewed. Dietary modelling in Australia (NHMRC 2011) demonstrated the most limiting nutrient of the 10 nutrients modelled in the low energy Omnivore Foundation Diets was iron. The dietary models developed were unable to provide sufficient iron to fulfil the estimated requirements of pregnant females as a group.

Legumes, nuts and seeds certainly provide valuable nutrients and should be included in a balanced diet, but these foods are not direct substitutes for foods of animal origin in terms of the nutrients they provide. The recommended number of servings from the meat and alternatives group, along with the serving sizes, may need to be reconsidered and recommendations in relation to legumes, nuts and seeds as alternatives to meat may need to be revised.

Specific and separate advice and recommendations may be needed for lacto-vegetarians and vegans to ensure their nutritional requirements are met. However, the total combination of foods consumed over time is a more important consideration than the intake of individual foods, so further research and analysis of this issue is warranted before firm recommendations can be made.

8. The role of red meat in health and disease

Meat consumption has been linked to a number of diseases, most notably cancer and heart disease. Research on heart disease and cancer is reviewed in sections 8.1.1 and 8.1.2.

Research evaluating the role of high-protein diets in promoting satiety and aiding weight loss is reviewed in section 8.3. Red meat is an excellent source of protein (see section 3.2) and could make a valuable contribution to protein intakes (along with other protein foods). This may be helpful for those managing their weight. The effects of a diet high in protein have also been evaluated in those with Type 2 diabetes and insulin resistance, with initial results showing such diets may be helpful (see section 8.4).

Emerging research suggests that red meat may also play a role supporting optimal mental health. Specific analysis of red meat in relation to mood and anxiety disorders among women has shown that those consuming less than the recommended intake of red meat are at increased risk of depression, although more research is needed in this area to confirm which dietary strategies support optimal mental health (see section 8.5).

The role of meat in health and disease has been evaluated in a number of studies, which are outlined below.

8.1. Coronary heart disease (CHD)

8.1.1 Dietary fats and coronary heart disease

A Cochrane review on modifying dietary fat intakes for preventing cardiovascular disease concluded that replacing saturated fats with plant oils and unsaturated spreads may reduce risk of heart and vascular disease, although it was not clear whether monounsaturated or polyunsaturated fats are more beneficial (Hooper et al., 2012).

More recent research has questioned whether a higher consumption of polyunsaturated fats and a lower consumption of saturated fats should be encouraged, and suggests this approach is not supported by recent evidence (Chowdhury et al., 2014; Schwingshackl & Hoffmann, 2014; Calder, 2013; Ramsden et al., 2013; Ravnskov et al., 2014; Thornley et al., 2014). However, the meta-analysis of dietary fatty acids and risk of coronary heart disease by Chowdhury et al. (2014), which reports no significant association betweem CHD outcomes and intakes of SFA, MUFA and both *n-3* PUFA and *n-6* PUFA has been highly criticised. Experts claim it contains multiple errors and omissions, and the conclusions are seriously misleading (Willett et al., 2014).

There have been a number of systematic reviews that have supported a reduction in intake of saturated fats; for example a pooled analysis of 11 prospective cohort studies by Jakobsen et al in 2009 found that substituting 5% of energy from saturated fats with 5% of energy from polyunsaturated fats was associated with a significant reduction in CHD events. MUFA was not associated with CHD in this review. A further review by Mozaffarian et al in 2010, which was a meta-analysis of 8 randomised controlled trials, also found that replacing saturated fats with polyunsaturated fats reduced CHD events. Further, a recent New Zealand review of the highest quality systematic reviews suggests that replacing 5% of daily energy consumed as saturated fat with polyunsaturated fats would reduce ischaemic heart disease events by about 10% and that such a dietary change would be desirable and feasible for the New Zealand population (Foster & Wilson, 2013). There are no benefits in replacing saturated fats with refined starches, especially sugar (Hooper et al., 2012; Lawrence, 2013; Te Morenga et al., 2014a, Te Morenga et al., 2014b).

Experts in New Zealand have recently reviewed the available literature and conclude that numerous high quality experimental trials have provided unequivocal evidence that dietary saturated fat raises serum cholesterol levels when compared with polyunsaturated and monounsaturated fats (Te Morenga et al., 2014a).

The New Zealand Heart Foundation recommends replacing foods high in saturated fat with unsaturated fats (Gorton, 2014). The Heart Foundation advises that a diet of mostly minimally processed foods (including plenty of vegetables and fruit; plus legumes, nuts, whole grains, plant oils, and fish; as well as choosing lean meats and reduced-fat dairy) is the best way of eating for a healthy heart. Dietitians New Zealand considers there not to be any substantive evidence that saturated fat is good for you in the long term (Dietitians New Zealand, 2014). It has been suggested that

saturated fats be replaced with more *n-3* polyunsaturated fatty acids. (Te Morenga et al., 2014a).

It is appropriate to regularly review nutrition recommendations in the light of new evidence; however, the best quality evidence at the present time supports current advice to reduce intake of SFA (Te Morenga et al., 2014b).

8.1.2 Meat and coronary heart disease

Health messages specifically in relation to meat can be confusing and misleading (Li et al., 2005) and advice to reduce red meat as part of a heart-healthy diet is inappropriate. A number of studies have shown lean red meat can be included in a heart-healthy diet as it is low in total fat and saturated fatty acids.

8.1.2.1. The role of lean meat in cholesterol-lowering diets

A study aiming to differentiate between lean beef and beef fat as risk factors for elevated plasma cholesterol, found total cholesterol concentrations fell significantly within one week of commencing a low-fat diet that included lean beef, and rose as beef dripping was added in a stepwise manner (O'Dea et al., 1990). This demonstrates clearly it is the beef fat and not the lean beef that is associated with elevations in cholesterol levels and shows lean beef can be part of a cholesterol-lowering diet. A further study, which looked at dietary determinants of ischaemic heart disease (IHD) in health conscious individuals, concluded that dietary saturated animal fat and cholesterol are important in the aetiology of IHD (Mann et al., 1997a). These factors, rather than simply meat, appeared to explain the higher IHD rates reported in meat eaters compared with vegetarians.

Substituting poultry for lean red meat is unlikely to have any effect on total or LDL cholesterol levels. A randomised controlled trial among hypercholesterolaemic free-living men and women comparing lean red meat with lean white meat found both produced similar reductions in LDL cholesterol and elevations in HDL cholesterol (Davidson et al., 1999). A further randomised cross-over study, with two 36-week phases separated by a 4-week washout period, compared the effects of lean red meat and poultry in reducing cholesterol in people with hypercholesterolaemia (Hunninghake et al., 2000). Results showed both had an identical effect, with a 1% reduction in total cholesterol and a 2% reduction in LDL cholesterol. In this study, the lean meat was part of a diet providing less than 30% energy from fat and 8-10% energy from saturated fatty acids.

A further study on hypercholesterolaemic men (Beauchesne-Rondeau et al., 2003) found diets containing lean beef or poultry reduced plasma total and LDL cholesterol concentrations by 8% each, with a 5% reduction in the lean fish-containing diet.

Analysis of the diets of adolescent girls also suggests that lean red meat may be included in a healthy diet without unfavourable effects on lipid profiles (Bradlee et al., 2013). Another meta-analysis found that changes in the fasting lipid profile were not significantly different with beef consumption compared with poultry and/or fish consumption (Maki et al., 2012). Including lean beef in the diet increases the variety of food choice and may improve the long-term adherence with dietary recommendations for lipid management, say the authors of this study.

It has been suggested iron can contribute to oxidative stress and inflammation, which are possible risk factors for heart disease and diabetes. One study investigated the effects of lean red meat on markers of oxidative stress and inflammation in humans (Hodgson et al., 2007). Sixty subjects were randomised to either maintain their usual diet, or to partly replace energy from carbohydrate with 200g of lean red meat daily. No elevation of oxidative stress or inflammation was found among the meat-eating group.

A review of 54 studies that looked at meat consumption and CHD risk factors, found substantial evidence that lean meat trimmed of visible fat does not raise blood cholesterol and LDL cholesterol levels (Li et al., 2005), as long as the overall diet is low in total and saturated fat. In fact, the overall effect was diets low in saturated fatty acids, which included lean red meat, were associated with a reduction of LDL cholesterol levels in both hypercholesterolaemic and healthy subjects. Thrombotic risk factors such as thromboxane and prostacyclin production, platelet function and haemostatic factors also remain unchanged with the inclusion of lean red meat (Mann et al., 1997b).

Where lean meat is eaten, there appears to be little difference between meat-eaters and vegetarians in terms of blood lipid levels, as long as the overall diet is low in fat and saturated fatty acids. The Heart Foundation states small or moderate servings of lean meat can be included as part of a normal, varied diet (National Heart Foundation, 1999).

8.1.2.2. Advice on meat in relation to CHD

The New Zealand Guidelines Group (2012) for cardiovascular risk factor management recommends including fish or dried peas, beans and soy products, or a small serving of lean meat or skinned poultry, at one or two meals each day. A serving of meat is 2 slices (100-120g) or half a cup of minced meat (125g). Intake of fatty meat and meat products (eg meat pies, sausage rolls, tinned corned beef and salamis) should be low, and all visible fat should be trimmed from meat before consumption (National Heart Foundation, 1999).

8.2. Cancer

8.2.1. Incidence of colorectal cancer in New Zealand

In 2008, 2,801 people were diagnosed with bowel cancer and 1,280 people died from the disease. Colorectal cancer was the second most common cause of death from cancer in New Zealand, accounting for 15% of all deaths from cancer (Ministry of Health, 2011).

8.2.2. Red meat and colorectal cancer

Some scientific studies have suggested a link between red meat consumption and colorectal cancer and the World Cancer Research Fund report (WCRF, 2007) and the 2011 Continuous Update Project (CUP) Report on Colorectal Cancer concluded red and processed meats are a convincing cause of colorectal cancer based on a substantial amount of data from cohort studies showing a dose-response relationship. However, this remains controversial and the subject of scientific debate. Diet is

remarkably difficult to measure, and the separation of the effects of individual food components is extremely complicated, given the multiple correlations that exist between the different elements (Boyle et al., 2008). The recommendation from the World Cancer Research Fund is to consume up to 500g cooked red meat per week with the average beef and lamb intakes in New Zealand currently sit below this level at around 400g/week. The 2011 CUP report on colorectal cancer confirms the evidence for a protective effect from foods containing dietary fibre has strengthened since the 2007 WCRF report.

Some meta-analyses have found that a high intake of red and processed meat is associated with an increased risk of colorectal cancer. (Sandhu et al., 2001; Norat et al., 2002; Larsson et al., 2006; Chan et al., 2011).

The meta-analysis by Sandhu et al. (2001), found a daily increase of 100g of all meat or red meat was associated with a significant 12-17% increased risk of colorectal cancer. A significant 49% increased risk was found for a daily increase of 25g of processed meat. However, as only a few of the studies reviewed attempted to examine the independent effect of meat intake on colorectal cancer risk, the overall association may have been confounded by other factors.

A further meta-analysis by Norat et al. in 2002 also found a high intake of red meat, and particularly processed meat, was associated with a moderate but significant increase in colorectal cancer risk. Average relative risks and 95% confidence intervals (CI) for the highest quantile of red meat consumption were 1.35 (CI: 1.21-1.51) and for processed meat were 1.31 (CI: 1.13-1.51). No significant association was found for total meat consumption and colorectal cancer risk. The relative risks for total and red meat were higher in studies including processed meat in the definition of these two meat groups, than in studies that evaluated fresh meat and fresh red meat.

Similar results were found in a meta-analysis in 2006 by Larsson et al., which found consumption of red meat and processed meat was positively associated with risk of both colon and rectal cancer. The summary relative risks of colorectal cancer for the highest versus the lowest intake categories were 1.28 (95% CI: 1.15-1.42) for red meat and 1.20 (95% CI: 1.11-1.31) for processed meat.

A more recent meta-analysis (Chan et al., 2011) found the summary relative risk of colorectal cancer for the highest versus the lowest intakes of meat was 1.22 (95% CI = 1.11-1.34). Relative risk for every 100g/day increase was 1.14 (95% CI = 1.04-1.24). The mean values of the highest category of red and processed meat intake in the studies ranged from 46g to 211g per day. The authors conclude that overall evidence supports limiting red and processed meat consumption as one of the dietary recommendations for the prevention of colorectal cancer.

One of the largest studies of diet and health ever undertaken is the European Prospective Investigation into Cancer (EPIC). Results from this study, based on 478,040 men and women, support the hypothesis that colorectal cancer risk is positively associated with intake of red and processed meat (highest intake was over 160g per day, versus the lowest intake which was less than 20g per day) (Norat et al., 2005). The association with colorectal cancer was stronger for processed than for unprocessed red meat.

An expert workshop held in New Zealand in 1999, concluded there is no convincing evidence from published epidemiological studies that moderate intakes of lean red meat increase the risk of colorectal cancer when eaten as part of a mixed diet including carbohydrates, vegetables and fruits, and dairy products (Tasman-Jones et al., 2000).

More recent meta-analyses have shown that associations between red meat consumption and colorectal cancer are generally weak in magnitude, with most relative risks being below 1.5 and not statistically significant, there is also a lack of a clear dose response trend (Alexander & Cushing, 2010; Alexander et al., 2011).

8.2.3. Possible mechanisms linking meat consumption with colorectal cancer

There are a number of possible mechanisms for a link between meat consumption and colorectal cancer; including the promotion of carcinogenesis by high-fat diets, the production of carcinogenic heterocyclic amines (HCAs) and polycyclic aromatic hydrocarbons (PAHs), the promotion of carcinogenesis by haem iron, and the formation of carcinogenic N-nitroso compounds (NOCs) both within meat and endogenously (WCRF, 2007; Baghurst, 2007; Santarelli et al., 2008).

Although fat intake from meat has been suggested to explain a link between colorectal cancer and meat intake, experimental studies show inconsistent results and epidemiological studies have failed to confirm a link (Santarelli et al., 2008). There is now little support for the notion that fat in meat promotes carcinogenesis (Baghurst, 2007). The 2011 WCRF Continuous Update Project (CUP) reports the evidence suggesting that consumption of foods containing animals fats is a cause of colorectal cancer is limited.

HCAs are produced during high-temperature cooking of meat, such as frying and when using a barbecue. Such high cooking temperatures cause amino acids and creatine to react together to form HCAs (WCRF, 2007). PAHs are produced from the incomplete combustion of organic compounds; the main sources are cooked and smoked meat and fish (notably barbecued meat) and tobacco smoke (Santarelli et al., 2008). Around one third of meat consumed on a daily basis in New Zealand is cooked by methods likely to result in the formation of HCAs (Thomson, 1999). However, a recent review of HCAs concluded there is not sufficient scientific evidence to support the hypothesis that human cancer risk is specifically due to the intake of HCAs in the diet (Alaejos et al., 2008). Data on PAHs in overcooked meat suggest these may be a risk factor, but there is insufficient evidence to draw firm conclusions (Santarelli et al., 2008). A more recent Australian population-based case-control study asked subjects to complete questionnaires on lifestyle and meat consumption (Tabatebaei et al., 2011). Baked red meat had a statistically significant inverse trend of association with colorectal cancer. Overall, results did not support an association between meat consumption or meat cooking practices, and the risk of colorectal cancer.

Haem iron may catalyse the formation of NOCs from natural precursors in the gut. Red meats are a richer source of haem iron than white meats, so such an effect may theoretically explain a stronger association between red meat and colorectal cancer, than between white meat and colorectal cancer. It would not explain, however, why white meat and fish (which also contain haem iron) appear to be protective against

colorectal cancer (Baghurst, 2007). The 2011 CUP panel agreed the evidence suggesting foods containing iron to be a cause of colorectal cancer to be limited.

NOCs are alkylating agents that can react with DNA and are produced by the reaction of nitrite and nitrogen oxides with secondary amines and N-alkylamides (Santarelli et al., 2008). NOCs are present in certain processed meats (eg grilled bacon), smoked fish, cheeses and beer, and can be formed endogenously after red and processed meat consumption (Santarelli et al., 2008). Although some research has linked NOCs to cancer, it is not yet clear whether red and processed meat-induced NOCs are colon carcinogens (Santarelli et al., 2008). Further research is needed in this area.

8.2.5. Reducing risk of colorectal cancer (CRC)

Epidemiological and mechanistic data on associations between red meat and colorectal cancer are inconsistent, and underlying mechanisms are unclear; there is a need for further research into the differences between white meat, red meat and processed meat, and there is a need for further investigation of biomarkers of meat intake and cancer occurrence (Oostindjer et al., 2014).

There are many dietary and lifestyle factors that have an influence on the development of cancer. In many studies looking at the effects of diet on cancer, it is difficult to disentangle the dietary and lifestyle factors that may be involved (such as Western lifestyles, high intake of refined sugars, alcohol, low intakes of fruits, vegetables and fibre) and behavioural factors (such as smoking, lack of physical activity and high body mass index). This limits the ability to analytically isolate the independent effects of red meat consumption; currently available epidemiological evidence is not sufficient to support an independent positive association between red meat consumption and colorectal cancer (Alexander & Cushing, 2010).

The key focus in terms of cancer prevention should be to: avoid smoking, limit sun exposure, maintain a healthy body weight and be physically active as part of everyday life. In terms of diet, it is recommended we eat at least five portions of a variety of fruits and vegetables each day, along with relatively unprocessed cereals and pulses, and limit intake of alcohol to no more than 1 unit a day for women and 2 units a day for men (WCRF, 2007). The 2011 CUP colorectal report confirms the evidence for ethanol from alcoholic drinks being a cause of colorectal cancer in men is convincing and probable in women. In addition the CUP panel agree the evidence showing physical activity to protect against colon cancer is convincing, and greater body and abdominal fatness as a CRC cause to be convincing.

Lean beef and lamb can make an important nutritional contribution to a balanced diet and complete avoidance is unnecessary in terms of cancer prevention. Also of note is that some of the nutrients in red meat, such as selenium, and vitamins B6, B12 and D, may have anti-cancer properties. Adjusting the dietary balance between meat and other dietary components may be critical in protecting against potential cancer (Ferguson, 2009). The 2011 CUP CRC report confirms evidence for foods containing vitamin D and/or selenium is limited.

As research in this area continues, it may be prudent to avoid very high intakes, particularly of processed meats, and to limit very-high-temperature cooking methods. The WCRF (2007) have recommended that intakes of cooked red meat can be up to

500g per week – this is higher than the current average intake of red meat in New Zealand of around 50g per day (Parnell et al; 2012) equating to 350g/week, so a reduction in average intakes is unnecessary.

8.3. Obesity

Conservative estimates suggest over 1 billion people worldwide are overweight or obese (Simpson & Raubenheimer, 2005). Obesity is certainly a significant problem in New Zealand, three out of ten adults (31%) are now obese, and one in nine (11%) of children aged 2-14 years are obese. This means that 1.2 million New Zealanders are obese (Ministry of Health 2013b).

8.3.1 Protein and weight management

Evidence is accumulating that increasing intakes of high-quality protein to a level above the recommended intake may be beneficial during weight loss (Layman, 2004), as well as for diabetes and cardiovascular disease (Rodriguez & Garlik, 2008). This may be related to the positive effects of protein on appetite control, satiety and food craving and reduction of intake of fat and carbohydrate (Santesso et al, 2013).

Astrup et al. 2013 looked at the effect of protein-induced satiety on appetite hormones which concluded protein dose-dependency increased satiety and postprandial changes in circulating GLP-1, PYY and glycagon were in part, responsible for the appetite suppressant effect of protein.

Energy intake has been shown to increase as dietary protein falls from 20% to 10%; a recent review on protein leverage and energy intake concludes that dilution of protein in the diet stimulates excess energy intakes, and that there is strong support for a role of protein leverage in lean, overweight and obese humans Gosby et al., 2014).

For most of our existence, the human diet has consisted of a high proportion of animal foods, with meat consumed from wild animals typically having a low fat content (see section 2). As a result, we have limited evolutionary experience of excess carbohydrates or fats and it has been suggested natural selection against over-consumption of these nutrients would not have been strong; this may account for their high level of palatability and may predispose us to their over-consumption today (Simpson & Raubenheimer, 2005).

In terms of systematic reviews and meta-analyses, 15 randomised controlled trials looked at the long term effects of higher vs lower protein diets on health outcomes including adiposity (Schwingshackl & Hoffman, 2013). Data analysis revealed no significant changes for weight, waist circumference, fat mass, total cholesterol and blood pressure. Significant decreases for fasting insulin were observed in high protein diets compared to low protein diets in the primary analysis, but not so in the secondary analysis. It summarised high protein diets exerted neither specific beneficial or detrimental effects on outcome markets of obesity, cardiovascular disease or glycaemic control.

In a large European study (Larson et al., 2010), 773 participants completed a low calorie phase, and were then randomly assigned to one of five weight maintenance diets; 548 completed the intervention. The mean initial weight loss on the low-calorie

diet was 11.0kg; among those who completed the study, only those following the low-protein, high-glycaemic index diet significantly re-gained the weight. The authors conclude that a modest increase in protein (to 25% of energy), and a modest reduction in glycaemic index, led to an improvement in study completion and maintenance of weight loss.

More recently, the DIOGENES 12 month randomised clinical trial (Aller et al., 2014) looked at both the GI and protein content effect on overweight subjects who were put on an initial low calorie diet for 8 weeks. After the intervention, the trial found no consistent effect of GI on weight gain, but did show a diet higher in protein (23-28%) improved weight loss maintenance in overweight and obese adults.

More evidence for the effect of protein is provided by a meta-analysis of 87 studies comprising 165 intervention groups, which found low carbohydrate, high-protein diets affected body mass and composition favourably, independent of energy intake (Kreiger et al., 2006). This supports the proposed metabolic advantage of such diets.

A more recent systematic review and meta-analysis compared an energy restricted standard protein diet with an isocalorically prescribed high protein diet and found a beneficial effect on weight loss, body composition and triglycerides with higher protein intakes (Wycherley et al., 2012).

Concern has been expressed about the effects of high-protein diets on renal function; however, there is little evidence high-protein diets pose a serious risk to kidney function in healthy people (Halton & Hu, 2004). Similarly, the impact of high-protein diets on markers of bone turnover has not been found to be deleterious (Noakes et al., 2005; Farnsworth et al., 2003).

Many of the studies into protein and weight loss have been relatively small. Optimal amounts and sources of protein cannot be determined, but the weight of evidence suggests it may be beneficial to partly replace refined carbohydrate intake with low-fat protein sources (Halton & Hu, 2004).

8.3.2 Fat and carbohydrates and weight management

It is important to consider not only the protein content of the diet but also the fat and carbohydrate content. Research into low-carbohydrate versus low-fat diets is mixed. One study on 96 normoglycaemic insulin-resistant women randomised to one of three dietary interventions (high carbohydrate, high fibre; high fat; or high protein) for 8 weeks of supervised weight loss, and 8 weeks of supervised weight maintenance, found significantly greater reductions in weight on the high-fat and high protein diets, when compared with the high-carbohydrate diets (McAuley et al., 2005). However, the authors suggest that to achieve similar benefits on a high-carbohydrate diet, it may be necessary to increase fibre-rich whole-grains, legumes, vegetables and fruits, and to reduce saturated fatty acids to a greater extent. Although the high-fat diet was successful for weight loss in the short term, the authors expressed concern that lipid levels should be monitored owing to the possible deleterious effects of this diet in the long-term.

A recent meta-analysis compared the effects of low-carbohydrate diets (≤ 45% energy from carbohydrates) versus low fat diets (≤ 30% energy from fats) on metabolic risk

factors and weight loss (Hu et al., 2012). Reductions in body weight, waist circumference and other metabolic risk factors were not statistically significant between the two diets.

When looking at high carbohydrate diets it is important to consider carbohydrate quality, which is not addressed in many studies. Recent research has compared a high protein diet (28% of energy from protein, of which 75% was derived from animal sources), with a low-fat high-carbohydrate diet (22% energy from protein) that was rich in dietary fibre from minimally processed grains, cereals and legumes (Te Morenga & Mann, 2012). Each diet provided 24g/d and 39g/d of dietary fibre respectively. After 8 weeks both groups lost weight, but the high protein participants lost 1.3kg more weight and achieved a greater reduction in diastolic blood pressure. Although improvements in risk factors were most marked on the high protein diet, results did not achieve statistical significance.

A recent position statement by the New Zealand Dietetic Association considers there not to be any evidence that a diet high in fat and low in carbohydrates is more beneficial for sustained weight loss than any other dietary regimen that results in a lower intake of energy (Dietitians New Zealand, 2014).

Further research in needed into the optimal dietary balance of fats and carbohydrates for long-term weight-loss. However, it seems reasonable to suggest that relatively higher protein intakes are an appropriate option for the treatment and avoidance of excess body fat (Te Morenga & Mann, 2012). For weight loss, the diet should be reduced in energy, and carbohydrate sources should be low in glycaemic index with minimally processed grains, cereals and legumes. The inclusion of lean red meat as part of a balanced diet would contribute to increased protein intakes.

8.4. Type 2 Diabetes

High-protein, low-carbohydrate diets have also been examined for treatment of Type 2 diabetes mellitus. Positive effects have been found on glycaemic regulation, including: reductions in fasting blood glucose; reductions in post-prandial glucose; reductions in insulin responses; and a reduced percentage of glycated haemoglobin (Layman et al., 2008). More recently, it has been claimed that although low carbohydrate diets are still controversial, they have continued to demonstrate effectiveness with little risk and good compliance for those with diabetes (Feinman et al., 2015).

A study comparing a high protein diet (28% of energy) with a low protein diet (16% of energy) in 54 obese men and women with Type 2 diabetes, during 8 weeks of energy restriction and 4 weeks of energy balance, found both diets improved the cardiovascular disease risk profile as a consequence of weight loss (Parker et al., 2002). However, there were greater reductions in total and abdominal fat mass in women, and greater LDL cholesterol reduction in both sexes, with the high protein diet. This suggests high protein diets are a valid choice for reduced risk of cardiovascular disease in people with Type 2 diabetes. Subjects in this study derived their protein from foods such as beef, chicken and dairy products.

A further study on overweight and obese hyperinsulinaemic men and women found no difference in weight loss or fat mass loss between subjects fed a high protein diet (27% of energy) compared with a lower protein diet (16% of energy) during 12 weeks of energy restriction and 4 weeks of energy balance (Farnsworth et al., 2003). However, in women total lean mass was significantly better preserved with the high protein diet (-0.1 $\pm$ 0.3 kg) than with the standard protein diet (-1.5 $\pm$ 0.3 kg). Further, those on the high protein diet had significantly less glycaemic response and a greater reduction in triacylglycerol concentrations than those on the standard protein diet.

Although there have been relatively few studies comparing the effects of high protein diets varying in macronutrient composition on insulin sensitivity, limited data do suggest that moderately high protein, weight loss diets (25-30% energy) improve glucose metabolism and insulin sensitivity when compared with low fat, high carbohydrate diets (Te Morenga & Mann, 2012).

Further studies are warranted into the effect of high protein diets on delaying the progression to Type 2 diabetes in obese adults with insulin resistance. Initial indications are however, for some individuals a diet providing an increased level of protein and a reduced level of carbohydrate may be effective for weight management, may improve lipid profiles, and may improve glycaemic regulation (Layman et al., 2008). However, it is important to note again the nature of the carbohydrates consumed in many studies was not considered (Te Morenga & Mann, 2012). More research is needed to determine the types and amounts of macronutrients to include in an optimal diet for people with diabetes.

8.5 Mental Health

Mental health is an integral part of health and well-being, as reflected in the definition of health in the Constitution of the World Health Organization: “Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.” (WHO, 2013).

Depression alone accounts for 4.3% of the global burden of disease and is among the largest single causes of disability worldwide (WHO, 2013). In New Zealand, rates of diagnosed mental health conditions are on the rise with rates of psychological distress high among Maori and Pacific adults, and adults living in the most deprived areas (Ministry of Health, 2014).

Recent research suggests nutrition is a key factor that underpins depression, with healthy dietary practices associated with a reduced likelihood of both clinically diagnosed depressive and anxiety disorders, and unhealthy dietary habits associated with an increased likelihood of major depressive disorder, dysthymia and anxiety disorders (Jacka et al., 2010).

Healthy dietary patterns consisting of vegetables, salads, fruits, rice, pasta, cereals, wine and non-processed meats have been compared with ‘Western’ dietary patterns consisting of processed meats, pizza, salty snacks, chocolates, sugar, sweets, soft drinks, margarine, mayonnaise, French fries, beer, coffee, cake and ice-cream. Those on better quality diets have been shown to be loss likely to be depressed whereas a higher intake of unhealthy and processed foods has been associated with an increased

level of anxiety (Jacka et al., 2011a). The hypothesis of reverse causality is not supported by the available data, in other words, the reported associations do not reflect poorer eating habits as a consequence of mental health problems (Jacka et al., 2011b).

Specific analysis among women eating red meat in relation to mood and anxiety disorders, has shown for those women consuming less than the recommended intake of red meat per week (3-4 serves of 65-100g a week of red meat such as beef and lamb), the odds for major depressive disorder/dysthymia were more than doubled compared to those consuming the recommended intakes (Jacka et al., 2012). The authors conclude that red meat consumption may play a role in mental health independently of overall dietary quality, but further studies are needed before recommendations can be made.

It is likely it is overall dietary patterns that are protective, rather than a single food component. I has been suggested, for example, the synergistic combination of *n-3* fatty acids together with other unsaturated fatty acids and antioxidants from olive oil and nuts, flavanoids and other phytochemicals from fruit and other plant foods, and large amounts of natural folates and other B vitamins exert a fair degree of protection against depression (Sánchez-Villegas et al., 2009).

A randomised controlled trial is currently underway to investigate the efficacy of dietary improvements in the treatment of depression (O'Neil et al., 2013). If the results of this study are positive, dietary intervention could provide an alternative or adjunctive treatment strategy for the management of mental disorders. In the meantime, it makes sense to follow a healthy diet for optimal physical and mental wellbeing.

9. Conclusions

Meat has been an important part of the human diet throughout our evolutionary history and today most New Zealanders include meat in their diet. Lean New Zealand beef and lamb are nutrient-dense foods that play a pivotal role throughout the life cycle – from young infants and children, through to adults and older people.

In particular, red meat is a rich source of bioavailable iron, which is important for vulnerable groups such as infants and toddlers, adolescents and women of childbearing age. Meat also provides zinc, selenium, B vitamins (particularly vitamin B_{12}), vitamin D and *n*-3 fatty acids, and liver is an excellent source of vitamin A. Red meat is also an excellent source of protein, and when fully trimmed, is low in total and saturated fatty acids.

The combination of nutrients found in meat can play an important role in the health issues facing many New Zealanders today. For example, lean meat can be a helpful part of a heart-healthy diet for those at risk of cardiovascular disease; it can form a part of a weight-reducing diet for obese and overweight people; and may have beneficial effects in preventing and managing Type 2 diabetes. In terms of cancer prevention, the key focus should be to avoid smoking, limit sun exposure, maintain a healthy weight, and be physically active. In relation to diet, the emphasis should be on fruits, vegetables and unprocessed cereals and pulses, as well as limiting alcohol

intake. A reduction in red meat intake in New Zealand is unnecessary based on current scientific evidence. However, it may be prudent to avoid very high intakes, particularly of processed meats, and to limit very-high-temperature cooking methods.

Appendix 1: Common myths and misconceptions about meat

Red meat is high in fat

When trimmed of all visible fat, lean red meat is low in fat. For example, a 100g portion of cooked beef silverside contains 5g fat and within that, only around half the fat in meat is saturated; the rest is mainly the beneficial monounsaturated and polyunsaturated fats. Since 1997, the red meat industry's Beef and New Zealand Quality Mark has required the trimming of beef and lamb cuts to be no more than 5mm of external fat and resulted in 30% less total fat and 65% less saturated fat in beef and lamb cuts.

People with heart disease should avoid red meat

A number of studies have shown lean red meat can be included in a cholesterol-lowering diet. Intake of fatty meat and meat products should be low for people with heart disease and all visible fat should be trimmed from meat before consumption. The New Zealand Guidelines Group (2012) for cardiovascular risk factor management recommends including fish or dried peas, beans and soy products, or a small serving of lean meat or skinned poultry, at one or two meals each day.

Weight-loss diets should exclude red meat

Lean red meat is low in fat and calories, and moderate amounts can be included in a weight-reducing diet. Evidence is accumulating that increasing the intake of high-quality protein to a level above the recommended daily amount (RDA), may be beneficial during weight loss; protein has been found to suppress food intake as it contributes to satiety, promoting a feeling of fullness. The inclusion of lean red meat as part of a balanced diet may therefore help weight loss as part of a reduced energy diet.

Red meat causes cancer

Some scientific studies have suggested an association between red meat consumption and colorectal cancer. However, associations are weak and overall evidence is mixed. An expert workshop in New Zealand concluded a moderate intake of lean meat as part of a balanced diet, which also provides adequate cereals and grain foods, vegetables and fruit, is not associated with an increased risk of bowel cancer. There are many dietary and lifestyle factors that influence the development of cancer and the key focus in terms of cancer prevention should be to avoid smoking, limit sun exposure, maintain a healthy body weight, be physically active, eat at least five portions of a variety of fruits and vegetables each day, along with unprocessed cereals and pulses, and limit intake of alcohol. The World Cancer Research Fund recommendation is that people who eat red meat (defined as beef, lamb and pork) should consume less than 500g cooked red meat per week. Current average red meat intakes in New Zealand are below this amount.

Meat-eaters should become vegetarian if they want to be healthy

A diet excluding meat can be nutritionally adequate, but as more foods are excluded it becomes important to plan the diet carefully to ensure nutrient needs are met. In particular, intakes of iron, zinc and vitamin B_{12} need careful consideration – especially for vegans. In terms of chronic disease, vegetarians have a lower mortality rate than omnivores, although it is likely much of this effect can be achieved by not smoking, by exercising more and by consuming a diet higher in fruits, vegetables and fibre. It is difficult to disentangle which features of a vegetarian diet may be protective, and there is currently no evidence to suggest meat eaters should change to an entirely vegetarian diet for health reasons.

Spinach is the best source of dietary iron

Spinach is a good source of iron, but the iron is present in the non-haem form, which is poorly absorbed therefore should be eaten with vitamin C-rich foods such as tomato or capsicum. Also, spinach contains substances that inhibit the absorption of iron, such as polyphenols and oxalic acid. As a result, spinach is a relatively poor source of iron, especially when compared with red meat, which contains the more readily-absorbed haem iron.

Eating too much meat can lead to an excess iron intake

Absorption of iron from dietary sources is well controlled by the body and although red meat is an excellent source of iron, including it regularly in the diet will not lead to an excess iron intake for healthy people. In fact, iron deficiency is much more likely to be a problem. The most common iron overload condition in New Zealand is hereditary haemochromatosis, a genetic condition that causes poor control of iron absorption. This condition is managed by therapeutic phlebotomy - in other words, the removal of blood on a regular basis, not by the avoidance of meat.

Meat takes a long time to digest

From an evolutionary perspective, humans are naturally omnivores and our digestive system is well adapted to digesting meat. Around 94% of the protein in meat is digested; this compares with 86% in whole wheat and 78% in beans (Williams, 2007). Meat is therefore an easily digested food. In addition, the nutrients in meat are well absorbed and utilised by the body.

Appendix 2: Production of red meat in New Zealand

Farming practices

The unique climate and landscape in New Zealand has set the global benchmark for pastoral farm production. Most meat is produced using naturally available resources – grass, rain and sunshine. In New Zealand, there is year-round access to grass, including hay, silage and feed crops.

Sustainability

Researchers in the USA have suggested a meat-based diet requires more energy, land and water resources than a lacto-ovo-vegetarian diet (Pimentel & Pimentel, 2003) implying the lacto-ovo-vegetarian diet is more sustainable. However, these suggestions often assume land used for grazing animals can be diverted to other uses, such as crop production (Thomason, 2007). Furthermore, these studies are likely to have made the comparison with feedlot beef, rather than the extensive pastoral systems. In New Zealand, most livestock production takes place on land unsuitable for producing crops, and if this land were not used for grazing, it would essentially be agriculturally unproductive.

Water foot-printing of New Zealand beef and lamb production shows that the majority of water used is from natural rainfall, rather than from other sources of water, and often not reflected in sustainability comparisons.

As such, beef and lamb production in New Zealand is highly sustainable.

Greenhouse emissions

A recent report has shown that greenhouse gases, including carbon dioxide (CO_2), methane (CH_4) and nitrous oxide, have continued to climb during 2013 once again reaching historic high values. Atmospheric CO_2 concentrations increased by 2.8 ppm in 2013, reaching a global average of 395.3 ppm for the year (Blunden & Arndt, 2014). Globally, livestock contributes a significant share towards emissions, but can also deliver a significant share of the necessary mitigation efforts (Gerber et al., 2013).

New Zealand is a signatory to the Kyoto Treaty on climate change and has made a commitment to reduce greenhouse emissions to 1990 levels. To help achieve this aim, the Pastoral Greenhouse Gas Research Consortium (PGgRc) was set up in 2002. A key goal of the PGgRc is to develop strategies to reduce and mitigate the two greenhouse gases associated with livestock: methane and nitrous oxide.

The contribution of agriculture to New Zealand's emissions profile is currently 46.1%, down from 50% in 1990. Emission levels from the beef and sheep sector have been decreasing and are now 17% lower than in 1990. Over the same period, emissions from agriculture have been increasing, therefore the sheep and beef sectors' contribution as a proportion is lower than it was 15 years ago. Breeding programmes along with the production of fewer but larger animals are largely responsible for the increase in efficiency in this sector to date.

Looking to the future, a recent report by PGgRc outlines 5 objectives which will build on knowledge and research tools developed by PGgRc over the last 10 years. These objectives are to: breed low-CH_4 emitting ruminants; identify low-greenhouse-gas feeds, develop a vaccine to reduce ruminant CH_4 emissions, identify inhibitors that reduce ruminant CH_4 emissions and to extend and enable technologies that can be readily adopted by farmers (Aspin et al., 2014).

Other environmental issues

The foundation of the New Zealand farming industry is fertile land, clean water and fresh air and a number of programmes are in place in New Zealand aimed at supporting environmental sustainability.

A significant environmental challenge is maintaining soil fertility while limiting nutrient loss to waterways. A recent high-profile project, funded by industry, farmers and government was 'The Wise Use of Nitrogen Fertiliser' project. This was a 4 year project aimed at promoting the sound use of nitrogen fertilisers in a range of hill farming situations, in order to encourage practices that enhance long-term profitability while minimising any detrimental effects to the environment.

The National Policy Statement for Freshwater Management (2011) requires communities to establish objectives that maintain or improve the quality of all freshwater in a region, with a planning framework to manage resources to achieve to the objectives. National bottom lines have been set for key water quality objectives.

The New Zealand economy is dependent on the environment to support activities such as agriculture. To sustain the environment, a range of policy initiatives are currently being implemented in the beef and sheep sector to ensure the industry remains economically profitable and environmentally sustainable in future years.

Antibiotics

In New Zealand, antibiotics are used sparingly in animals for therapeutic reasons only. Any treatment with antibiotics is recorded and statutory declarations are made. Animals treated with antibiotics are required to be withheld from the market for a specified period of time.

Hormonal growth promotants

Hormonal growth promotants are only used in a very small number of livestock (less than 1%) and are only provided under veterinary supervision. Their use in New Zealand is very tightly controlled and any animals which have received such hormones must be tagged and included in a central government database.

There is no evidence of any adverse effect on human health through consumption of meat produced from animals given hormonal growth promotants. Any beef or lamb

products displaying the Quality Mark have come from animals not treated with hormonal growth promotants.

Risk management

The Animal Products Act 1999 (APA) is legislation that requires all animal products traded and used in New Zealand be fit for intended purpose and this is achieved through risk management programmes, which involve identifying and managing hazards and other risks (NZFSA, 2010). Individual plants must operate a risk management programme that is independently audited by the Ministry for Primary Industries (MPI).

Risk management programmes must comply with the required industry standards. Plants may also operate ISO (International Organisation for Standardisation) standards that incorporate HACCP (Hazard Analysis and Critical Control Points).

If a plant is to supply the overseas market, then the appropriate standards for the destination country must be met. For example, meat exported to the USA must meet United States Department of Agriculture market access standards, and meat being exported to the European Union (EU) must meet EU standards.

New Zealand Beef and Lamb Quality Mark

The New Zealand Beef and Lamb Quality Mark was introduced in 1997 to ensure consistent quality of New Zealand beef and lamb. The quality mark is a black, red and gold rosette and it provides assurance that the highest standards have been met for leanness, tenderness and food safety.

Meat must be trimmed to a maximum of 5mm external fat along with the removal of internal fat where practical. Often cuts are trimmed completely and have no visible fat at all. To be eligible for the Quality Mark, mince must contain less than 10% fat.

A significant amount of New Zealand beef and lamb (ie cuts containing less than 4% saturated fat with a maximum 5mm fat trim) also qualifies for the Heart Foundation's Two Ticks, being recognised as core foods as part of a healthy diet.

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Document 12

11 March 2015

Louise McIntyre & Elizabeth Aitken
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To Louise and Elizabeth

RE: FEEDBACK ON THE DRAFT EATING AND ACTIVITY GUIDELINES STATEMENTS (EAGS) FOR NEW ZEALAND ADULTS

Firstly, thank you for the opportunity to provide feedback on the above mentioned draft document. In addition to today's email and tracked document, I would like to express my concern that the draft document currently pinpoints red meat as a food linked with cancer and the overall tone of the document does not profile lean red meat as a key, nutritious core food. Currently there are over 40 lean cuts of beef and lamb under the Heart Foundation's Two Ticks programme, of which includes healthy core foods. Alignment between the Ministry of Health and the National Heart Foundation recommendations of what constitutes a core food is paramount for consumer and health professional understanding and education.

In its current format, the document does not provide enough context for New Zealanders, given the recommendations are based on overseas research where eating patterns differ than they do here in New Zealand. In addition, the evidence base drawn from the WCRF and its recommendations around red meat intake are based on association, not cause, and has been heavily criticised, hence the references I have provided in the email and in our own Role of Red Meat in a Healthy New Zealand Diet report.

Serious consideration should be given to the recommendation which says to eat less red meat as general population advice and any future deliberation on decreasing serving size advice, when there are many New Zealanders who are not meeting an adequate intake of dietary iron; the Ministry of Health recognises and states in the draft, the issue of low iron intake, particularly amongst women. As red meat is an excellent source of well absorbed haem iron, this needs to be acknowledged in the overall guidelines statements.

I would also like to highlight the amount of work the beef and lamb industry does to contribute to a healthier New Zealand population:

Resources for Maori – in collaboration with Toi Tanagata, over 60,000 copies of the consumer resource *Nga Miti He Kai Reka* has been produced for over a decade by Beef + Lamb New Zealand providing advice around healthy eating, in particular recognition of the importance of iron-rich foods for Maori.

Resources for Pacific peoples – further to the document draft comment on the three Pacific meal posters, this was an industry-led project by Beef + Lamb New Zealand from its initiation in 2003. To date over 10,000 copies of the posters have been distributed with the latest revised version done in collaboration with the Heart Foundation's Pacific Heartbeat. See ANA abstract attached to email.

Reduction of total and saturated fat – in response to comment in draft document in appendix 3 on page 59 where it states mostly saturated fat from meat, the beef and lamb industry's Quality Mark programme has led to a reduction of 30% total fat and 65% less saturated fat in the meat supply. See NZ Medical Journal paper by Laugesen attached to email. The last adult nutrition survey highlights beef and lamb contributed

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only 6.8% of total fat intake, and 7.3% of saturated fat intake, both having reduced slightly from the previous national survey.

To emphasise red meat's place in a heart healthy diet for New Zealanders, Beef + Lamb New Zealand has worked closely with the Heart Foundation for the last two decades. To this end, over 40 lean beef and lamb cuts meet the criteria for Two Ticks having less than 4% saturated fat. The evolvement of the Tick programme to include Two Ticks was established to recognise core foods as part of a healthy diet, of which lean red meat fits, as mentioned above.

In addition the industry has been involved with the Pie Group, which was collaboration between industry and the Heart Foundation to improve the fat and sodium content of pies in response to the Food and Beverage Classification System.

As a globally-recognised industry which provides quality, nutritious and economical options for all New Zealanders, I hope the above highlighted initiatives and the attached evidence supporting red meat's role in a healthy diet is recognised in the wording of the guidelines statements for adults.

Yours sincerely

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Enc: Email and attachments

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13 March 2015

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Dear Elizabeth and Louise

The New Zealand Food & Grocery Council (the "FGC") very much appreciates the opportunity to make further comments on the **Eating and Activity Guideline Statements for New Zealand Adults 2015** (confidential draft 2 March).

We wish to acknowledge and thank the Ministry of Health for its keenness to engage with the food industry in the preparation of this document and welcome further dialogue in order to ensure we can assist with providing the most up to date evidence in which to base these eating and activity statements to enable them to be supported by the latest scientific opinion and research.

We would like to point out that it appears that our comments on the earlier draft of the Guidelines omitted to include comments on the components related to dairy. As a result we have included detailed comments now.

As noted in our earlier comments, FGC supports the development of easy to read Eating and Activity Guidelines for health practitioners and others who provide advice on nutrition and physical activity to the general public. Our main concern is that the guidelines do not reflect the latest evidence, especially in relation to dairy.

Throughout: there are multiple references to choosing low fat milk products because of the saturated fat content of higher fat dairy products (eg p17, p23). The rationale for the reduction of saturated fat given in the document relates to the effect on cardiovascular disease risk. However, the current scientific evidence does not suggest an increased risk of cardiovascular disease with consumption of core dairy products such as milk, yoghurt and cheese (including full fat products), despite their saturated fat content. Also higher fat dairy products provide significantly more fat soluble vitamins such as vitamins A and D, compared to their lower fat counterparts (Fayet et al 2013; Murphy et al 2008; Albala et al 2008; Johnson et al 2002)

To better align with the evidence base and acknowledge the role of whole foods rather than individual nutrients in isolation, we recommend **avoiding a specific recommendation to**

avoid higher fat milk, yoghurt or cheese for this reason. The reference to milk and milk products could be worded to state "New Zealand adults need more…. milk, yoghurt and cheese, preferably low/reduced fat as a lower kilojoule option."

We also make several comments related to sugar that we particularly draw your attention to.

Specific Comments

p5 Contents

For ease of reading we recommend the title for each eating and activity statement be included in the Contents list eg "Eating statement 1 – enjoy a variety of nutritious foods".

p9 Current nutrient intake and physical activity levels for New Zealand adults

We recommend appropriate and consistent use of the terms 'low fat' and 'reduced fat' in relation to dairy products, in line with the Australia New Zealand Food Standards Code (the Food Standards Code). A good example of this on p9: "low fat milk and yoghurt and reduced fat cheeses". It is important to note that '*low fat*' in the Food Standards Code is limited to products which contain no more than 3g fat per 100g for solid foods and no more than 1.5g fat per 100ml for liquids.

p9 **Most New Zealand adults need more section – whole grain foods**

We question the placement of pasta under the title 'Whole grain foods' and recommend this reference be removed.

Throughout document, the term 'cooked dried beans' is used, yet this is not common language for New Zealanders. Very few New Zealanders would make their own baked beans for example. As recommended in our last submission we recommend this be changed to 'canned, tinned or cooked dried beans'.

p9-10 **Most New Zealand adults need to eat and drink fewer/less**

The list provided under this heading reads:

- Meat pies, etc …
- etc
- Ice cream and desserts
- etc
- Wine, beer and spirits

We suggest amending the item in the foods to eat less of that reads 'Ice cream and desserts' to refer to 'nutrient-poor desserts' to distinguish them from nutrient-rich desserts such as yoghurt. The entry would then read 'Ice cream and nutrient-rich desserts'.

In relation to alcohol, the entry in this list is in direct contradiction to the statement further on in the Guidelines (p30) that 15% of New Zealand adults in 2013/14 drank harmful amounts of alcohol for health. That means that 85% either do not drink or drink within safer limits. This is in direct contradiction to the word 'Most'. We suspect that the same could be said of 'Processed meats like salami, bacon, sausages, ham and luncheon' and 'Ice-cream and desserts'.

We recommend that an additional list might refer to wine, beer and spirits and other items currently on the 'most' list that could more accurately refer to 'some' New Zealand adults:

"**Some New Zealand adults need to eat and drink fewer/less**

- Wine, beer and spirits".

p10 Reference is made in a list to 'fizzy' drinks. We recommend that 'Soft drinks' replace this as being more accurate for a wide range of non-alcoholic drinks. We recommend this change be made throughout the document, on p27 under the heading 'New Zealand situation' and under Eating Statement 3 on p31.

p11 Eating and Activity Guidelines Statements for New Zealand Adults

The heading should refer to 'Guideline Statements'.

The table under this heading should be split in two. There is no correlation between eating Statement 1 and Activity Statement 1 nor with the respective statements 2-5 yet the juxtaposition suggests this, creating confusion

Regarding the Eating statement 1 "Enjoy a variety of nutritious foods every day including …some low fat milk products…", we recommend that in order to align with the recommendation that most New Zealand adults eat more low fat milk and yoghurt and reduced fat cheeses, the word 'some' should be removed because otherwise this suggests a restriction of intake.

As well, acknowledging both low fat and reduced fat dairy products as a preference (the latter being particularly relevant to cheese), we query the change from 'milk and milk products' in current Food and Nutrition guidelines to 'milk products' in the current draft of the Eating Statements. We recommend the reinsertion of 'milk and' to the statement.

Regarding Eating statement 3 "Make plain water your first choice over other drinks", we recommend **the provision of more information that would help users of the Guidelines to understand the intent,** as has been done for other eating statements such as:

"3. Make plain water your first choice over other drinks:
- low fat milk or herbal teas are also good options
- sugary drinks should be limited."

p12 Eating statement 1

Our key concern with this statement relates to the absence of justification for advice that milk, yogurt and cheese should be "low-fat". The Australian Dietary Guidelines are, for this reason, taking a more circumspect position and we recommend the Eating and Activity Guidelines also take this approach. We refer you to the relevant pages in the Australian Dietary Guidelines (p v and p56) which can be found at http://www.eatforhealth.gov.au/sites/default/files/files/the_guidelines/n55_australian_dietary_guidelines.pdf and which are copied at Attachment A and to the supporting document *A review of the evidence to address targeted questions to inform the revision of the Australian Dietary Guidelines* specifically p170 which is reproduced at Attachment B and can be found at: http://www.eatforhealth.gov.au/sites/default/files/files/the_guidelines/n55d_dietary_guidelines_evidence_report.pdf .

From a scientific standpoint, there is no justification for the advice that milk, yogurt and cheese should be "low-fat". Several further amendments are therefore proposed to the Guidelines as a result but the sentence under the title "Evidence summary on p19 will need to change. We recommend "Consuming less saturated fats is associated with a reduced risk of heart disease, stroke, type 2 diabetes and hypertension.

The statement is made that "Healthy eating patterns emphasise eating a range of foods from the four food groups which include…" Eggs are not included in this statement. We recommend adding 'eggs' into the 4th point so that it reads:

"4. legumes, nuts, seeds, fish, eggs, and poultry in the diet."

p13 **Choosing different coloured vegetable and fruit**
We note Footnote 4 indicates that "This serving size advice is under review, but until new advice is issued this information remains the current advice".

We wish to acknowledge that the current recommendations for adults for 1 serving of fruit juice [1 cup of fruit juice (250mL) is counted as only one serving of fruit for the day] are consistent with guidelines provided by a number of programmes and agencies e.g. Fuelled4Life, NZFAVA (NZ Fruit and Vegetable Alliance) and a number of beverage sector companies produce a portion-controlled single serve 250mL unit to this recommendation, including 125mL mini's or multi-serves based on the 250mL serve size.

We would support retaining this recommendation as 1 cup of fruit juice does provide some of the phytonutrients found in fruit and it is a valuable source of vitamin C which helps with the absorption of non-haem iron. Fruit juice can be a useful "sometimes" option for those in the underweight ageing population and for children who do not readily get their 2 or more servings of fruit a day. www.nzfava.org.nz

In the table, the 3rd column under ½ cup of vegetables 'kamokamo (squash),,' an extra comma has been inserted than is necessary and needs to be removed.

p15 **What are whole grains?**
We recommend reflecting as far as possible the definition of whole grains in the Australia New Zealand Food Standards by:

- deleting the first sentence in the paragraph at the top of page since this raises confusion and adds little, ~~"There is no one widely agreed definition of the term whole grain".~~
- leading with the second sentence which goes on to describe a whole grain
- amending this **second sentence to read:**
  "Other definitions include milled, dehulled, cracked, flaked or ground grains ~~e.g. flour~~ that still contain the bran, endosperm and germ in the same proportions as the intact grain e.g. flour~~This is~~ sometimes called wholemeal."

It is important for health professionals to recognise that dehulled, cracked, flaked grains that retain the required components as the intact grain are as beneficial.

p15 **What are refined grains?**
We recommend a phrase be added to link this text with the next 'What about added fibre breads?'. The second sentence might then read:

"They generally provide fewer nutrients and much less fibre unless steps have been taken to address these losses such as through supplementation."

This is on the basis that 'Fibre white or Simply Fibre White' breads that are fortified with soluble fibre have a higher nutritional value compared with plain white bread and these are suitable for the whole family. These breads offer a choice for parents who may sometimes struggle to introduce wholegrain breads to younger children.

p15 **What about added fibre breads?**
There is recent evidence to support the use of fibres such as inulin and polydextrose and we would refer you to the latest EFSA Opinion on the substantiation of a health claim related to "native chicory inulin". The wording that has been used in this section of the Guidelines are

based on the assumption that these fibres offer no benefit. The statement should say that research continues to look at the potential benefits.

The latest EFSA Opinion referred to above concerning the substantiation of a health claim related to "native chicory inulin", concludes that the scientific evidence supports the claim that "chicory inulin contributes to maintenance of normal defecation by increasing stool frequency". See http://www.efsa.europa.eu/en/efsajournal/doc/3951.pdf

We therefore recommend that the first sentence under this heading reads as follows:

> "Fibre enriched bread is typically refined white bread with manufactured fibre such as inulin and polydextrose added to it. ~~There is not yet enough evidence to know whether this type of fibre enriched bread is beneficial to health.~~ The research in this area is expanding and in the meantime, ~~Ideally,~~ choosing products that still have their fibre intact, such as whole grain breads, is a ~~better~~ good ~~option."~~

We also recommend adding the following sentence because it is plainer language that might be better understood. It is also somewhat future proofed by referring to beverages with added fibre, an area of development that could emerge shortly:

> "Some white breads, such as 'Fibre white' or 'Simply Fibre White' are fortified with soluble fibre which has a higher in nutritional value compared with plain white bread and these are suitable for the whole family. These breads offer a choice for parents who may sometimes struggle to introduce wholegrain breads to younger children. There may well be 'added fibre beverages' in time as well."

p16 **Choosing (whole) grain foods**

The use of the term '(whole)' makes the table confusing as some of the examples in the 3rd column titled 'Serving size examples' are not all whole grains i.e. pasta, rice, biscuits. However, we think the examples are realistic and add a dimension of practicality to the Guidelines. We therefore recommend the title of this section change from "Choosing (whole) grain foods" to "Choosing grain foods" then retain the text as proposed.

Additionally, the sentence under 1st column titled 'Food group' talks to whole grains where again not all serving size examples are whole grain. This is potentially misleading. We recommend that the text under the 1st column talk about grains and choosing whole grains as much as possible along the lines of:

> "Grain foods are in general naturally high in fibre especially where these are whole grain foods (includes breakfast cereals, breads, grains, rice and pasta)."

p17 **Enjoy a variety of nutritious foods including: some low fat milk products**

As noted at the outset, we are concerned that this heading sends the wrong message and is contrary to the overall importance of dairy products in the diet. We recommend the heading read:

> **"Enjoy a variety of nutritious foods including: some milk and milk products including some low fat products"**

p17 **Evidence summary**

We recommend removing the words 'low fat' from this statement as the health benefits described are not exclusive to low fat milk and milk products (as demonstrated in the evidence base used for this document).

p17 **Background**

We recommend that the second paragraph be amended by replacing the second sentence with the inclusion of a practical recommendation that acknowledges the higher fat content of butter, cream and products like cream cheese and sour cream but that they might be

considered when an individual's calcium needs are not being met, if those individuals are at low risk for heart disease, stroke, type 2 diabetes and hypertension. The text would then read:

> "Butter, cream and products like cream cheese and sour cream are made from milk fat and are not included as part of this food group. ~~They have high levels of fat, particularly saturated, and are low in protein and calcium.~~ These are nutrient dense products and have a higher fat content and lower protein and calcium levels than other milk and milk products. Nevertheless, they may be considered when an individual's calcium needs are not being met, if the individual is at low risk for heart disease, stroke, type 2 diabetes and hypertension since these foods are still useful sources of calcium. Ice cream is also high in fat and contains added sugar."

p17 **What about non-dairy milk products?**
The terminology used here appears incorrect and does not align with the Food Standards Code definition of 'milk'. That definition limits 'milk' to the 'mammary secretion of milking animals'. This includes goats and sheep. It is also the case that goats and sheep milk is comparatively high in calcium when compared to plant derived milk alternatives.

We recommend changing the heading to 'non-dairy milk alternatives' and that references to milk alternatives refer to those sourced from soy, rice etc. The section would then read:

> **"What about non-dairy milk alternatives?**
>
> While most New Zealand milk is obtained from cows or other animals such as goats and sheep, milk sourced from ~~goats, sheep and~~ plants such as soy, rice and nuts, is available. Milk sourced from plants ~~like soy, rice or nuts~~ provides alternatives for those seeking a dairy-free option. Non-dairy milks are not naturally high in calcium so choosing products with calcium added is important as it is essential for bone health.

p17 **New Zealand situation**
We consider it would be helpful to acknowledge the under-consumption of calcium in New Zealand in this section.

p17 **Choosing low fat milk products**
There is no justification for the milk products to be low fat. We therefore recommend tha the heading read:

> **"Choosing milk and milk products including low fat options".**

The recommendation statement "Adult New Zealanders are recommended to eat at least two servings of low fat milk products" is not consistent with the amount recommended and listed in the table that follows: "Eat at least 3 servings per day (choose low or reduced fat options".

Use of word 'eat' could be confusing as not all dairy is eaten. We recommend changing this to 'eat/drink' or 'consume' so as to also include milk such as a drink or consumed with cereal. The text might then read:

> "Adult New Zealanders are recommended to ~~eat~~ consume at least ~~two~~ three servings of low fat milk products each day."

We would also point out that on p17 the statement is made that "Ice cream is also high fat, and contains added sugar" and the example in the Table on p18 and the recommendation in the table for serving sizes refers to "1 cup of ice cream". A low fat or reduced fat ice cream is not an ice cream under the Food Standards Code which requires ice cream to have 100 g/kg of milk fat (Standard 2.5.6). We therefore recommend that this example be:

> "1 cup fat reduced dairy dessert".

To refer to ice cream in the table is also inconsistent with the examples shown in the Appendix to the Guidelines. This is another reason for removing the reference, to protect the integrity of core dairy products. Further information could be provided by including an additional comment to suggest that higher calcium plain ice creams can be enjoyed in moderation to assist calcium intake.

In the same table on p18, serving size examples include "1 small pottle yoghurt". It would be clearer to use "1 small tub yoghurt (150g)" which would be consistent with the format of the adjacent example of "1 large glass milk (250 ml)" and would be consistent with the recommendation in the current Food and Nutrition guidelines of 150g.

p18 **What about cheese?**
We believe separating cheese from milk and yoghurt in this section is unhelpful, confusing and does not align with the evidence base used for this document which demonstrates health benefits from the consumption of milk, yoghurt **and cheese**, despite their saturated fat content. Ricotta can also be suggested as a lower fat alternative, along with cottage cheese.

p20 **Choosing legumes*, nuts, seeds, kaimoana, eggs, poultry or red meat with fat removed**
In the last sentence on p20 under this heading, there is a typo in the sentence commencing "Instead use alternative sandwich fillings…". The sentence should read:

> "Instead use alternative sandwich fillings such as hummus, leftover ~~me~~ meat, canned tuna or salmon."

p22 Eating Statement 2

p22 **Choose and/or prepare foods and drinks – with unsaturated fats instead of saturated fats**

p22 **Background**
At the end of the second paragraph under this heading, the statement is made that "Trans-fats are thought to be more harmful to the body than saturated fats (see box on following page)." The problem we have with this statement is that it does not distinguish between trans fatty acids (TFAs) that are inherent in a food such as in dairy and the TFAs that result from food manufacturing processes.

The evidence is not available to link inherent TFAs with the TFAs resulting from food manufacturing processes and it is possible that inherent TFAs may have **no** harmful effect, and may even be beneficial. We therefore suggest that the statement read:

> "Trans-fats that result from manufacturing processes (that is trans fats that are not inherent in a product) are thought to be more harmful to the body than saturated fats (see box on following page)."

Similarly in the box on p23 we suggest the second sentence read:

> "There is strong evidence that TFAs resulting from food manufacturing processes increase the bad low-density lipoprotein (LDL) cholesterol in the blood, which is a major risk factor for coronary heart disease."

p23 **Choosing foods and drinks with unsaturated fats instead of saturated fats**
We recommend that the statement in this section reflect the broader range of oils available by it reading:

> "Unsaturated fats come mainly from plants (e.g. the oil in nuts, seeds, avocados) although some are from animals (e.g. oily fish like salmon, tuna, mackerel, sardines)

- healthy plant based fats and oils include canola, sunflower and olive oil and plant based margarine spreads
- other sources of healthy fats include seeds, nuts, and avocados."

p24 **Choose and/or prepare foods and drinks – that are low in salt (sodium); if using salt, choose iodised salt**

p25 Choosing foods and drinks that are low in salt
A typo has been made by omitting a 'less than' sign in the bullet referring to low salt foods. The phrase whould read:

- "(<120g of sodium per 100g)".

p25 **Choose and/or prepare foods and drinks – with little or no added sugar**
FGC suggests the focus of this section should be on nutrient density, not on a single nutrient such as sugar, as this does not drive the consumption of healthier or more nutritious diets. The following comments need to be considered.

Sugar is not independently associated with obesity risk. Recent research by Barclay & Brand-Miller (2011) shows that, in the Australian context, sugar intakes do not correlate with the incidence of obesity. It is an important point to note that sugar may help to improve nutrient intakes when they are added to nutrient dense foods. Recent evidence suggests that the addition of sugar to nutrient dense foods may favourably affect total nutrient intakes. In the US, Frary et al (2004) investigated the impact of the addition of sugar on nutrient intakes in children aged 6-17yr. Specifically, they considered the impact of 5 sugar-sweetened food groups: sugar-sweetened beverages, sugars and sweets, sweetened grains, sweetened dairy products and pre-sweetened breakfast cereals. The authors report that intakes of calcium, folate, iron and fibre increased as consumption of pre-sweetened cereals increased in the children.

A similar pattern was observed for increasing consumption of sweetened dairy drinks and intakes of calcium and fibre together with an inverse association in saturated fat consumption. Albertson et al (2009) has also reported a similar finding in the US population, where pre-sweetened cereals (defined as ≥21.8% sugar) were associated with improved micronutrient and fibre intakes and no greater BMI than those consuming lower sugar breakfast cereals.

Sub-analysis of the Australian National Children's Nutrition and Physical Activity Survey has shown that whilst breakfast cereal consumers (including those who consume pre-sweetened cereals) did have higher energy and total sugar intakes, their intakes of key micronutrients were also significantly higher than non-cereal consumers and their BMI was significantly lower (Table 1, $P<0.05$). Cereals contributed >20% of Australian children's daily intakes of iron, thiamin, folate and riboflavin and 13% of their daily fibre intakes. Breakfast cereals, including pre-sweetened cereals, also helped encourage consumption of milk with one third of children's daily milk consumption being enjoyed with breakfast cereals.

p25-26 **Background**
We consider the evidence better supports an amended second sentence in the second paragraph under this heading (on p26) such that it reads:

"In particular, drinking excessive quantities of sugar sweetened beverages along with a sedentary lifestyle is associated with increased risk of weight gain".

p26 **New Zealand situation**
We recommend amending the statement under this heading so that it is consistent with the statement on p10. The statement would read:

"Major sources of added sugars in the New Zealand diet include:

- non-alcoholic beverages e.g. ~~sugary fizzy~~ sugar sweetened soft drinks, fruit juice, fruit drinks, cordial and powdered drinks, energy and sports drinks
- sugar and sweets …

p26 **What about fruit juice and dried fruit?** (contained in a box)
Overall, FGC considers the interests in fruit juice and dried fruits are useful to highlight and the recommendations here are generally useful. However the second sentence that reads "Fruit juice is a high sugar drink" implies that it is higher in sugar than other sugar sweetened drinks which it is not. We recommend replacing this sentence with the following:

> "~~Fruit juice is a high sugar drink~~ Encourage the consumption of fresh fruit and plain water rather than fruit juice" is more positive."

The boxed information also implies that whole fruit has vitamins and phytonutrients while juice does not. FGC recommends this is amended to read:

> "The whole fruit is more filling than juice and provides more available vitamins, phytonutrients (beneficial chemicals), fibre…".

p26 **Choosing foods and drinks with little or no added sugar**
Some commentary would be helpful to health care professionals to remind them that adding a small amount of refined sugar can increase the palatability of some highly nutritious foods and increase the overall nutrient intake. It is argued that the addition of sugar to nutrient dense foods can appropriately and effectively play a role to improve palatability and intake of nutrient dense foods resulting in higher nutritional quality diets. As noted in the foregoing, an evidence base currently exists in this regard with reference to two key food categories, namely breakfast cereals and flavoured milks. A sentence might be added at the end of this section that reads:

> "The addition of a small amount of sugar to nutrient dense foods can appropriately and effectively play a role to improve palatability and intake of nutrient dense foods resulting in higher nutritional quality diets."

We would also refer you to the American Dietary Guidelines which provide in a recent 2010 review commentary on this matter the following:

> "Most people's eating patterns can accommodate only a limited number of calories from solid fats and added sugars. These calories are best used to increase the palatability of nutrient-dense foods rather than to consume foods or beverages that are primarily solid fats, added sugars, or both. A few examples of nutrient-dense foods containing some solid fats or added sugars include whole-grain breakfast cereals that contain small amounts of added sugars, cuts of meat that are marbled with fat, poultry baked with skin on, vegetables topped with butter or stick margarine, fruit sprinkled with sugar, and fat-free chocolate milk. In addition, for those who consume alcohol, the calories in these beverages need to be considered as part of total calorie intake; they reduce the allowance for calories from solid fats and added sugars that can be accommodated in an eating pattern." (Chapter Five, p.46)

We also recommend amending paragraph 3 under this heading since nowadays there is a low or zero sugar version of most beverages including cordial, energy and sports drinks. It would be helpful to acknowledge this wide variety of low or zero sugar beverages that people can choose from. The term 'low sugar' in the Food Standards Code is defined as containing no more than 2.5g sugar per 100ml (Standard 1.2.7). With regard to sports drinks, it is worth considering adding a statement such as 'a sugar sports drink is beneficial when undertaking prolonged or intensive activity / exercise' depending on a person's individual circumstances'.

The last para might therefore read:

> "Choose plain water or ~~low~~ reduced sugar or zero sugar drinks such as diet soft drinks rather than ~~sugary~~ sugar sweetened soft drinks, fruit juice, fruit drinks, cordial

and powdered drinks, energy and ~~or~~ sports drinks. The term 'low sugar' means containing no more than 2.5g sugar per 100ml. A sugar sports drink is beneficial when undertaking prolonged or intensive activity/exercise depending on a person's individual circumstances."

p27 – **Choosing unprocessed or minimally processed foods and drinks -**
The third paragraph contains a typo by omission of the word 'food'. The text should read:

"Examples of highly processed foods to limit include:".

p28 Eating statement 3

p28 **What about other drinks?**
A statement is made in the second paragraph that caffeine is a stimulant and a diuretic. FGC recommends that the text in brackets is misleading and that a strong statement concerning the vital contribution that coffee and tea make to overall hydration is required.

In the US, a Beverage Guidance Board was assembled to provide guidance on the relative health and nutritional benefits and risks of various beverage categories (Popkins et al 2006). The Panel's purpose was to attempt to systematically review the literature on beverages and health and provide guidance to the consumer. Drinking water was ranked as the primary and preferred beverage to fulfil daily water needs followed secondly by coffee and tea. Importantly the Panel noted that "there are greater amounts of caffeine in coffee than in tea. Although caffeine is a mild diuretic, human studies indicate that caffeine consumption of up to ~500mg/d does not cause dehydration or chronic water imbalance. A caffeinated beverage's fluid content compensates for an acute diuretic effect" (Popkins et al 2006)

Similarly, Maughan and Griffin (2003) concluded that most of the published studies offer no support for the suggestion that consumption of caffeine containing beverages, as part of a normal lifestyle, led to fluid loss in excess of volume ingested or is associated with poor hydration status. These conclusions are supported by Ganio et al (2007). A recent comprehensive review of more than 75 years of research found that caffeinated beverages contribute to the daily water requirement in a manner that is similar to water (Armstrong et al 2007; Jiang et al 2014).

Caffeine containing beverages may initially cause a mild diuretic effect, but this diminishes over time with regular consumption (Maughan and Griffin 2003). Recent research around caffeine being a diuretic shows that it is no more of a diuretic than water. As a result, the word 'diuretic' has been removed from the Australian dietary guidelines.

FGC also considers that some guidance around what is 'moderate coffee consumption' could be helpful for healthcare professionals who are asked for this advice. For most healthy adults, consuming moderate amounts of 3-4 cups of coffee per day (equivalent to 300-400 mg caffeine per day), there is little evidence of health risks and some evidence of health benefits. (Higdon, 2006)

The text in the third paragraph might therefore read:

"Black tea and coffee are also popular and there is some evidence that both can provide benefits for health, such as anti-oxidative properties. Tea and coffee both contain caffeine ~~(a stimulant and diuretic)~~ and tea contains tannins which decrease absorption of iron in the gut. While both tea and coffee make an important contribution to overall hydration, ~~Therefore~~ moderation of tea and coffee consumption is recommended (around 3-4 cups of coffee or 5-6 cups of tea per day).

p29 **What about other drinks?**
The second paragraph on p29 needs to be amended to:

- provide the reference number as a superscript:
  "Sugar drinks include fruit drinks [11], …".
- Insert the word "whole" and correct the last sentence to read:
  "Fruit juice without added sugar, contains the natural sugar from the several pieces of (whole) fruit that is used to produce it"
- Amend the third paragraph to read:
  " ~~Diet fizzy drinks~~ Reduced sugar or zero sugar drinks use intense sweeteners instead of sugar and usually have little or no energy (~~calorie~~ kilojoule) content. Plain water is the best choice of drink, but ~~diet fizzy drinks~~ reduced sugar and zero sugar drinks in moderation are a better option than ~~sugary~~ sugar-sweetened drinks."

We suggest that a statement regarding the safety of intense sweeteners be added and that the addition to beverages is highly regulated by the Food Standards Code.

p29 **New Zealand situation**
We recommend that a statement be added regarding the increase in consumption of low kilojoule and zero sugar drinks to highlight the more trends in the drinks market in New Zealand. As well links to the websites of the New Zealand Beverage Council and the Australian Beverage Council, both of which contain more advice about choosing drinks could usefully be added.

p36 **Useful Links – HIIRC**
To avoid confusion, we recommend the full term "Ministry of Health" be used in this section not just "Ministry" such that the entry reads:

> "The Health Improvement Innovation Research Centre (HIIRC) is a health research focused website run by the Ministry of Health."

p38 The activity statements

p38 **Introduction**
In the first paragraph, reference is made to "… resistance activities are good for strong muscles, lean body mass and for reducing the risk of falls …." The reference to 'lean body mass' requires a qualification similar to that provided for the risk of falls such that the phrase should read:

> "…while resistance activities are good for strong muscles, increasing lean body mass and for reducing the risk of falls, and improving insulin sensitivity."

p45 Activity statement 4

p45 **Evidence summary**
Muscle strengthening activities will not reduce the risk of developing falls. FGC recommends the sentence be reworded along the following lines:

> "Reduce the risk of developing metabolic syndrome, pre-diabetes, osteoarthritis and reduce the risk of falls and fractures"

p51 **Useful Links**
Under the heading 'Nutrition" we recommend adding the website of the Nutrition Foundation www.nutritionfoundation.org.nz.

Thank you once again for engaging with the New Zealand Food & Grocery Council on this very important area.

Yours sincerely

Katherine Rich
Chief Executive

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Attachment A

Extract from Australian Dietary Guidelines p v p56

GUIDELINE 2

Enjoy a wide variety of nutritious foods from these five groups every day:

- Plenty of vegetables, including different types and colours, and legumes/beans
- Fruit
- Grain (cereal) foods, mostly wholegrain and/or high cereal fibre varieties, such as breads, cereals, rice, pasta, noodles, polenta, couscous, oats, quinoa and barley
- Lean meats and poultry, fish, eggs, tofu, nuts and seeds, and legumes/beans
- Milk, yoghurt, cheese and/or their alternatives, mostly reduced fat (reduced fat milks are not suitable for children under the age of 2 years)

And drink plenty of water.

2.5.2 The evidence for consuming 'milk, yoghurt, cheese and/or alternatives, mostly reduced fat'

The evidence for the health benefits of consumption of these dairy foods (mainly reduced fat varieties) has strengthened since the 2003 edition of the dietary guidelines,[36] however the evidence base primarily comprises small, short-term studies with varied definitions of dairy foods. The evidence for the relationship between foods containing calcium and increased bone density in post-menopausal women was not re-examined because it was regarded as an accepted relationship.[36]

Attachment B

Extract from Australian Dietary Guidelines p170

5. DAIRY (S1.1 & Cat 2 S2.6)

Search results

The search of the databases included 2738 references for dairy and the specified disease outcomes. An additional 18 studies were found by reviewing reference lists of retrieved studies and through hard copies submitted from external sources. Unless otherwise specified, throughout this document dairy consumption is defined as the total consumption of cheese, milk, and yoghurt. Unless specified in the narrative and the data extraction table, butter was not included as a dairy food. Due to few studies that examined high fat dairy foods versus low fat dairy foods, the body of evidence statements include dairy foods of varying fat levels unless otherwise specified. The detailed search is included in a separate document on searches. Data was extracted from 53 references concerning dairy foods, and 38 publications were used to form the final body of evidence statements. Sufficient evidence was found to make statements for the relationships between dairy foods and bone health, hip fracture, heart disease, stroke, hypertension, type 2 diabetes, metabolic syndrome, obesity, social equity, and colorectal, rectal, renal cell, prostate, breast, and endometrial cancers. Evidence was found on the following factors, but was not strong enough to develop a body of evidence statement: mental health (two cohort studies), lipid profile in adults (two randomised controlled trials), lipid profile in infants (three randomised controlled trials), adiposity in children (one randomised controlled trial), dental health (one cohort), child growth (one cohort study), pancreatic cancer (one cohort study), ovarian cancer (one cohort study), dairy consumption during pregnancy and size of infant (one cohort study), and the effect of nutrition education on dairy consumption (two randomised controlled trials).

Grains & Legumes Nutrition Council™

Cultivating Good Health

Grains & Legumes Nutrition Council

Submission

Eating and Activity Guidelines Statements for New Zealand Adults

2015

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Document 16

PREFACE

This submission has been prepared by Grains & Legumes Nutrition Council™ (GLNC), the independent authority on the nutrition and health benefits of grains and legumes. The primary objective of GLNC is to link the Australian and New Zealand grains and legumes industry value chain from grain growers to food manufacturers, providing scientifically-based evidence about the role of grains and legumes in nutrition and health, to develop resources to support health promotion and education.

GLNC members are:

- Grains Research and Development Corporation
- GrainGrowers
- Bakers Delight
- Campbell Arnott's
- H.J. Heinz Company Australia
- George Weston Foods Baking Division
- Goodman Fielder
- Kellogg Australia
- Nestle / Cereal Partners Worldwide
- Sanitarium Health and Wellbeing Company
- SunRice
- Simplot Australia
- UniGrain
- Ward McKenzie

Associates:

- Australian Food & Grocery Council
- Pulse Australia

CONTENTS

INTRODUCTION

The Grains & Legumes Nutrition Council (GLNC) appreciates the opportunity to respond to the consultation on New Zealand Eating and Activity Guidelines Statements for New Zealand Adults.

The following GLNC submission is structured as recommendations based on order of appearance in the consultation document. For each recommendation the section and page reference from the consultation document is noted.

RECOMMENDATIONS

Recommendation 1

(*Eating Statement 1*, page 11)
GLNC suggests that in view of the benefits of foods high in cereal fibre, Eating Statement 1 is changed to: "Enjoy a variety of nutritious foods every day including... whole grain and/or high cereal fibre foods".

Rationale
The inclusion of 'high cereal fibre foods ' in the recommendation will more accurately reflect the evidence on the health benefits of both whole grain and grain foods high in cereal fibre that are not whole grain. This will assist health care professionals and people who provide health advice in encouraging a variety of grain foods including non-whole grain foods such as bran-based breakfast cereals.

GLNC acknowledges that the evidence of a health benefit of non-cereal fibres such as inulin are not well established. However, these foods may be added to grain foods to increase total dietary fibre. Therefore GLNC recommends the descriptor 'cereal fibre' is used.

The evidence to support this change is based on the scientific evidence to support the intake of whole grains:

- The majority of evidence underpinning the recommendation of whole grain foods comes from studies which use the Jacobs et al. definition of whole grain foods, including wheatbran which is not technically whole grain.[1,2]
- Cereal fibre has been shown to be linked to reduced risk of coronary heart disease, type 2 diabetes and weight gain.[3-5]
- Focussing only on whole grain effectively excludes foods such as wheat bran which is a not a whole grain but is high in cereal fibre.
- In most studies of whole grain, the mechanism of how grain foods improve health outcomes gives particular emphasis to the role of fibre in the benefit of whole grains.[1,2]
- Nutrients and biologically active substances are concentrated in the bran and germ. High fibre foods that containing these fractions of the grain, while not whole grain, provide the fibre benefit as well as other nutrients/biologically active factors present within those fractions.

Recommendation 2

(*What are whole grains?* page 15)
GLNC suggests the inclusion of the FSANZ Food Standards Code definition of whole grain and the inclusion of a definition for whole grain food of 8 grams per serve.

Rationale

The Statement currently states 'There is no one widely agreed definition of the term whole grain'. However, Australia New Zealand Food Standards Code, Standard 2.1.1 – Cereals and Cereal Products, defines whole grain as follows:

> ***Whole grain*** *means the intact grain or the dehulled, ground, milled, cracked or flaked grain where the constituents – endosperm, germ and bran – are present in such proportions that represent the typical ratio of those fractions occurring in the whole cereal, and includes wholemeal*

GLNC's Code of Practice for Whole Grain Ingredient Content Claims which is an established voluntary industry standard in Australia and New Zealand, defines a whole grain food as a food that contains at least 8 grams of whole grains per serve.[6] In addition, the international characterisation of a whole grain food is 8 grams per serve.

Recommendation 3

(*What are whole grains?* page 15)
GLNC suggests the inclusion of an explanation that the whole grain content of foods varies and guidance to choose foods higher in whole grain.

Rationale
The whole grain content of foods on shelf varies widely from less than 2 grams to over 80 grams per serve. In order for people to achieve the established 48 gram whole grain Daily Target Intake from the recommended six serves of grain foods, they need to be choosing foods high in whole grain content.[7]

Guidance to encourage people to choose foods higher in whole grain would help people make informed choices and more likely to meet the 48 gram Daily Target Intake.

Whole grain content can be determined by the Code of Practice for Whole Grain Ingredient Content Claims industry standard for whole grain claims on pack which are: contains whole grain (8 grams), high in whole grain (16 grams) and very high in whole grain (24g).[6] Percentage whole grain in the ingredient list can also be used to choose foods higher in whole grain.

Recommendation 4

GLNC suggests the document is reviewed to ensure consistency of the whole grain recommendation as choose mostly whole grain. GLNC recommends a quantified recommendation of 'at least half of you grain intake as whole grain or high cereal fibre foods'

Rationale
The recommendation regarding the proportion of grain foods to be eaten as whole grain varies throughout the document as demonstrated below. This inconsistency makes the recommendation difficult to interpret. A consistent recommendation of a quantified amount would assist people understand how much of their grain food should be whole grain.

- Page 16: Choose whole grain breads and cereals where possible
- Page 16: Choose whole grain options as much as possible
- Page 58: Eat at least 6 servings per day (choose whole grain breads and cereals)

The evidence that underpins the whole grain recommendation indicates the intake of three serves of whole grain or high fibre grain foods is associated with reduced risk of weight gain and chronic disease including cardiovascular disease, type 2 diabetes and colorectal cancer. However, a recent survey conducted by GLNC indicates New Zealanders are not eating enough whole grain to benefit

from improved health outcomes. A nationally representative survey of New Zealand people in 2014 indicated on average people eat only 2.4 serves of whole grain per day, with over 30% of adults eating less than one serve per day.[8]

More explicit recommendations are needed to encourage people to eat more whole grain foods. GLNC believes that providing a quantified target will encourage people to choose whole grain and high fibre core foods more often. A quantified statement would also provide opportunities for government agencies and the food industry to promote consumption with consistent messages and in doing so support the work of the Ministry of Health to improve the diet of New Zealanders.

Recommendation 5

(*Choosing and preparing whole grain foods*, page 18).
GLNC has some suggestions for websites to be included as sources of information on choosing and preparing whole grain foods.

- Grains & Legumes Nutrition Council www.glnc.org.au
- Whole Grain Council www.wholegrainscouncil.org

Recommendation 6

(*Eating Statement 1,* page 12)
GLNC supports the inclusion of legumes as the first on the list of protein source foods. GLNC suggests canned legumes (preferably with no added salt) are included in the explanation of legumes.

Rationale

- Currently Eating Statement 1 includes an explanation of legumes as, '*Legumes include cooked dried beans (e.g. baked beans), split peas (e.g. dhal), lentils and chickpeas (e.g. hummus)*'. This does not include canned legumes which are common in New Zealand.
- In contrast, vegetables are recommended in Eating Statement 1 as fresh, frozen and canned.
- A recent survey conducted by GLNC indicates New Zealanders are not eating enough legumes to benefit from improved health outcomes. Only 29% of people reported eating legumes, eating them on average just twice a week. The most common barrier to including legumes in meals was a lack of knowledge of preparation techniques.[8]
- Legumes are now available in a range of convenient formats including single serve cans. Representing legumes in a way that appears convenient and may be familiar is more likely to encourage consumers to include legumes in their diet.
- The salt content of canned legumes may be a concern. However low salt varieties are available and research indicates rinsing canned legumes can reduce the salt content by half.[9]

Recommendation 7

(*Choosing and preparing legumes*, page 21).
GLNC has some suggestions for websites to be included as sources of information on choosing and preparing legumes.

- Grains & Legumes Nutrition Council www.glnc.org.au
- Pulse Canada www.pulsecanada.com

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