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Nutrient composition of Australian goatmeat

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Executive summary

The aim of this project was to compile data describing the nutritional composition of goatmeat. The methodology was designed primarily such that results would be appropriate for inclusion in the Food Standards Australia and New Zealand nutritional database (NUTTAB).

A total of 24 goat carcasses representing the predominant production systems used for goatmeat production in Australia (specifically rangeland goats raised on native vegetation in pastoral regions and Boer-cross goats raised on pasture in agricultural regions) were sourced from a Western Australian abattoir and wholesaler. Carcasses were boned out by qualified butchers to AusMeat specifications. Duplicate cuts were made for each carcass (left and right cut from respected carcass half for each animal). Half the cuts from each carcass were cooked, specifically roasted at 180^{o}C to an internal temperature of 72-78^{o}C. Raw and cooked cuts were dissected into components (dissectible lean muscle, connective tissue, fat and bone/waste) and gross composition data were compiled for uncooked (raw) and cooked forequarter, loin and leg cuts for all carcasses. Composite samples of dissectible lean were prepared for each portion of the carcass (forequarter, loin and leg) each for the cooked and raw samples. Composite samples of dissectible fat were prepared by pooling fat from all three regions of the carcass for each carcass, then equal amounts of pooled fat from each carcass were used to prepare the composite fat samples (cooked and raw). Nutrient composition analysis for composite samples were performed using NATA-accredited methods/laboratories.

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Abbreviations

DHA:	Docosahexaenoic acid – 22:6 (n−3)
DPA:	Docosapentaenoic acid - 22:5 (n−3)
EPA:	Eicosapentaenoic acid - 20:5 (n−3)
FA:	Fatty acids
HCW:	Hot carcase weight
LL:	*Longissimus lumborum* muscle
MUFA:	Monounsaturated fatty acids
NATA:	National Association of Testing Authorities (Australia)
NUTTAB:	Food Standards Australia and New Zealand nutritional database
PUFA:	Polyunsaturated fatty acids
RDI:	Recommended daily intake
SE:	Standard error
SFA:	Saturated fatty acids

Aims and objectives

The aim of this project was to compile data describing the nutritional composition of goatmeat using methodology such that results would be appropriate for inclusion in the Food Standards Australia and New Zealand nutritional database (NUTTAB) to support nutrition content claims and general level health claims for goatmeat where appropriate.

Background

The Australian Bureau of Statistics (ABS) reported that 1.7 million goats were slaughtered in Australia in 2010 (BCS Agribusiness, 2011). There is a diverse range of destination markets for goatmeat, but the vast majority of Australian production is exported, primarily to the United States of America. The main markets for Australian goatmeat are shown in Table 1.

Market	Numbers (approx.)	
Export - meat	1,524,000	Predominantly to USA for wet cooking (culture-based consumers)
Domestic	152,000	General; wet cooking (culture-based consumers) Premium; high-end food service, markets and some retailers
Export – live (meat)	65,000	Predominantly to SE Asia (Malaysia) for slaughter (culture-based consumers)

Table 1: Australian Goat markets (BCS Agribusiness, 2011)

The current markets seek out different qualities in goatmeat, depending on preferred cooking methods and culture. Most processors require goats of at least 10 kg, but there is a wide range of market requirements, including:

- High-end domestic markets prefer more fat content and favour Boer-cross or rangeland goats in very good condition, such as a young nanny or a wether in the 12-18 kg range.
- Islamic cultures prefer goat for religious events such as Eid (celebrating the end of Ramadan), and the Hajj (which traditionally includes the sacrifice of livestock and the sharing of the meat).
- Many cultures (e.g. Hispanic and some Pacific Islanders) use goat at celebrations (e.g. birthdays and marriages) and their needs will range from carcases to cubed meat.
- Mediterranean cultures (e.g. Greek and Italian) prefer small goats (under 10kg) especially for religious events (Easter and Xmas) and festivals. They may be sold as carcases through specialist retailers or processers.
- Some islanders and African markets prefer the strongly flavoured meat from entire male goats.

Nearly 26 thousand tonnes of goatmeat, worth nearly $120 million, was exported from Australia in 2010, with nearly 15 thousand tonnes of that going to the USA. Taiwan, the Caribbean and Canada were other significant importers of Australian product. Goatmeat is commonly exported as a 6-way cut boxed carcase (forequarter x2, loin x2 and leg x2) and is used mainly for ‘wet’ dishes by ethnic communities. Some goatmeat is exported as ‘skin-on’ carcases for use in Asian (particularly Chinese) cooking. The meat export markets are supplied nearly exclusively by extensively managed Rangeland goats from Pastoral regions.

The domestic market for goatmeat is smaller in volume and value than the export markets. Currently the majority of the domestic market is for culturally-based sub-markets, specifically restaurants and butchers supplying ethnic communities that want goatmeat for ‘wet’ cooking.

Boer-cross and rangeland goats may be used to supply to these markets. Smaller niche markets exist for premium goatmeat, including high-end food service outlets (restaurants and butchers), along with farmers markets and food festivals. Some cultural niche-markets also exist for high-quality goatmeat, each with their own specifications. Boer and Boer-cross are often supplied to this market; although rangeland goats in good condition may also be accepted.

The distribution of Rangeland goats is shown in Figure 1. Estimates of Australian rangeland goat numbers have ranged from 1.5 million to 5.0 million. A likely range of 2.6 – 4.0 million was adopted in a recent study (BCS Agribusiness, 2011). Rangeland goats make up the majority of goat numbers in Australia, but it is difficult to estimate the number of rangeland goats from year to year because their numbers fluctuate with seasons, they are mobile and they are often managed in terrain that makes surveying numbers difficult. In good seasons they may disperse widely, so even though numbers may be up, sightings may be down.

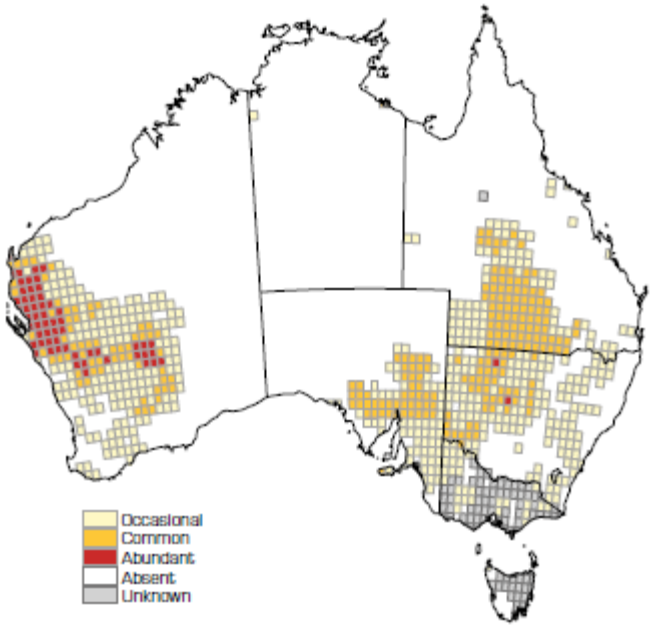

Figure 1: Rangeland goat distribution (West 2008)

Apart from extensively-managed Rangeland goats in Pastoral regions, BCS Agribusiness concluded there were probably another 0.4 million farmed goats; including 165,000 fibre goats and around 25,000 dairy goats. Hence the Australian goat population is estimated to be within 3.0 to 4.4 million, with approximately 87-91% of these being extensively managed Rangeland goats in Pastoral regions.

Methodology

A total of 30 goat carcasses were sourced for this project. The goat carcasses utilised in this study were selected to represent the major breed (Rangeland and Boer-cross) and production systems in Australia, specifically extensive management in Pastoral regions (14 goats) and semi-intensive pasture-based management in agricultural zones (10 goats). All carcasses were classified as “goat” (G) using AusMeat classifications and were processed according to the AusMeat definitions for a standard carcass.

Carcasses were purchased through commercial wholesale processors. Carcasses were selected to represent major production systems and geographical regions:

- 10 carcasses from Boer-cross animals (Boer goat x Rangeland) - female, aged 2-tooth or older originating in great southern region of WA and finished on pasture with hay and grain supplements. Mean hot carcass weight (HCW) was 15.2kg (range 11.8-17.2kg). Goats from this consignment are pictured in Figures 2 and 3.
- 8 carcasses from Rangeland goats that were consigned from the Goldfields region - were female Rangeland goats aged 2-tooth or older. Mean HCW was 12.9kg (range 10.9-16.6kg). Goats from this consignment are pictured in Figure 4.
- 6 carcasses from Rangeland goats that were consigned the Mount Magnet (Murchison) region – female, dentition not recorded. Mean HCW was 14.7kg (range 14.2-15.5kg).

Figure 2: Boer-cross goats being transported to abattoir

Figure 3: Boer-cross goats in lairage

Figure 4: Rangeland goats sourced from Goldfields Region in lairage

Carcass sample collection – carcass handling and boning

Carcasses were identified on the slaughter chain with a numbered snap tag. Once carcasses were in the chiller (Figures 5 and 6), the identified carcasses were covered with a plastic carcass bag and were transported to Murdoch University within 48 hours of slaughter in a refrigerated vehicle maintained at 2^{o}C (Figure 7), then transferred to a refrigerated cool room (2^{o}C).

Figure 5: Selection of rangeland and Boer-cross goat carcasses in chiller

Figure 6: Carcasses (Goldfields pastoral and Boer-cross) in chiller

Figure 7: Refrigerated vehicles were used for transporting carcasses (2^{o}C) between abattoir and Murdoch University Meat Science Laboratory

Within 72 hours of slaughter, cold carcass weight was recorded and cacasses were boned out by a qualified butcher to the AusMeat specifications.

The first level of processing to primal cuts was:

- Bone in forequarter 6-rib (AusMeat 4972)
- Bone in leg chump on (AusMeat 4800)
- Loin 8-rib (AusMeat 4860)

The primal cuts were weighed and further processed to the following specifications:

- Boneless square cut shoulder 6-rib (AusMeat 5050) – rolled and tied up with butchers' string
- Rack cap off 6-rib (AusMeat 4746)
- Short loin 1-rib (AusMeat 4880)
- Boneless leg chump on (AusMeat 5060) – rolled and tied up with butchers' string

All cuts were weighed (Figure 8), labeled, vacuum packed and refrigerated at 2^{o}C for 24 hours, then frozen at -20^{o}C.

The cuts from the left half of each carcass were allocated to "cooking" and the right half of the carcass were allocated to "raw dissection".

Figure 8: Weighing primal cuts (short loin) in the Murdoch University Meat Science Laboratory

Cooking

All meat cuts from the right half of each carcass were cooked as-purchased (untrimmed) with all separable (dissectible) fat intact. Frozen vacuum-packed cuts from the right side of each carcass were thawed at 2^{o}C, weighed, placed on metal racks on foil trays, roasted in a commercial oven at 180^{o}C to an internal temperature of 72-78^{o}C and rested 1 minute prior to weighing (Figure 9).

Drip loss that occurred during freeze-thawing was determined by difference of the weight of cuts before freezing and after thawing. Moisture loss during cooking was determined by difference of the weight of thawed cuts before and after cooking.

Cooked samples were cooled at room temperature for 30 minutes, then at 2^{o}C overnight before being vacuum-packed and frozen at -20^{o}C for no more than 3 weeks before dissection.

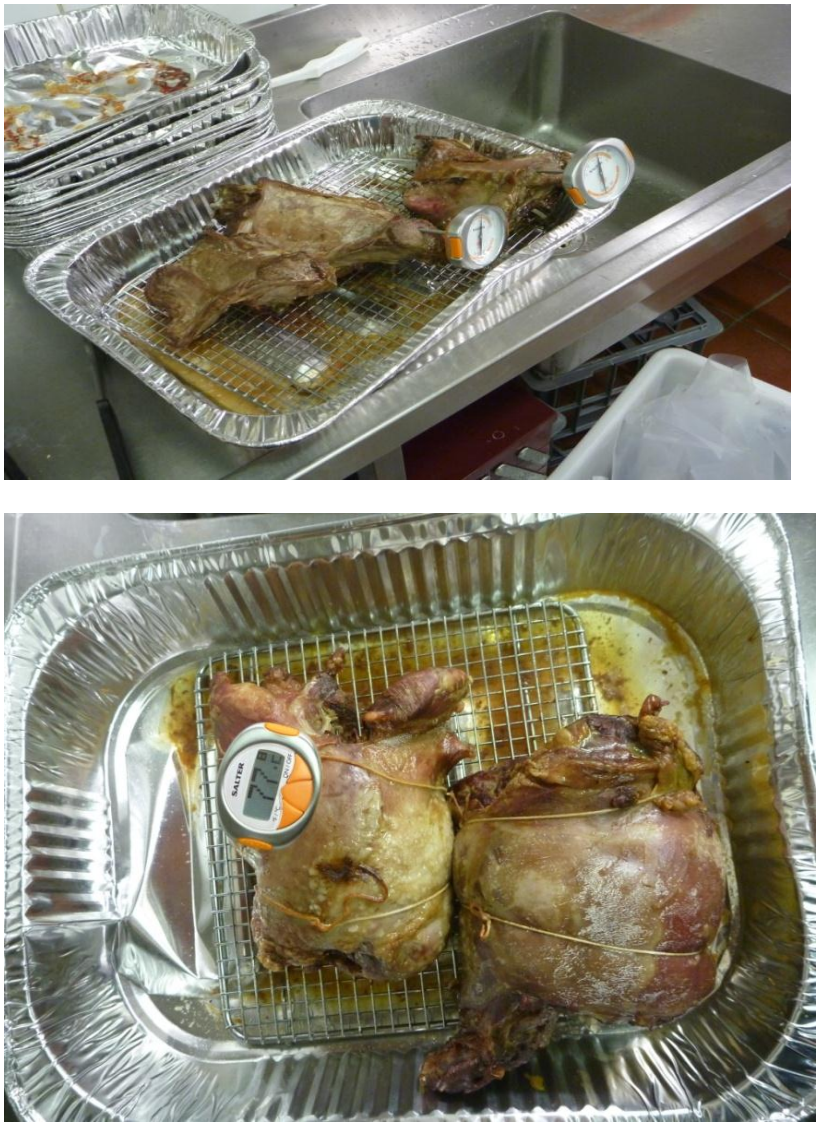

Figure 9: Cooked (roasted) short loin and rack (top photo) and boneless shoulder (bottom photo) goatmeat cuts resting on metal rack with meat thermometers used for monitoring internal temperature

Gross composition - dissection

Primal cuts allocated to raw dissection were trimmed of excess visible external (salvageable) fat by the butcher during boning out, but were not denuded (semi-trimmed). The weight of discarded external fat was recorded.

Frozen vacuum-packed meat cuts were thawed in vacuum packs at 2^{o}C. Vacuum packs were opened immediately before dissection. Any moisture in the bag was discarded and the sample weighed immediately before dissection commenced. Drip loss following freezing-thawing was calculated by difference and was included with separable lean portion.

Cooked samples were sliced into portions approximately 1cm thick for dissection.

Meat cuts were dissected (Figure 10) into:

- **separable lean** (muscle, light connective tissue)
- **separable fat** with internal (intermuscular) separable fat and external separable fat (salvageable fat on outside of cut) weighed separately where possible. Light connective tissue that could not be separated from separable fat was included with fat.
- **waste** (bone, cartilage, heavy connective tissue)

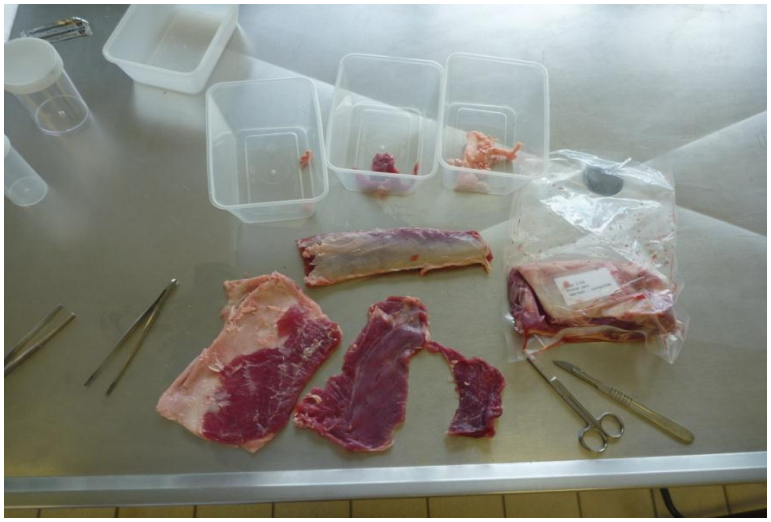

Figure 10: Uncooked rack being dissected into lean, separable fat (external and internal), separable light (edible) connective tissue and waste (bone, cartilage, gristle, heavy connective tissue)

Components were weighed separately using a laboratory balance (Figure 11). Samples were covered with plastic and stored at 2^{o}C when not being handled to minimise moisture loss during handling and dissection. Recoveries (weight of components relative to total weight before dissection) were calculated and were less than 2%

Figure 11: Dissected components being weighed on laboratory balance

Fat on the outer aspect of the raw rolled shoulder and leg cuts that could not be readily trimmed and separated from underlying muscle/light connective tissue without dissecting out individual muscles was pooled with internal fat. Consequently for lightly trimmed raw cuts, gross composition reflects the total fat that includes a combination of internal and external fat that could not be readily separated during dissection.

For the cooked samples, external and internal fat was readily separable and so external and internal fat was recorded separately for cooked samples. For cooked samples, the proportions of lean and fat in “semi-trimmed” cuts would reflect the composition of a cut that is untrimmed before cooking and where all visible external fat is trimmed off after cooking. For rack and loin cuts, “semi trimmed” cuts had the external fat (both cap fat and fat within connective tissue) and the tail removed, so gross composition results for these cuts represent composition of a trimmed backstrap muscle that was cooked “on the bone” and trimmed out after cooking.

Sample preparation for nutrient composition analyses

Following dissection of raw and cooked cuts, samples of lean from each primal cut and pooled samples of fat were stored in air-tight containers and frozen at -20^{o}C.

After all dissections had been completed, frozen lean samples from each primal cut (forequarter, loin, leg) and pooled fat samples were thawed at 2^{o}C. Composite samples were prepared for each primal cut (forequarter, loin, leg) and pooled fat by mincing and mixing 100g from each carcass to form forequarter lean, loin lean, leg lean and pooled fat composite samples each for raw and cooked samples. Composite samples were stored in air-tight containers and frozen at -20^{o}C.

Sample analyses for nutrient composition

Composite samples were sent to National Measurement Institute (Port Melbourne, Victoria) for nutrient composition. The methods used for each assay are outlined in Table 1 and described in more detail in Appendix 3.

Table 2: Methodology for nutrient composition of composite samples

Determination Method	Method description	NMI/NATA method reference	Limit of reporting	NATA accredited
Moisture	Oven drying of sample at 102°C. Gravimetric determination.	VL298	0.2g/100g	Yes
Protein	Total nitrogen by Kjeldahl method. Conversion factor for protein 6.25.	VL299	0.2g/100g	Yes
Fat	Soxhlet extraction (diethyl ether) with gravimetric determination.	VL300	0.2g/100g	Yes
Cholesterol	Solvent extraction. Gas chromatography with flame ionisation detection of cholesterol acetate.	VL288	1mg/kg	Yes
Sugars	Sugars extracted from homogenized sample in solution at 60^{o}C and sugars measured by HPLC using amino column	VL295	0.2g/100g	Yes
Ash	Drying in furnace at 525^{o}C. Gravimetric determination.	VL286	0.1g/100g	Yes
Carbohydrates	By calculation	VL412	-	Yes
Energy	By calculation	VL412	-	Yes
Fatty acid profile (including trans fatty acids) – composite samples	Oven dried sample. Chloroform/methanol or petroleum ether/iso-propyl alcohol extraction, esterification using methanolic sodium methoxide solution and sulphuric acid in methanol, neutralization and re-extraction with n-hexane. Gas chromatography.	VL289	0.1/100g	Yes
Fatty acid profile – individual samples	Freeze-dried sample. Alkaline hydrolysis (KOH and MeOH), sulphuric acid methylation and hexane extraction. Gas chromatography. Method described by O'Fallon *et al* (2007)	DAFWA		No
Amino acid profile		outsourced		
Thiamin (Vitamin B1)	Acid hydrolysis and enzymatic digestion. Separation by HPLC with post-column derivitisation to thiochrome. Fluorescence detection.	VL290	0.05mg/100g	Yes
Riboflavin (Vitamin B2)	Acid hydrolysis and enzymatic digestion. Separation by reverse phase HPLC with fluorescence detection.	VL290	0.05mg/100g	Yes
Niacin (Vitamin B3)	Alkaline digestion (calcium hyroxide) followed by extraction and clean-up using solid phase C18 & SCX cartridges. HPLC separation with photo diode array (PDA) detection as nicotinic acid.	VL293	0.5mg/100g	Yes
Pyridoxine (Vitamin B6)	Acetate extraction of B6 compounds followed by conversion to a single form (pyridoxol). Separation by reverse phase HPLC with fluorescence detection.	VL320	0.02mg/100g	Yes

Table 2 (continued): Methodology for nutrient composition of composite samples

Determination Method	Method description	NMI/NATA method reference	Limit of reporting	NATA accredited
Retinol (Vitamin A)	Alkaline digestion followed by solvent extraction (petroleum ether). Separation by reverse phase HPLC with PDA detection.	VL287	5ug/100g	Yes
Alpha- and Beta-Carotene (Pro-vitamin A)	Alkaline digestion followed by solvent extraction. Separation by reverse phase HPLC with PDA detection.	VL292	5ug/100g	Yes
25-OH-Vitamin D3 and cholecalciferol (Vitamin D)	Alkaline digestion followed by solvent extraction. Vitamin D3 and D fraction collection by HPLC. Separation by reverse cholecalciferol phase HPLC with PDA or UV detection.	VL392	0.1ug/100g	Yes
Tocopherol isomers-alpha, beta, gamma, delta (Vitamin E)	Alkaline digestion followed by solvent extraction (petroleum ether). Separation by HPLC with fluorescence detection.	VL291	0.1mg/100g	Yes
Cobalamin (Vitamin B12)	Extraction by autoclaving in acidified acetate buffer. Innoculation with *Euglena gracilis* with a 5-day growth period. Determination by absorbance at 640 nm.	Outsourced (Royal Perth Hospital)	0.18ng/g	Yes
Pantothenic acid	Extraction by autoclaving in acidified acetate buffer. Acid innoculation with *Lactobacillus planatarum* with a 20h growth period. Determination by measuring turbidity at 550 nm.	outsourced		Yes
Folate	Extraction in acidified acetate buffer followed by 3 enzyme treatments. Innoculation with *Lactobacillus casei*. Determination by turbidity.	Outsourced (Royal Perth Hospital)	40ng/g	Yes
Minerals - Calcium, Copper, Iron, Magnesium, Manganese, Phosphorus, Potassium, Selenium, Sodium, Zinc	Nitric acid digest and milestone microwave digest. Inductively coupled plasma (ICP) - Atomic emission spectrometry	VL247	0.2-1mg/kg for Na, K, S, P, Fe, Ca and Mg 0.01-0.5mg/kg for Mn, Se and Zn	Yes

Gross composition of goatmeat cuts

Summaries of the gross composition of raw (uncooked) and cooked samples are shown in Table 3 (uncooked) and Table 4 (cooked).

Overall, the amount of dissectible fat was variable between carcasses and cuts, but generally low. The leg had 2% lower dissectible fat than shoulder (uncooked cuts as purchased, but this was not statistically significant (paired sample t-test p=0.063). This trend was consistent with other studies that found higher separable fat content for lamb and mutton cuts derived from the forequarter (Williams 2005).

Semi-trimmed cut had lower levels of separable fat, but external fat was difficult to separate from associated connective tissue, underlying muscle and internal fat in the uncooked shoulder and leg cuts because most dissectible fat was located along the muscle seams (intramuscular fat) rather than as subcutaneous fat. Fully trimmed cuts (diced) had no separable fat as all intermuscular fat was discarded. The cooked shoulder had less separable external fat (3.3% +/- 3.6) than internal fat (5.8% +/- 4.0) (p=0.008) but there was no difference in the amount of external (2.6%) and internal (2.9%) fat in cooked legs (p=0.734).

Weight loss on cooking was 29.7% +/- 15.7 (mean +/- SD) which was comparable to 28.6% loss for Australian lamb, mutton, veal and beef cuts reported by Williams et al (2006). There was a significant effect of cut type on weight loss during cooking with boneless leg losing more weight than all other cuts ($p<0.001$) and both rack and loin losing less weight then either leg or shoulder during cooking ($p<0.001$). Both the rack and loin cuts were cooked with the bone in-situ, whereas shoulder and leg cuts were boneless. Overall, weight loss during cooking for boneless cuts (shoulder and leg roast) was 42.0%+/- 10.5 compared to 17.5% +/- 10.0 in the bone-in cuts (rack and loin) ($p<0.001$).

Webb *et al* (2005) summarized a number of factors that have been shown influence fat content of goat carcasses including age, sex, nutrition, liveweight, physiological condition and physical activity and concluded that goat carcasses are generally lean with lower levels of subcutaneous fat than sheep, even when compared at the same degree of body fatness.

This is the first study that we are aware of that describes the separable fat content for goatmeat cuts prepared to AusMeat specifications. Other studies have reported total separable lean, fat and waste (bone, gristle) proportions for whole goat carcasses. . Tshjabalala et al (2003) reported total subcutaneous fat being higher in Boer goats (2.88% total carcass) compared to African indigenous goats (1.26%), but both goat breeds had less subcutaneous fat than Dorper or Damara sheep (>10%). It should be noted that this study only included subcutaneous fat and not intermuscular fat.

Table 3: Gross composition of raw cuts of goatmeat

	Separable lean (%) mean ± SD (range)	**Separable fat (%)** mean ± SD (range)	**Waste (%)** mean ± SD (range)
Bone in forequarter 6-rib (AusMeat 4972)			
As purchased			
Untrimmed	59.8 ± 5.3 (50.5 – 69.9)	4.7 ± 3.2 (0.2 – 10.1)	33.2 ± 5.6 (23.8 – 42.5)
Semi-trimmed	59.8 ± 5.0 (51.0 – 69.2)	4.7 ± 3.3 (0.2 – 10.5)	33.2 ± 5.6 (23.8 – 42.5)
Edible portion			
Untrimmed	90.6 ± 5.9 (79.2 – 99.5)	8.8 ± 6.4 (0.3 – 21.4)	-
Semi-trimmed	92.9 ± 4.5 (84.0 – 99.5)	7.0 ± 4.6 (0.3 – 15.2)	-
Boneless square cut shoulder 6-rib (AusMeat 5050)			
Untrimmed	90.6 ± 5.9 (79.2 – 99.5)	8.8 ± 6.4 (0.3 – 21.4)	-
Semi-trimmed	92.1 ± 4.5 (84.0 – 99.5)	7.0 ± 4.6 (0.3 – 15.2)	-
Diced forequarter meat (AusMeat 5280)			
Untrimmed	90.6 ± 5.9 (79.2 – 99.5)	8.8 ± 6.4 (0.3 – 21.4)	-
Fully trimmed (denuded)	100	0	-
Rack 6-rib (AusMeat 4746)			
As purchased			
Untrimmed	51.0 ±8.0 (38.5 – 68.3)	7.1 ± 7.2 (0 – 25.4)	41.2 ± 8.1 (29.6 – 55.4)
Semi-trimmed	51.6 ± 7.5 (39.1 – 68.3)	5.8 ± 5.9 (0 - 16.8)	41.8 ± 8.0 (29.6 – 55.4)
Edible portion			
Untrimmed	88.3 ± 11.5 (60.3 – 100)	11.7 ± 11.5 (0 – 39.7)	-
Cap-fat removed	90.3 ± 9.53 (72.5 – 100)	9.7 ± 9.5 (0 – 27.5)	-
Fully trimmed (AusMeat 5101)	100	0	-
Short loin 1-rib (AusMeat 4880)			
As purchased			
Untrimmed	59.1 ± 8.6 (44.5 – 72.7)	7.6 ± 6.7 (0 – 22.3)	33.3 ± 9.1 (17.2 – 49.3)
Semi-trimmed	61.4 ± 9.0 (47.2 – 77.0)	4.1 ± 4.8 (0 - 18.8)	34.5 ± 9.1 (21.7 – 52.3)
Edible portion			
Untrimmed	89.0 ± 8.9 (72.5 – 100)	11.0 ± 8.9 (0 – 27.5)	-
Cap-fat removed	94.0 ± 6.8 (75.3 – 100)	6.0± 6.7 (0 – 24.7)	-
Fully trimmed (AusMeat 5080 + 5150)	100	0	-
Bone in leg chump on (AusMeat 4800)			
As purchased			
Untrimmed	71.1 ± 4.4 (60.6 – 76.5)	5.3 ± 4.0 (0 – 12.7)	25.6 ± 3.3 (18.5 – 33.0)
Semi-trimmed	72.3 ± 3.3 (63.4 – 77.1)	3.1 ± 1.9 (0 – 8.1)	24.1 ± 3.3 (19.5 ± 33.0)
Edible portion			
Untrimmed	93.1 ± 5.2 (82.7 – 100)	6.9 ± 5.2 (0 – 17.3)	-
Semi-trimmed	96.0 ± 2.5 (89.7 – 100)	4.0 ± 2.5 (0 – 10.3)	-
Boneless leg chump on (AusMeat 5060)			
Untrimmed	93.1 ± 5.2 (82.7 – 100)	6.9 ± 5.2 (0 – 17.3)	-
Semi-trimmed	96.0 ± 2.5 (89.7 – 100)	4.0 ± 2.5 (0 – 10.3)	-
Diced leg meat (AusMeat 5300)			
Untrimmed	93.1 ± 5.2 (82.7 – 100)	6.9 ± 5.2 (0 – 17.3)	-
Fully trimmed (denuded)	100	0	-

Table 4: Gross composition of cooked (roasted) cuts of goatmeat

	Separable lean (%) mean ± SD (range)	**Separable fat**			**Waste (%)** mean ± SD (range)
		Total (%) mean ± SD (range)	**External fat (%)** mean ± SD (range)	**Internal fat (%)** mean ± SD (range)	
Boneless square cut shoulder 6-rib (AusMeat 5050)					
As purchased					
Untrimmed	90.5 ± 6.4 (78.2 – 100)	9.1 ± 6.4 (0 – 20.3)	3.3 ± 3.6 (0 – 10.5)	5.8 ± 4.0 (0 – 13.9)	0.5 ± 0.6 (0 – 2.0)
Semi-trimmed	93.5 ± 4.4 (84.6 – 100)	6.1 ± 4.3 (0 – 14.7)	-	6.1 ± 4.3 (0 – 14.7)	0.5 ±0.6 (0 – 2.0)
Edible portion					
Untrimmed	90.9 ± 6.5 (79.7 – 100)	9.1 ± 6.5 (0 – 20.3)	3.3 ± 3.6 (0 – 10.5)	5.8 ± 4.0 (0 – 14.0)	-
Semi-trimmed	93.9 ± 4.3 (85.2 – 100)	6.1 ± 4.3 (0 – 14.8)	-	6.1 ± 4.3 (0 – 14.8)	-
Rack 6-rib (AusMeat 4746)					
As purchased (bone in)					
Untrimmed	61.0 ± 6.2 (48.8 – 71.2)	5.0 ± 5.5 (0 – 16.2)	5.0 ± 5.5 (0 – 16.2)	0 ± 0 (0 – 0)	34.0 ± 7.7 (20.1 – 49.2)
Semi-trimmed	64.4 ± 7.0 (50.6 – 77.2)	0 ± 0 (0 – 0)	0 ± 0 (0 – 0)	0 ± 0 (0 – 0	35.6 ± 7.0 (22.8 – 49.4)
Edible portion					
Untrimmed	92.9 ± 7.7 (78.4 – 100)	7.1 ± 7.7 (0 – 21.6)	7.1 ± 7.7 (0 – 21.6)	0 ± 0 (0 – 0)	-
Fully-trimmed (backstrap AusMeat 5101)	100 ± 0 (100 – 100)	0 ± 0 (0 – 0)	-	0 ± 0 (0 – 0)	-
Short loin 1-rib (AusMeat 4880)					
As purchased					
Untrimmed	61.0 ± 7.9 (46.3 – 79.1)	11.1 ± 7.7 (0 – 27.0)	11.1 ± 7.7 (0 – 27.0)	0 ± 0 (0 – 0)	27.9 ± 9.1 (9.3 – 50.2)
Semi-trimmed	68.8 ± 8.9 (49.8 – 89.5)	0 ± 0 (0 – 0)	-	0 ± 0 (0 – 0)	31.1 ± 8.9 (10.5 – 50.2)
Edible portion					
Untrimmed	85.1 ± 9.9 (64.7 – 100)	14.9 ± 9.9 (0 – 35.3)	14.9 ± 9.9 (0 – 35.3)	0 ± 0 (0 – 0)	-
Semi-trimmed (AusMeat 5080 + 5150)	100 ± 0 (100 – 100)	0 ± 0 (0 – 0)	-	0 ± 0 (0 – 0)	-
Boneless leg chump on (AusMeat 5060)					
As purchased					
Untrimmed	94.5 ± 4.7 (81.5 – 100)	5.5 ± 4.7 (0 – 18.5)	2.6 ± 2.9 (0 – 10.8)	2.9 ± 2.6 (0 – 11.6)	0 ± 0 (0 – 0)
Semi-trimmed	97.0 ± 2.8 (87.6 – 100)	3.0 ± 2.8 (0 – 12.4)	-	3.0 ± 2.8 (0 – 12.4)	0 ± 0 (0 – 0)
Edible portion					
Untrimmed	94.5 ± 4.7 (81.5 – 100)	5.5 ± 4.7 (0 – 18.5)	2.6 ± 2.9 (0 – 10.8)	2.9 ± 2.6 (0 – 11.6)	-
Semi-trimmed	97.0 ± 2.8 (87.6 – 100)	3.0 ± 2.8 (0 – 12.4)	-	3.0 ± 2.8 (0 – 12.4)	-

Nutrient composition

Nutrient composition: Proximates, vitamins and minerals

Mean values for proximate components are shown in Table 5.

The sum of the measured proximate values (moisture, protein, fat, carbohydrate and ash) for composite samples ranged from 99.9-102.6 g/100g and sum of calculated proximate values for all cuts ranged from 99.2-101.9 g/100g, with all values being within the accepted level of accuracy ranging between 97-103% (Greenfield and Southgate, 2003).

The mean fat content of uncooked cuts was ≤6.5g/100g for untrimmed (as purchased) cuts, ≤5.6g/100g for cap-fat removed rack and loin, ≤4.7g/100g for semi-trimmed shoulder/leg and ≤2.1g/100g for fully trimmed cuts (Table 4a). USDA database lists the fat content of uncooked goatmeat as 2.6g/100g which is higher than the values for fully trimmed goatmeat (1.4g/100g, 1.8g/100g and 2.1g/100g for forequarter, loin and leg respectively) in the present study, but lower than values for untrimmed cuts (Table 4a). Other studies have reported fat content of 2.0-2.3 g/100g in fully trimmed muscle samples (Park et al 1991), similar to the levels in the present study.

Cholesterol levels ranged from 70-80 mg/100g for all cuts with an average of 73mg/100g for fully trimmed cuts (Table 4a). The previously reported level of cholesterol in goatmeat varies with values for uncooked muscles samples of 57 mg/100g (USDA database), 58-69 mg/100g (Park et al 1991), 94-100.3mg/100g (Johnson et al 1995), 67-99 mg/100g (Sheridan et al 2003) and 58.0 – 62.5 mg/100g (Madruga et al 2001) reported in other studies. Madruga et al (2001) demonstrated that castration and slaughter age had a significant effect on total cholesterol, therefore differences in gender and age of goats used in different studies may explain differences in levels of total cholesterol reported.

Carbohydrate content of all cuts was ≤1.0g/100g for all cuts (Table 4a and 4b). Of all the composite samples tested, only the uncooked (raw) separable lean from the forequarter had carbohydrate present at or above the level of detection (1.0g/100g). Total sugars were below the level of reporting (1.0g/100g) for all samples tested.

The mean crude protein content of the uncooked separable lean samples was 22.0g/100g. The mean crude protein levels in different cut ranged from 20.6-22.2g/100g which was comparable to previously reported levels of 18.2-28.6% for Australian beef, veal, lamb and mutton cuts (Williams 2005). The USDA database reports crude protein content of goatmeat at 20.6g/100g (USDA 2010). Webb et al (2005) reviewed a number of studies that reported mean protein content of lean tissue from South African goat breeds ranging from 17.7-29.2%, again comparable to the levels observed in the present study.

The levels of fat-soluble vitamins (A, D and E) were low in separable lean samples (Table 6). Vitamin A (retinol) was above the level of reporting (5 ug/100g) only in separable lean from forequarter (Table 6). The mean cholecalciferol (vitamin D3) level in the uncooked separable lean samples was 0.25ug/100g. Of the 4 Vitamin E isomers included in the assay, only α-tocopherol was measured at or above the level of reporting (0.1 mg/100g) (Table 6). Mean α-Tocopherol was 0.95 mg/100g in the uncooked separable lean from forequarter and leg, but was below the level of reporting (0.1 mg/100g) in separable lean from the loin, both uncooked and cooked

(Table 6). Vitamin E levels for goatmeat were not reported in USDA database (USDA 2011). Mean α-Tocopherol levels 0.2-0.8 have been reported in separable lean from Australian lamb, mutton and beef (Williams et al 2007).

The mean level of thiamin (Vitamin B1) in the uncooked separable lean samples was 0.11 mg/100g and 0.025 mg/100g in the uncooked fat sample (Table 7). This was similar to the levels reported in USDA database of 0.11 mg/100g (USDA 2011), 0.1mg/100g reported by Casey et al (2003). Johnson et al (1995) also reported a similar level of 0.19-0.22 mg/100g for broiled goatmeat.

The mean level of riboflavin (vitamin B2) in uncooked separable lean was 0.08 mg/100g and in uncooked fat was 0.025 mg/100g (Table 7). This was lower than the level of 0.49 mg/100g reported in USDA database (USDA 2011), 0.56 mg/100g reported by Casey et al (2003) for uncooked goatmeat and 0.25-0.27 mg/100g reported by Johnson et al (1995) for broiled goatmeat, but similar riboflavin levels (0.07-0.25 mg/100g) have been reported for uncooked separable lean from Australian beef, lamb and mutton using similar analytical methods to those used in this study (Williams et al 2007).

The mean level of niacin (vitamin B3) in uncooked separable lean was 3.6 mg/100g and in uncooked fat was 1.5 mg/100g (Table 7). This level was similar to levels of 3.75 mg/100g reported in USDA (2010) and 3.6 mg/100g reported by Casey et al (2003) for uncooked goatmeat and 3.5-3.7 mg/100g reported by Johnson et al (1995) for broiled goatmeat.

The mean levels of pantothenic acid (vitamin B5) and pyroxidine (vitamin B6) in uncooked separable lean were 0.29 mg/100g and 0.04 mg/100g respectively. Levels of pantothenic acid and pyroxidine were not reported in USDA database (2010).

The mean level of total folate in uncooked separable lean was 21 ug/100g (Table 7). This was higher than the level of 5 ug/100g reported for goatmeat in the USDA database (2010). Differences in storage and handling of samples and also analytical methods can explain variability of total folate measured in meat samples between different studies.

The mean level of Vitamin B12 (cobalamin) in uncooked separable lean was 1.0 ug/100g (Table 7). Vitamin B12 levels were lower in loin samples than forequarter or leg for both cooked and uncooked samples (Table 6). The level of cobalamin was similar to levels of 1.1 ug/100g reported in USDA database (2010) for uncooked goatmeat and 1.09-1.12 ug/100g reported by Johnson et al (1995) for broiled goatmeat.

The mean level of iron in uncooked separable lean was 2.6g/100g (Table 8). This is similar to the level of 2.83g reported in the USDA database (2010). Other studies have reported iron levels in muscle of 2.1 mg/100g (Webb et al 2005) and 1.01-1.78 mg/100g (Sheridan et al 2003).

Table 5: Summary of proximates, energy (by calculation) and cholesterol of goatmeat cuts (per 100g edible portion)

	Moisture g/100g	**Crude protein** g/100g	**Total Fat (Soxhlet)** g/100g	**Ash** g/100g	**Carbohydrates** g/100g	**Total sugars** g/100g	**Energy** kJ/100g	**Cholesterol** mg/100g
Uncooked								
Boneless shoulder								
Untrimmed	71.5	20.6	5.5	1.0	<1.0	<1.0	566	77
Semi trimmed	71.8	20.7	4.7	1.0	<1.0	<1.0	540	76
Diced shoulder meat								
Untrimmed	71.5	20.6	5.5	1.0	<1.0	<1.0	566	77
Fully trimmed	74.6	21.6	1.8	1.1	1.0	<1.0	445	72
Rack								
Untrimmed	71.7	21.1	6.5	1.0	<1.0	<1.0	596	77
Cap fat removed	72.3	21.3	5.6	1.0	<1.0	<1.0	568	76
Loin								
Untrimmed	71.9	21.1	6.2	1.0	<1.0	<1.0	587	76.9
Cap fat removed	73.4	21.6	4.0	1.0	<1.0	<1.0	516	74
Backstrap + tenderloin								
Fully trimmed	75.2	22.2	1.4	1.0	<1.0	<1.0	430	70
Boneless leg								
Untrimmed	72.3	21.4	5.0	1.0	<1.0	<1.0	547	80
Semi trimmed	73.7	21.8	4.0	1.0	<1.0	<1.0	516	79
Diced leg meat								
Untrimmed	72.3	21.4	5.0	1.0	<1.0	<1.0	547	80
Fully trimmed	75.0	22.2	2.1	1.0	<1.0	<1.0	455	77
Composite samples								
Forequarter lean	74.6	21.6	1.8	1.1	1.0	<1.0	445	72
Loin lean	75.2	22.2	1.4	1.0	<1.0	<1.0	430	70
Leg lean	75.0	22.2	2.1	1.0	<1.0	<1.0	455	77
Fat (pooled)	45.4	12.2	44.6	0.6	<1.0	<1.0	1855	129

Table 5 (continued): Summary of proximates, energy (by calculation) and cholesterol of goatmeat cuts (per 100g edible portion)

	Moisture g/100g	**Crude protein** g/100g	**Total Fat (Soxhlet)** g/100g	**Ash** g/100g	**Carbohydrates** g/100g	**Total sugars** g/100g	**Energy** kJ/100g	**Cholesterol** mg/100g
Cooked (roasted)								
Boneless shoulder								
Untrimmed	60.9	28.8	9.6	1.0	<1.0	<1.0	846	139
Semi trimmed	62.1	29.5	7.8	1.1	<1.0	<1.0	790	141
Diced shoulder meat								
Untrimmed	60.9	28.8	9.6	1.0	<1.0	<1.0	846	139
Fully trimmed	64.4	30.8	4.2	1.1	<1.0	<1.0	675	145
Rack								
Untrimmed	64.7	27.9	7.5	0.9	<1.0	<1.0	749	97
Semi trimmed	67.6	29.2	3.1	1.0	<1.0	<1.0	610	98
Loin								
Untrimmed	61.5	26.4	12.2	0.9	<1.0	<1.0	900	95
Semi trimmed	67.6	29.2	3.1	1.0	<1.0	<1.0	610	98
Backstrap + tenderloin								
Fully trimmed	67.6	29.2	3.1	1.0	<1.0	<1.0	610	98
Boneless leg								
Untrimmed	61.6	32.5	6.6	1.2	<1.0	<1.0	793	113
Semi trimmed	62.5	33.1	5.1	1.2	<1.0	<1.0	746	114
Diced leg meat								
Untrimmed	61.6	32.5	6.6	1.2	<1.0	<1.0	793	113
Fully trimmed	63.6	33.8	3.2	1.2	<1.0	<1.0	690	116
Composite samples								
Forequarter lean	64.4	30.8	4.2	1.1	<1.0	<1.0	675	145
Loin lean	67.6	29.2	3.1	1.0	<1.0	<1.0	610	98
Leg lean	63.6	33.8	3.2	1.2	<1.0	<1.0	690	116
Fat (pooled)	26.4	10.0	64.5	0.6	<1.0	<1.0	2555	75

Table 6: Summary of fat-soluble vitamin content of composite goatmeat samples

	Vitamin A			**Vitamin D**		**Vitamin E**			
	α-carotene µg/100g	**β-carotene** µg/100g	**Retinol** µg/100g	**25-hydroxy vitamin D3** µg/100g	**Cholecalciferol (vitamin D3)** µg/100g	**α-tocopherol** mg/100g	**β-tocopherol** mg/100g	**δ-tocopherol** mg/100g	**γ-tocopherol** mg/100g
Uncooked									
Forequarter lean	<5	<5	5.5	0.06	0.30	1.3	<0.1	<0.1	<0.1
Loin lean	<5	<5	<5	<0.05	0.21	<0.1	<0.1	<0.1	<0.1
Leg lean	<5	<5	<5	<0.05	0.23	0.6	<0.1	<0.1	<0.1
Fat (pooled)	<5	<5	65.5	0.44	1.66	3.7	<0.1	<0.1	<0.1
Cooked (roasted)									
Forequarter lean	<5	<5	5.8	<0.05	0.25	1.65	<0.1	<0.1	<0.1
Loin lean	<5	<5	<5	<0.05	0.36	<0.1	<0.1	<0.1	<0.1
Leg lean	<5	<5	<5	<0.05	0.33	0.45	<0.1	<0.1	<0.1
Fat (pooled)	-	-	-	-	-	-	-	-	-

Table 7: Summary of water-soluble vitamin content of composite goatmeat cuts

	Thiamin (Vit B1) mg/100g	**Riboflavin (Vit B2)** mg/100g	**Niacin (Vit B3)** mg/100g	**Pantothenic acid (Vit B5)** mg/100g	**Pyroxidine (Vit B6)** mg/100g	**Cobalamin (Vit B12)** µg/100g	**Total Folate** µg/100g
Uncooked							
Boneless shoulder							
Untrimmed	0.11	0.07	3.03	0.34	0.03	1.30	29.4
Semi trimmed	0.11	0.08	3.05	0.34	0.03	1.30	29.7
Diced shoulder meat							
Untrimmed	0.11	0.07	3.03	0.34	0.03	1.30	29.4
Fully trimmed	0.12	0.08	3.20	0.36	0.04	1.30	31.5
Rack							
Untrimmed	0.08	0.05	3.71	0.18	0.05	0.73	8.7
Cap fat removed	0.08	0.05	3.76	0.18	0.05	0.71	8.6
Loin							
Untrimmed	0.08	0.05	3.73	0.18	0.05	0.72	8.7
Cap fat removed	0.09	0.05	3.85	0.18	0.05	0.68	8.6
Backstrap + tenderloin							
Fully trimmed	0.09	0.06	4.00	0.18	0.05	0.63	8.5
Boneless leg							
Untrimmed	0.13	0.09	3.47	0.31	0.04	1.00	21.9
Semi trimmed	0.13	0.10	3.56	0.32	0.04	0.99	22.4
Diced leg meat							
Untrimmed	0.13	0.09	3.47	0.31	0.04	1.00	21.9
Fully trimmed	0.14	0.10	3.65	0.33	0.04	0.97	23.0
Composite samples							
Forequarter lean	0.12	0.08	3.20	0.36	0.04	1.30	31.5
Loin lean	0.09	0.06	4.00	0.18	0.05	0.63	8.5
Leg lean	0.14	0.10	3.65	0.33	0.04	0.97	23.0
Fat (pooled)	0.03	0.03	1.50	0.14	0.02	1.49	10.0
Cooked (roasted)							
Composite samples							
Forequarter lean	0.05	0.06	3.25	0.15	0.02	2.83	21.0
Loin lean	0.05	0.04	4.10	0.10	0.02	2.30	23.0
Leg lean	0.06	0.05	3.60	0.08	0.02	2.70	14.0
Fat (pooled)	-	-	-	-	-	-	-

Table 8: Mineral content of uncooked goatmeat

	Calcium mg/100g	**Copper** mg/100g	**Iron** mg/100g	**Magnesium** mg/100g	**Manganese** mg/100g	**Phosphorus** mg/100g	**Potassium** mg/100g	**Selenium** mg/100g	**Sodium** mg/100g	**Zinc** mg/100g
Uncooked										
Boneless shoulder										
Untrimmed	9.97	0.08	2.30	18.78	<0.5	169.96	296.43	0.01	70.55	4.73
Semi trimmed	9.89	0.08	2.30	18.94	<0.5	171.24	298.86	0.01	70.84	4.78
Diced shoulder meat										
Untrimmed	9.97	0.08	2.30	18.78	<0.5	169.96	296.43	0.01	70.55	4.73
Fully trimmed	9.75	0.08	2.35	20.00	<0.5	180.00	315.00	0.01	73.50	5.10
Rack										
Untrimmed	10.22	0.08	2.84	20.30	<0.5	172.51	314.91	0.01	72.82	3.23
Cap fat removed	10.16	0.08	2.86	20.59	<0.5	174.63	319.16	0.01	73.45	3.28
Loin										
Untrimmed	10.20	0.08	2.85	20.40	<0.5	173.24	316.37	0.01	73.04	3.25
Cap fat removed	10.04	0.08	2.89	21.12	<0.5	178.54	327.01	0.01	74.60	3.36
Backstrap + tenderloin										
Fully trimmed	9.85	0.08	2.95	22.00	<0.5	185.00	340.00	0.01	76.50	3.50
Boneless leg										
Untrimmed	6.84	0.09	2.44	20.80	<0.5	180.57	322.12	0.01	62.57	3.68
Semi trimmed	6.73	0.09	2.48	21.37	<0.5	185.13	330.65	0.01	63.65	3.78
Diced leg meat										
Untrimmed	6.84	0.09	2.44	20.80	<0.5	180.57	322.12	0.01	62.57	3.68
Fully trimmed	6.45	0.09	2.50	22.00	<0.5	190.00	340.00	0.01	64.50	3.90
Composite samples										
Forequarter lean	9.75	0.08	2.35	20.00	<0.5	180.00	315.00	0.01	73.50	5.10
Loin lean	9.85	0.08	2.95	22.00	<0.5	185.00	340.00	0.01	76.50	3.50
Leg lean	6.45	0.09	2.50	22.00	<0.5	190.00	340.00	0.01	64.50	3.90
Fat (pooled)	13.00	0.04	2.00	7.45	<0.5	78.00	125.00	0.01	45.00	1.20

Table 8 (continued): Mineral content of cooked goatmeat

	Calcium mg/100g	**Copper** mg/100g	**Iron** mg/100g	**Magnesium** mg/100g	**Manganese** mg/100g	**Phosphorus** mg/100g	**Potassium** mg/100g	**Selenium** mg/100g	**Sodium** mg/100g	**Zinc** mg/100g
Cooked (roasted)										
Boneless shoulder										
Untrimmed	9.38	0.12	3.20	21.95	<0.5	186.71	293.15	0.02	70.49	7.10
Semi trimmed	9.45	0.13	3.27	22.30	<0.5	189.46	297.08	0.02	71.49	7.25
Diced shoulder meat										
Untrimmed	9.38	0.12	3.20	21.95	<0.5	186.71	293.15	0.02	70.49	7.10
Fully trimmed	9.60	0.13	3.40	23.00	<0.5	195.00	305.00	0.02	73.50	7.55
Rack										
Untrimmed	15.37	0.09	2.83	20.79	<0.5	179.22	309.65	0.01	81.36	4.04
Semi trimmed	16.00	0.09	2.95	21.50	<0.5	185.00	320.00	0.01	84.50	4.15
Loin										
Untrimmed	14.69	0.09	2.70	20.01	<0.5	172.93	298.39	0.01	77.94	3.93
Semi trimmed	16.00	0.09	2.95	21.50	<0.5	185.00	320.00	0.01	84.50	4.15
Backstrap + tenderloin										
Fully trimmed	16.00	0.09	2.95	21.50	<0.5	185.00	320.00	0.01	84.50	4.15
Boneless leg										
Untrimmed	7.81	0.16	3.71	24.73	<0.5	218.32	326.17	0.02	59.40	5.96
Semi trimmed	7.83	0.16	3.77	25.08	<0.5	221.39	330.23	0.02	59.90	6.05
Diced leg meat										
Untrimmed	7.81	0.16	3.71	24.73	<0.5	218.32	326.17	0.02	59.40	5.96
Fully trimmed	7.85	0.17	3.85	25.50	<0.5	225.00	335.00	0.02	60.50	6.15
Composite samples										
Forequarter lean	9.60	0.13	3.40	23.00	<0.5	195.00	305.00	0.02	73.50	7.55
Loin lean	16.00	0.09	2.95	21.50	<0.5	185.00	320.00	0.01	84.50	4.15
Leg lean	7.85	0.17	3.85	25.50	<0.5	225.00	335.00	0.02	60.50	6.15
Fat (pooled)	7.20	0.06	1.25	11.50	0.01	104.00	175.00	0.01	40.50	2.65

Fatty acids

The saturated fatty acid content of goatmeat cuts are shown in Tables 9a and 9b. Saturated fatty acids accounted for 47.8% total fatty acids in uncooked separable lean (Table 9a), but the low level of overall fat present meant that average saturated fat content of lean goatmeat was 0.82g/100g (uncooked cuts) and 1.61g/100g (cooked cuts). All of the uncooked goat cuts included in the study had ≤3.4g/100g saturated fat (including the untrimmed cuts) and the leg and shoulder cuts were ≤2.85g/100g saturated fat.

The monounsaturated fatty acid content of goatmeat cuts are shown in Tables 10a and 10b. Monounsaturated fatty acids accounted for 41.1% total fatty acids in uncooked separable lean (Table 10a). Mean monounsaturated fat content of uncooked separable lean was 0.68g/100g (Table 10b). All of the uncooked goat cuts included in the study had ≤2.36g/100g monounsaturated fat, including the untrimmed cuts and the leg and shoulder cuts were ≤2.05g/100g monounsaturated fat.

The n-6 fatty acid content of goatmeat cuts are shown in Tables 11a and 11b. Dissectible lean samples had mean n-6 fatty acid content <0.1g/100g in uncooked samples and 0.27g/100g in cooked samples. Uncooked (raw) dissectible fat had 0.7g/100g n-6 fats and cooked dissectible fat had 1.15g/100g n-6 fats.

The n-3 fatty acid content of goatmeat cuts are shown in Tables 12a and 12b. Dissectible lean samples had mean n-3 fatty acid content <0.1g/100g in uncooked samples and cooked loin. Cooked dissectible lean samples from forequarter and leg had 0.1g/100g n-3 fatty acids. Both raw and cooked dissectible fat had 0.4g/100g n-3 fatty acids.

Trans fats (monounsaturated and polyunsaturated) were <0.1g/100g in all separable lean samples (uncooked and cooked). Mean trans fatty acids in uncooked separable fat was 1.3g/100g and in cooked separable fat was 2.1g/100g.

Table 9a: Saturated fatty acid profile goatmeat (g/100g)

	Saturated fatty acids g/100g edible portion *					**Total saturated fat** g/100g edible portion
	C14:0	C15:0	C16:0	C17:0	C18:0	
Uncooked						
Boneless shoulder						
Untrimmed	0.14	0.04	1.27	0.11	1.37	2.82
Semi trimmed	0.12	0.03	1.09	0.09	1.16	2.40
Diced shoulder meat						
Untrimmed	0.14	0.04	1.27	0.11	1.37	2.82
Fully trimmed	0.04	0.01	0.38	0.03	0.33	0.75
Rack						
Untrimmed	0.17	0.05	1.51	0.13	1.66	3.39
Semi trimmed	0.15	0.04	1.31	0.11	1.42	2.92
Loin						
Untrimmed	0.16	0.05	1.44	0.12	1.58	3.23
Semi trimmed	0.10	0.03	0.94	0.07	0.99	2.04
Backstrap + tenderloin						
Fully trimmed	0.03	0.01	0.33	0.02	0.26	0.60
Boneless leg						
Untrimmed	0.12	0.04	1.19	0.10	1.31	2.70
Semi trimmed	0.09	0.03	0.94	0.07	1.02	2.12
Diced leg meat						
Untrimmed	0.12	0.04	1.19	0.10	1.31	2.70
Fully trimmed	0.03	0.01	0.51	0.04	0.51	1.10
Composite samples						
Forequarter separable lean	0.04	0.01	0.38	0.03	0.33	0.75
Loin separable lean	0.03	0.01	0.33	0.02	0.26	0.60
Leg separable lean	0.03	0.01	0.51	0.04	0.51	1.10
Fat (pooled)	1.27	0.38	10.51	0.94	12.18	24.50
Cooked (roasted)						
Boneless shoulder						
Untrimmed	0.22	0.07	2.09	0.19	2.18	4.60
Semi trimmed	0.17	0.05	1.69	0.15	1.71	3.65
Diced shoulder meat						
Untrimmed	0.22	0.07	2.09	0.19	2.18	4.60
Fully trimmed	0.08	0.02	0.87	0.06	0.77	1.75
Rack						
Untrimmed	0.16	0.05	1.66	0.16	1.88	3.79
Semi trimmed	0.05	0.02	0.69	0.05	0.77	1.55
Loin						
Untrimmed	0.28	0.09	2.72	0.28	3.08	6.24
Semi trimmed	0.05	0.02	0.69	0.05	0.77	1.55
Backstrap + tenderloin						
Fully trimmed	0.05	0.02	0.69	0.05	0.77	1.55
Boneless leg						
Untrimmed	0.11	0.04	1.35	0.14	1.72	3.29
Semi trimmed	0.07	0.03	1.01	0.10	1.33	2.49
Diced leg meat						
Untrimmed	0.11	0.04	1.35	0.14	1.72	3.29
Fully trimmed	0.02	0.01	0.60	0.06	0.87	1.55
Composite samples						
Forequarter separable lean	0.08	0.02	0.87	0.06	0.77	1.75
Loin separable lean	0.05	0.02	0.69	0.05	0.77	1.55
Leg separable lean	0.02	0.01	0.60	0.06	0.87	1.55
Fat (pooled)	1.58	0.52	14.32	1.55	16.22	33.00

* Calculated (% total fatty acids x % Soxhlet fat)

Table 9b: Saturated fatty acid profile of goatmeat s (% total fatty acids)

	Saturated fatty acids % total fatty acids					**Total saturated fat** % total fatty acids
	C14:0	C15:0	C16:0	C17:0	C18:0	
Uncooked						
Boneless shoulder						
Untrimmed	2.1	0.5	21.9	1.5	19.7	46.1
Semi trimmed	2.0	0.5	21.8	1.5	19.5	45.8
Diced shoulder meat						
Untrimmed	2.1	0.5	21.9	1.5	19.7	46.1
Fully trimmed	2.0	0.5	21.9	1.5	19.1	45.4
Rack						
Untrimmed	1.9	0.5	22.6	1.4	19.4	46.4
Semi trimmed	1.9	0.5	22.6	1.4	19.2	46.2
Loin						
Untrimmed	1.9	0.5	22.6	1.4	19.3	46.3
Semi trimmed	1.9	0.5	22.5	1.4	18.8	45.7
Backstrap + tenderloin						
Fully trimmed	1.8	0.5	22.5	1.4	18.3	45.0
Boneless leg						
Untrimmed	1.7	0.5	24.0	1.7	24.2	53.0
Semi trimmed	1.7	0.5	24.2	1.7	24.4	53.3
Diced leg meat						
Untrimmed	1.7	0.5	24.0	1.7	24.2	53.0
Fully trimmed	1.6	0.5	24.3	1.7	24.3	53.2
Composite samples						
Forequarter separable lean	2.0	0.5	21.9	1.5	19.1	45.4
Loin separable lean	1.8	0.5	22.5	1.4	18.3	45.0
Leg separable lean	1.6	0.5	24.3	1.7	24.3	53.2
Fat (pooled)	2.9	0.9	23.6	2.1	27.4	57.5
Cooked (roasted)						
Boneless shoulder						
Untrimmed	2.0	0.5	21.0	1.5	19.1	44.7
Semi trimmed	1.9	0.5	21.0	1.5	18.9	44.4
Diced shoulder meat						
Untrimmed	2.0	0.5	21.0	1.5	19.1	44.7
Fully trimmed	1.9	0.5	20.9	1.4	18.5	43.9
Rack						
Untrimmed	1.7	0.5	22.2	1.7	25.0	52.0
Semi trimmed	1.7	0.5	22.2	1.7	25.0	51.9
Loin						
Untrimmed	1.8	0.5	22.2	1.8	25.0	52.1
Semi trimmed	1.7	0.5	22.2	1.7	25.0	51.9
Backstrap + tenderloin						
Fully trimmed	1.7	0.5	22.2	1.7	25.0	51.9
Boneless leg						
Untrimmed	0.7	0.4	18.6	1.8	26.8	49.3
Semi trimmed	0.7	0.4	18.5	1.8	26.8	49.2
Diced leg meat						
Untrimmed	0.7	0.4	18.6	1.8	26.8	49.3
Fully trimmed	0.7	0.4	18.4	1.8	26.9	49.1
Composite samples						
Forequarter separable lean	1.9	0.5	20.9	1.4	18.5	43.9
Loin separable lean	1.7	0.5	22.2	1.7	25.0	51.9
Leg separable lean	0.7	0.4	18.4	1.8	26.9	49.1
Fat (pooled)	2.5	0.8	22.2	2.4	25.2	53.5

Table 10a: Monounsaturated fatty acid profile of goatmeat (g/100g)

	Monounsaturated fatty acids g/100g *				**Total mono-unsaturated fat** g/100g	**Total trans mono-unsaturated fat** g/100g
	C14:1	C16.1	C17.1	C18.1		
Uncooked						
Boneless shoulder						
Untrimmed	0.01	0.13	0.06	1.95	2.05	<0.18
Semi trimmed	<0.01	0.11	0.05	1.70	1.79	<0.17
Diced shoulder meat						
Untrimmed	0.01	0.13	0.06	1.95	2.05	<0.18
Fully trimmed	<0.01	0.04	0.02	0.72	0.75	<0.10
Rack						
Untrimmed	0.01	0.15	0.06	2.24	2.36	<0.21
Semi trimmed	0.01	0.13	0.05	1.96	2.06	<0.19
Loin						
Untrimmed	0.01	0.15	0.05	2.14	2.26	<0.20
Semi trimmed	<0.01	0.10	0.03	1.44	1.51	<0.16
Backstrap + tenderloin						
Fully trimmed	<0.01	0.03	0.00	0.58	0.60	<0.10
Boneless leg						
Untrimmed	<0.01	0.11	0.04	1.65	1.72	<0.16
Semi trimmed	<0.01	0.09	0.03	1.30	1.35	<0.14
Diced leg meat						
Untrimmed	<0.01	0.11	0.04	1.65	1.72	<0.16
Fully trimmed	<0.01	0.04	0.01	0.68	0.70	<0.10
Composite samples						
Forequarter separable lean	<0.01	0.04	0.02	0.72	0.75	<0.10
Loin separable lean	<0.01	0.03	0.00	0.58	0.60	<0.10
Leg separable lean	<0.01	0.04	0.01	0.68	0.70	<0.10
Fat (pooled)	0.04	1.07	0.47	14.79	15.70	1.05
Cooked (roasted)						
Boneless shoulder						
Untrimmed	0.01	0.23	0.11	3.67	3.86	<0.26
Semi trimmed	0.01	0.18	0.09	3.01	3.16	<0.21
Diced shoulder meat						
Untrimmed	0.01	0.23	0.11	3.67	3.86	<0.26
Fully trimmed	<0.01	0.10	0.04	1.67	1.75	<0.10
Rack						
Untrimmed	0.01	0.17	0.08	2.69	2.80	<0.23
Semi trimmed	<0.01	0.07	0.02	1.08	1.10	<0.10
Loin						
Untrimmed	0.01	0.28	0.14	4.45	4.65	<0.37
Semi trimmed	<0.01	0.07	0.02	1.08	1.10	<0.10
Backstrap + tenderloin						
Fully trimmed	<0.01	0.07	0.02	1.08	1.10	<0.10
Boneless leg						
Untrimmed	0.01	0.12	0.06	2.21	2.32	<0.20
Semi trimmed	0.01	0.09	0.04	1.63	1.71	<0.15
Diced leg meat						
Untrimmed	0.01	0.12	0.06	2.21	2.32	<0.20
Fully trimmed	<0.01	0.04	0.02	0.95	1.00	<0.10
Composite samples						
Forequarter separable lean	<0.01	0.10	0.04	1.67	1.75	<0.10
Loin separable lean	<0.01	0.07	0.02	1.08	1.10	<0.10
Leg separable lean	<0.01	0.04	0.02	0.95	1.00	0.10
Fat (pooled)	0.06	1.48	0.77	23.70	24.95	1.90

* Calculated (% total fatty acids x % Soxhlet fat)

Table 10b: Monounsaturated fatty acid profile of goatmeat (% fatty acids)

	Monounsaturated fatty acids % total fatty acids				**Total mono-unsaturated fat** % total fatty acids
	C14:1	C16.1	C17.1	C18.1	
Uncooked					
Boneless shoulder					
Untrimmed	0.1	2.4	1.0	40.3	43.9
Semi trimmed	0.1	2.4	1.0	40.3	43.9
Diced shoulder meat					
Untrimmed	0.1	2.4	1.0	40.3	43.9
Fully trimmed	0.1	2.5	1.0	41.3	44.9
Rack					
Untrimmed	<0.1	2.4	0.3	39.3	42.5
Semi trimmed	<0.1	2.4	0.3	39.4	42.6
Loin					
Untrimmed	<0.1	2.4	0.3	39.3	42.5
Semi trimmed	<0.1	2.4	0.3	39.7	42.8
Backstrap + tenderloin	<0.1				
Fully trimmed	<0.1	2.4	0.3	40.1	43.2
Boneless leg					
Untrimmed	<0.1	2.1	0.4	32.2	35.0
Semi trimmed	<0.1	2.1	0.4	32.5	35.3
Diced leg meat					
Untrimmed	<0.1	2.1	0.4	32.2	35.0
Fully trimmed	<0.1	2.1	0.4	32.5	35.3
Composite samples					
Forequarter separable lean	0.1	2.5	1.0	41.3	44.9
Loin separable lean	<0.1	2.4	0.3	40.1	43.2
Leg separable lean	<0.1	2.1	0.4	32.5	35.3
Fat (pooled)	0.1	2.4	1.1	33.2	36.9
Cooked (roasted)					
Boneless shoulder					
Untrimmed	<0.1	2.4	1.1	39.8	43.6
Semi trimmed	<0.1	2.4	1.1	39.9	43.7
Diced shoulder meat					
Untrimmed	<0.1	2.4	1.1	39.8	43.6
Fully trimmed	0.1	2.4	1.1	40.2	43.9
Rack					
Untrimmed	<0.1	2.2	0.8	34.9	38.6
Semi trimmed	<0.1	2.2	0.8	34.8	38.5
Loin					
Untrimmed	<0.1	2.2	0.9	35.1	38.8
Semi trimmed	<0.1	2.2	0.8	34.8	38.5
Backstrap + tenderloin					
Fully trimmed	<0.1	2.2	0.8	34.8	38.5
Boneless leg					
Untrimmed	<0.1	1.4	0.5	29.8	32.4
Semi trimmed	<0.1	1.4	0.5	29.6	32.2
Diced leg meat					
Untrimmed	<0.1	1.4	0.5	29.8	32.4
Fully trimmed	<0.1	1.4	0.5	29.4	32.0
Composite samples					
Forequarter separable lean	0.1	2.4	1.1	40.2	43.9
Loin separable lean	<0.1	2.2	0.8	34.8	38.5
Leg separable lean	<0.1	1.4	0.5	29.4	32.0
Fat (pooled)	<0.1	2.3	1.2	36.8	40.5

Table 11a: n-6 Polyunsaturated fatty acid profile of goatmeat(g/100g)

	n-6 Polyunsaturated fatty acids % total fatty acids							**Total n-6** % total fatty acids
	C18:2 n-6	C18:3 n-6	C20:2 n-6	C20:3 n-6	C20:4 n-6	C22:2 n-6	C22:4 n-6	
Uncooked								
Boneless shoulder								
Untrimmed	0.11	<0.01	<0.01	<0.01	<0.03	<0.01	<0.01	<0.15
Semi trimmed	0.10	<0.00	<0.01	<0.00	<0.03	<0.01	<0.01	<0.14
Diced shoulder meat								
Untrimmed	0.11	<0.01	<0.01	<0.01	<0.03	<0.01	<0.01	<0.15
Fully trimmed	0.05	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	<0.10
Rack								
Untrimmed	0.12	<0.01	<0.01	<0.01	<0.03	<0.01	<0.01	0.17
Semi trimmed	0.11	<0.01	<0.01	<0.01	<0.03	<0.01	<0.01	0.16
Loin								
Untrimmed	0.12	<0.01	<0.01	<0.01	<0.03	<0.00	<0.01	0.17
Semi trimmed	0.09	<0.01	<0.01	<0.01	<0.03	<0.01	<0.01	0.14
Backstrap + tenderloin								
Fully trimmed	0.05	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	0.10
Boneless leg								
Untrimmed	0.12	<0.01	<0.01	<0.01	<0.04	<0.01	<0.01	0.14
Semi trimmed	0.10	<0.01	<0.01	<0.01	<0.04	<0.01	<0.01	0.13
Diced leg meat								
Untrimmed	0.12	<0.01	<0.01	<0.01	<0.04	<0.01	<0.01	0.14
Fully trimmed	0.08	<0.01	<0.01	<0.01	<0.04	<0.01	<0.01	0.10
Composite samples								
Forequarter separable lean	0.05	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	<0.10
Loin separable lean	0.05	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	0.10
Leg separable lean	0.08	<0.01	<0.01	<0.01	0.04	<0.01	<0.01	0.10
Fat (pooled)	0.69	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	0.70
Cooked (roasted)								
Boneless shoulder								
Untrimmed	0.27	<0.01	<0.01	<0.01	<0.08	<0.01	<0.01	0.38
Semi trimmed	0.24	<0.01	<0.01	<0.01	<0.08	<0.01	<0.01	0.35
Diced shoulder meat								
Untrimmed	0.27	<0.01	<0.01	<0.01	<0.08	<0.01	<0.01	0.38
Fully trimmed	0.19	<0.01	<0.01	**0.01**	0.08	<0.01	<0.01	0.30
Rack								
Untrimmed	0.14	<0.01	<0.01	<0.01	<0.05	<0.01	<0.01	0.17
Semi trimmed	0.07	<0.01	<0.01	<0.01	<0.05	<0.01	<0.01	0.10
Loin								
Untrimmed	0.22	<0.01	<0.01	<0.01	<0.05	<0.01	<0.01	0.26
Semi trimmed	0.07	<0.01	<0.01	<0.01	<0.05	<0.01	<0.01	0.10
Backstrap + tenderloin								
Fully trimmed	0.07	<0.01	<0.01	**0.01**	0.05	<0.01	<0.01	0.10
Boneless leg								
Untrimmed	0.23	<0.08	<0.01	<0.01	<0.11	<0.01	<0.01	0.44
Semi trimmed	0.21	<0.08	<0.01	<0.01	<0.11	<0.01	<0.01	0.42
Diced leg meat								
Untrimmed	0.23	<0.08	<0.01	<0.01	<0.11	<0.01	<0.01	0.44
Fully trimmed	0.18	0.08	<0.01	**0.01**	0.11	<0.01	0.01	0.40
Composite samples								
Forequarter separable lean	0.19	<0.01	<0.01	**0.01**	0.08	<0.01	<0.01	0.30
Loin separable lean	0.07	<0.01	<0.01	**0.01**	0.05	<0.01	<0.01	0.10
Leg separable lean	0.18	0.08	<0.01	**0.01**	0.11	<0.01	0.01	0.40
Fat (pooled)	1.10	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	1.15

* Calculated (% total fatty acids x % Soxhlet fat)

Table 11b: n-6 Polyunsaturated fatty acid profile of goatmeat (% fatty acids)

	n-6 Polyunsaturated fatty acids % total fatty acids							**Total n-6** % total fatty acids
	C18:2 n-6	C18:3 n-6	C20:2 n-6	C20:3 n-6	C20:4 n-6	C22:2 n-6	C22:4 n-6	
Uncooked								
Boneless shoulder								
Untrimmed	2.9	<0.1	<0.1	<0.1	<1.5	<0.1	<0.1	4.6
Semi trimmed	2.9	<0.1	<0.1	<0.1	<1.5	<0.1	<0.1	4.7
Diced shoulder meat								
Untrimmed	2.9	<0.1	<0.1	<0.1	<1.5	<0.1	<0.1	4.6
Fully trimmed	3.1	<0.1	<0.1	0.1	1.6	<0.1	0.1	5.0
Rack								
Untrimmed	3.2	<0.1	<0.1	<0.2	<1.9	<0.1	<0.1	5.6
Semi trimmed	3.3	<0.1	<0.1	<0.2	<2.0	<0.1	<0.1	5.7
Loin								
Untrimmed	3.2	<0.1	<0.1	<0.2	<1.9	<0.1	<0.1	5.7
Semi trimmed	3.3	<0.1	<0.1	<0.2	<2.0	<0.1	<0.1	5.9
Backstrap + tenderloin								
Fully trimmed	3.5	<0.1	<0.1	0.3	2.2	<0.1	0.2	6.2
Boneless leg								
Untrimmed	3.5	<0.1	<0.1	<0.2	<1.9	<0.1	<0.1	5.8
Semi trimmed	3.6	<0.1	<0.1	<0.2	<2.0	<0.1	<0.1	6.0
Diced leg meat								
Untrimmed	3.5	<0.1	<0.1	<0.2	<1.9	<0.1	<0.1	5.8
Fully trimmed	3.7	<0.1	<0.1	0.2	2.1	<0.1	0.1	6.2
Composite samples								
Forequarter separable lean	3.1	<0.1	<0.1	0.1	1.6	<0.1	0.1	5.0
Loin separable lean	3.5	<0.1	<0.1	0.3	2.2	<0.1	0.2	6.2
Leg separable lean	3.7	<0.1	<0.1	0.2	2.1	<0.1	0.1	6.2
Fat (pooled)	1.6	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.7
Cooked (roasted)								
Boneless shoulder								
Untrimmed	4.2	<0.1	<0.1	<0.2	<1.8	<0.1	<0.1	6.5
Semi trimmed	4.3	<0.1	<0.1	<0.2	<1.9	<0.1	<0.1	6.6
Diced shoulder meat								
Untrimmed	4.2	<0.1	<0.1	<0.2	<1.8	<0.1	<0.1	6.5
Fully trimmed	4.5	<0.1	<0.1	0.2	2.0	<0.1	0.1	7.0
Rack								
Untrimmed	2.2	<0.1	<0.1	<0.2	<1.5	<0.1	<0.1	4.2
Semi trimmed	2.3	<0.1	<0.1	<0.2	<1.7	<0.1	<0.1	4.4
Loin								
Untrimmed	2.2	<0.1	<0.1	<0.2	<1.4	<0.1	<0.1	4.0
Semi trimmed	2.3	<0.1	<0.1	<0.2	<1.7	<0.1	<0.1	4.4
Backstrap + tenderloin								
Fully trimmed	2.3	<0.1	<0.1	0.2	1.7	<0.1	0.1	4.4
Boneless leg								
Untrimmed	5.4	<2.2	<0.1	<0.3	<3.2	<0.1	<0.1	11.4
Semi trimmed	5.5	<2.3	<0.1	<0.3	<3.3	<0.1	<0.1	11.7
Diced leg meat								
Untrimmed	5.4	<2.2	<0.1	<0.3	<3.2	<0.1	<0.1	11.4
Fully trimmed	5.6	2.4	0.1	0.3	3.4	<0.1	0.2	12.0
Composite samples								
Forequarter separable lean	4.5	<0.1	<0.1	0.2	2.0	<0.1	0.1	7.0
Loin separable lean	2.3	<0.1	<0.1	0.2	1.7	<0.1	0.1	4.4
Leg separable lean	5.6	2.4	0.1	0.3	3.4	<0.1	0.2	12.0
Fat (pooled)	1.7	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.9

Table 12a: n-3 Polyunsaturated fatty acid profile of goatmeat (% fatty acids) (g/100g)

	n-3 Polyunsaturated fatty acids (g/100g)*					**Total n-3** (g/100g)
	C18:3 n-3	C20:3 n-3	C20:5 n-3 EPA	C22:5 n-3 DPA	C22:6 n-3 DHA	
Uncooked						
Boneless shoulder						
Untrimmed	0.04	<0.01	<0.01	0.02	<0.01	0.08
Semi trimmed	0.03	<0.01	<0.01	0.02	<0.01	0.07
Diced shoulder meat						
Untrimmed	0.04	<0.01	<0.01	0.02	<0.01	0.08
Fully trimmed	0.01	<0.01	0.01	0.02	<0.01	0.04
Rack						
Untrimmed	0.05	<0.01	<0.01	0.03	<0.01	0.09
Semi trimmed	0.04	<0.01	<0.01	0.02	<0.01	0.09
Loin						
Untrimmed	0.04	<0.01	<0.01	0.02	<0.01	0.09
Semi trimmed	0.03	<0.01	<0.01	0.02	<0.01	0.07
Backstrap + tenderloin						
Fully trimmed	0.02	<0.01	0.01	0.02	<0.01	0.05
Boneless leg						
Untrimmed	0.03	<0.01	<0.02	0.03	<0.01	0.09
Semi trimmed	0.02	<0.01	<0.02	0.03	<0.01	0.08
Diced leg meat						
Untrimmed	0.03	<0.01	<0.02	0.03	<0.01	0.09
Fully trimmed	0.01	<0.01	0.02	0.03	0.01	0.06
Composite samples						
Forequarter separable lean	0.01	<0.01	0.01	0.02	<0.01	0.04
Loin separable lean	0.02	<0.01	0.01	0.02	<0.01	0.05
Leg separable lean	0.01	<0.01	0.02	0.03	0.01	0.06
Fat (pooled)	0.27	<0.04	<0.04	0.09	<0.04	0.45
Cooked (roasted)						
Boneless shoulder						
Untrimmed	0.06	<0.01	<0.03	0.05	<0.01	0.15
Semi trimmed	0.06	<0.01	<0.03	0.05	<0.01	0.14
Diced shoulder meat						
Untrimmed	0.06	<0.01	<0.03	0.05	<0.01	0.15
Fully trimmed	0.05	<0.01	0.02	0.05	0.01	0.12
Rack						
Untrimmed	0.05	<0.01	<0.02	0.04	<0.01	0.12
Semi trimmed	0.04	<0.01	<0.02	0.03	<0.01	0.09
Loin						
Untrimmed	0.07	<0.01	<0.03	0.05	<0.01	0.14
Semi trimmed	0.04	<0.01	<0.02	0.03	<0.01	0.09
Backstrap + tenderloin						
Fully trimmed	0.04	<0.01	0.02	0.03	0.01	0.09
Boneless leg						
Untrimmed	0.05	<0.01	<0.04	0.06	<0.01	0.15
Semi trimmed	0.05	<0.01	<0.04	0.05	<0.01	0.15
Diced leg meat						
Untrimmed	0.05	<0.01	<0.04	0.06	<0.01	0.15
Fully trimmed	0.04	<0.01	0.04	0.05	0.01	0.14
Composite samples						
Forequarter separable lean	0.05	<0.01	0.02	0.05	0.01	0.12
Loin separable lean	0.04	<0.01	0.02	0.03	0.01	0.09
Leg separable lean	0.04	<0.01	0.04	0.05	0.01	0.14
Fat (pooled)	0.23	<0.06	<0.06	0.13	<0.06	0.39

* Calculated (% total fatty acids x % Soxhlet fat)

Table 12b: n-3 Polyunsaturated fatty acid profile of goatmeat (% fatty acids

	n-3 Polyunsaturated fatty acids (% total fatty acids)					**Total n-3** (% total fatty acids)
	C18:3 n-3	C20:3 n-3	C20:5 n-3 EPA	C22:5 n-3 DPA	C22:6 n-3 DHA	
Uncooked						
Boneless shoulder						
Untrimmed	0.8	<0.1	<0.5	0.9	<0.2	2.3
Semi trimmed	0.8	<0.1	<0.5	0.9	<0.2	2.3
Diced shoulder meat						
Untrimmed	0.8	<0.1	<0.5	0.9	<0.2	2.3
Fully trimmed	0.9	<0.1	0.6	1.0	0.2	2.5
Rack						
Untrimmed	1.1	<0.1	<0.7	1.0	<0.2	3.0
Semi trimmed	1.1	<0.1	<0.7	1.1	<0.2	3.1
Loin						
Untrimmed	1.1	<0.1	<0.7	1.0	<0.2	3.0
Semi trimmed	1.1	<0.1	<0.7	1.1	<0.2	3.2
Backstrap + tenderloin						
Fully trimmed	1.2	<0.1	0.8	1.2	0.2	3.3
Boneless leg						
Untrimmed	0.6	<0.1	<0.7	1.2	<0.2	2.7
Semi trimmed	0.6	<0.1	<0.7	1.3	<0.2	2.8
Diced leg meat						
Untrimmed	0.6	<0.1	<0.7	1.2	<0.2	2.7
Fully trimmed	0.6	<0.1	0.8	1.3	0.3	2.9
Composite samples						
Forequarter separable lean	0.9	<0.1	0.6	1.0	0.2	2.5
Loin separable lean	1.2	<0.1	0.8	1.2	0.2	3.3
Leg separable lean	0.6	<0.1	0.8	1.3	0.3	2.9
Fat (pooled)	0.6	<0.1	<0.1	0.2	<0.1	1.0
Cooked (roasted)						
Boneless shoulder						
Untrimmed	1.0	<0.1	<0.6	1.0	<0.2	2.8
Semi trimmed	1.1	<0.1	<0.6	1.0	<0.2	2.9
Diced shoulder meat						
Untrimmed	1.0	<0.1	<0.6	1.0	<0.2	2.8
Fully trimmed	1.1	<0.1	0.6	1.1	0.2	3.0
Rack						
Untrimmed	1.1	<0.1	<0.6	1.0	<0.2	2.9
Semi trimmed	1.2	<0.1	<0.6	1.1	<0.2	3.1
Loin						
Untrimmed	1.1	<0.1	<0.5	1.0	<0.2	2.7
Semi trimmed	1.2	<0.1	<0.6	1.1	<0.2	3.1
Backstrap + tenderloin						
Fully trimmed	1.2	<0.1	0.6	1.1	0.2	3.1
Boneless leg						
Untrimmed	1.2	<0.1	<1.1	1.5	<0.2	4.0
Semi trimmed	1.3	<0.1	<1.1	1.6	<0.2	4.1
Diced leg meat						
Untrimmed	1.2	<0.1	<1.1	1.5	<0.2	4.0
Fully trimmed	1.3	<0.1	1.2	1.6	0.2	4.3
Composite samples						
Forequarter separable lean	1.1	<0.1	0.6	1.1	0.2	3.0
Loin separable lean	1.2	<0.1	0.6	1.1	0.2	3.1
Leg separable lean	1.3	<0.1	1.2	1.6	0.2	4.3
Fat (pooled)	0.4	<0.1	<0.1	0.2	<0.1	0.6

* Calculated (% total fatty acids x % Soxhlet fat)

Amino acids

The amino acid content of composite samples are shown in Table 13. The amino acid composition of muscle from male kids, young females, castrates and does were summarized and compared to estimated requirements by Webb et al (2005) who concluded that “goatmeat adequately meets the dietary amino acid requirements of an adult consumer”.

Table 13: Amino acid composition of composite goatmeat samples (mg/g)

	Uncooked (raw)					Cooked (roasted)			
	Separable lean				Pooled	Separable lean			
	Forequarter	**Loin**	**Leg**	**Mean**	**fat**	**Forequarter**	**Loin**	**Leg**	**Mean**
Alanine	12.1	11.5	12.3	11.9	5.5	17.1	13.8	17.6	16.1
Arginine	15.8	15.1	15.2	15.3	5.6	23.1	16.6	24.0	21.2
Aspartic Acid	19.7	19.6	17.5	18.9	5.9	27.4	22.0	29.2	26.2
Glutamic Acid	34.2	33.8	29.9	32.6	9.3	48.0	37.1	50.3	45.1
Glycine	10.6	8.7	14.4	11.2	10.2	16.0	13.2	15.1	14.8
Histidine	6.2	6.5	5.4	6.0	1.8	8.4	7.0	9.1	8.2
Isoleucine	10.0	10.1	8.4	9.5	2.2	14.2	11.1	15.3	13.5
Leucine	17.9	17.5	15.1	16.8	4.5	25.2	19.7	26.9	23.9
Lysine	19.5	19.5	16.4	18.5	4.6	26.9	21.6	28.9	25.8
Methionine	5.8	5.9	4.9	5.5	1.1	8.3	6.4	8.9	7.8
Phneylalanine	9.1	8.8	7.8	8.6	2.6	12.9	10.1	13.6	12.2
Proline	9.6	8.2	11.1	9.6	6.5	14.0	11.0	13.6	12.9
Serine	8.4	8.2	7.5	8.0	2.9	11.9	9.4	12.4	11.2
Threonine	9.6	9.7	8.3	9.2	2.5	13.8	10.8	14.6	13.1
Tyrosine	7.6	7.6	6.1	7.1	1.6	10.9	8.3	11.7	10.3
Valine	10.7	10.3	9.0	10.0	3.1	15.1	11.7	15.9	14.2
Total Amino Acids	**206.5**	**200.5**	**189.0**	**198.7**	**69.5**	**293.0**	**229.5**	**306.5**	**276.3**

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Appendix 1: Sampling plan - project design

10 x Boer-cross goats								14 x Pastoral Rangeland goats (8 Goldfields + 6 Murchison) 6 x Feedlot Rangeland							
Forequarter (30)		Loin (30)		Leg (30)				Forequarter (30)		Loin (30)		Leg (30)			
Raw	**Cooked**	Raw	**Cooked**	Raw	**Cooked**			Raw	**Cooked**	Raw	**Cooked**	Raw	**Cooked**		
Samples dissected for gross composition															
Lean	Fat	**Lean**	**Fat**	Lean	Fat	**Lean**	**Fat**	Lean	Fat	**Lean**	**Fat**	Lean	Fat	**Lean**	**Fat**
Composite samples generated and homogenised for proximate analysis and nutrient composition (10x Boer-cross + 14x Rangeland Pastoral)															
Forequarter meat composite sample (comprises 24 animals)				Loin meat composite sample (comprises 24 animals)				Leg meat composite sample (comprises 24 animals)				Fat composite sample (comprises 24 animals)			
Raw		**Cooked**		Raw		**Cooked**		Raw		**Cooked**		Raw		**Cooked**	

Appendix 2: Basic sample collection protocol

Time frame	Action
1 week prior to estimated slaughter date	Confirm that goats are booked in for transport/processing. Confirm nutrition/management history with owner prior to transport. Confirm transport for carcasses to Murdoch University
1 day before slaughter	Liaise with goat transporter and abattoir staff to confirm time of arrival and scheduled time of processing
Kill day - lairage	Inspect and photograph goats
Kill day – kill floor	For each carcass record the: ➢ time of death ➢ sex ➢ ear tag ➢ dentition Label carcass with snap tag Record hot carcass weight and fat score
Kill day – chiller	When carcass fat is firm record fat depth at GR site (12th rib, 110mm from the midline) Photograph carcasses Place plastic cover over carcasses
Kill day - 24 hours	Transport back to Murdoch University – maintain carcasses at 2^{o}C Store carcasses in Meat science lab chiller (2^{o}C) with plastic cover in place
24 hours-36 hours after kill	Butcher to bone out carcass to AusMeat specifications: ➢ Forequarter (4972) ➢ Loin (4860) ➢ Rack (4931) ➢ Tenderloin 5080 ➢ Leg chump on (5060) ➢ Leg chump on (4800) ➢ Leg cuts (5065) All cuts to be: ➢ weighed ➢ photographed ➢ divided into cuts to be dissected raw (right side) and cooked (left side) for each carcass Subsample of LL muscle weighed, trimmed, placed in labelled airtight container and frozen at -20^{o}C Cuts labelled, vacuum-packed and frozen at -20^{o}C

Time frame	Action
2 days – 6 weeks hours after kill	Frozen cuts thawed in vacuum-packs at 2^{o}C for 12-24 hours. Weigh cuts after thawing. Raw samples dissected into lean, heavy connective tissue, fine connective tissue, fat and bone. Muscle and fat samples stored in airtight containers and frozen at -20^{o}C. Cooked samples oven roasted in oven set at 180^{o}C to internal temperature endpoint of 72-78^{o}C and rested 1 minute prior to weighing Cooked samples cooled at 2^{o}C for 12 hours, vacuum-packed and frozen at -20^{o}C. Frozen cuts thawed in vacuum-packs at 2^{o}C for 12-24 hours. Weigh cuts after thawing. Cooked cuts sliced into 1-2cm slices. Dissection of cooked samples into lean, heavy connective tissue, fine connective tissue, internal fat, external fat and bone. Muscle and fat samples stored in airtight containers and frozen at -20^{o}C
6-8 weeks	Loin LL sub-samples freeze dried. Frozen lean and fat samples (cooked and uncooked) thawed at 2^{o}C for 12 hours. 100g subsample from each carcass pooled, minced and then homogenised to produce composite samples. Composite samples placed into airtight containers, frozen at -20^{o}C and dispatched to NMI laboratory within 48 hours.

Appendix 3: NATA accreditation for nutrient composition methodologies

Method Summary of	VL247
Summary Issued	13th March 2007
Trace Elements in food and biota	

Australian Government
National Measurement Institute

Analysis Description	Determination of trace elements in food and biota by inductively coupled plasma-mass spectrometry (ICP-MS) and inductively coupled atomic emission spectrometry (ICP-AES).
Matrix / Matrices	Food and biota
Reference Method(s)	1. USEPA Method 6010B & 6020 2. NMI NSW Method 2.46
Limit of Reporting (LOR)	0.01-0.5 mg/kg for most metals 0.2-1 mg/kg for sodium, potassium, sulfur, phosphorous, iron, calcium, magnesium
NATA Accredited	Yes
Preparation & procedure	Sample is homogenised and a sub-sample (0.2-0.5g) is digested with re-distilled nitric acid on a DigiPrep block for one hour until vigorous reaction is complete. Samples are then transferred to a Milestone microwave to be further digested. After making up to appropriate volume with Milli-Q (high purity) water, the digest is analysed for trace elements using ICP-MS and / or ICP-AES.
Comments, limitations or known interferences	In ICP-MS some elements are prone to interferences from molecular ions, doubly charged ions and isotopes of similar mass. The analysis of matrices containing high concentrations of salts or organic compounds may not be possible for some elements. In some cases the ICP-AES may be an alternative. Spectral interferences are common in ICP-AES due to many excitation lines generated by the plasma.
Equipment used	ICP-MS: Agilent 7500CE ICP-AES: Optima 4300DV
QA Protocols per batch	One blank every 20 samples with a minimum of 2 blanks per batch One sample reference material (SRM) every batch (if available) One sample spike and one blank spike every 20 samples One sample every 10 samples to be analysed in duplicate
Mass of Sample required	
Comments	

Method Summary of	VL286
Summary Issued	February 2008
DETERMINATION OF ASH	

Australian Government
National Measurement Institute

Analysis Description	Determination of ash in food.
Matrix / Matrices	Processed and unprocessed food and beverages.
Reference Method(s)	AOAC 16th Edn. 1995, 923.03 and 900.02
Limit of Reporting (LOR)	0.1g/100g or 0.1g/100ml
NATA Accredited	Yes
Preparation & procedure	Sample must be homogenous. Weigh an appropriate weight of sample into a prepared weighed dish, beaker or crucible. Disperse sample on bottom of container, remove excess moisture on a water bath. Transfer container to muffle furnace and slowly heat to 525°C ± 25°C until all organic matter is destroyed. It may be necessary to dissolve salts in water to allow destruction of occluded carbon particles. Weigh container and ash. Calculate ash content.
Comments, limitations or known interferences	Samples high in sugar swell when heated and may exude from container. If sample ignites particulate matter may be lost with smoke.
Equipment used	Muffle furnace, weighing apparatus. Platinum crucibles are the most suitable containers for the analysis.
QA Protocols per batch	One control (flour sample) per batch At least one duplicate per batch
Mass of Sample required	10 grams
Comments	If ashing is incomplete high results can be obtained. Sulphated ash can be obtained by adding a few drops of sulphuric acid prior to ashing.

Method Summary of	**VL287_Retinol in Food by HPLC**
Summary Issued	**17th September 2008**
Determination of Retinol in Food by HPLC	

Australian Government
National Measurement Institute

Analysis Description	Retinol in Food by HPLC
Matrix / Matrices	Foods and Beverages
Reference Method(s)	Analytical Methods Committee, Analyst, 110, 1019-1026 (1985) Brubacher, G., Muller-Mulot, W. & Southgate, D.A.T. (eds.) (1985). "Methods for the Determination of Vitamins in Food", Elsevier Applied Science Publishers Ltd
Limit of Reporting (LOR)	**5 ug/100g**
NATA Accredited	Yes
Preparation & procedure	**Preparation & Saponification:** Approximately 2-3g of sample is accurately weighed into a 250ml flask and 30 ml of alcoholic KOH is added. The solution is then saponified by stirring constantly overnight at room temperature **Alternative:** Approximately 2-3g of sample is accurately weighed into a 250ml flask and 30ml alcoholic KOH is added. The solution is then placed in a water bath at 80c for 30 minutes. **Extraction:** The saponified sample is cooled. The solution is transferred to a 50ml volumetric flask. 10 ml of the solution is loaded onto a 'Chromobond XTR' column (i.e solid phase extraction) and eluted with petroleum ether. The petroleum ether extract is then reduced under rotary evaporation and then dried under a stream of nitrogen gas. The sample is then made up to a known volume in heptane prior to HPLC analysis. **Determination:** The retinol content of the extracts is separated by normal phase HPLC on a 5um silica column using hexane and iso-propyl alcohol mobile phase. Detection is by PDA at 325 nm absorbance. A spectra is run from 220-400 nm. Results are expressed to two significant figures in units of ug/100g.
Comments, limitations or known interferences	Retinol is sensitive to degradation caused by exposure to oxygen, heat and light. Analyses should be conducted in such a way as to minimise exposure.
Equipment used	Glassware, Balance, HPLC system with PDA detection, Rotary evaporator, filters, tubes, water bath
QA Protocols per batch	One recovery per 10 samples, One duplicate per 10 samples, Control "FAPAS SRM" sample once per batch (10 samples).
Mass of Sample required	For solid samples approximately 2-3g is normally taken, depending on expected concentration of analyte.

Method Summary of	VL288	Australian Government National Measurement Institute
Summary Issued	April 2009	
DETERMINATION OF CHOLESTEROL AND STEROLS IN FOOD PRODUCTS BY GAS-LIQUID CHROMATOGRAPHY		

Analysis Description	The method involves saponification of a test portion with potassium hydroxide in ethanolic solution, the unsaponifiables (sterols) are then extracted with hexane. The extracted sterols are derivatised into trimethyl-silyl ethers and are analyzed by capillary-column gas chromatography.
Matrix / Matrices	Food Commodities
Reference Method(s)	AOAC (1995). Cholesterol in Food Gas Chromatographic Method 976.26, Ch 45 pp. 68-70. Punwar, J.K. (1975) JAOAC, **58**, 804-810. International Olive Oil Council COI/T.20/Doc. no.10/Rev1 2001 **Joint Expert Committee on Food Additives (FAO/WHO)** *69th JECFA (2008) FAO JECFA Monographs 5 (2008)*
Limit of Reporting (LOR)	1 mg/kg solids, 1 mg/L liquids
NATA Accredited	Cholesterol only
Preparation & procedure	**Preparation & Extraction:** **Foods** An homogenous sample is prepared form the supplied sample. A known amount of food is weighed or spiked into a glass vial, 5-a-cholestane internal standard is added and ethanolic potassium hydroxide is added. This mixture is incubated at 60°C for one hour. Water is then added and extracted with hexane. An aliquot of the hexane is blown down to dryness, then derivatised with silyating reagent. The silylated sterol derivatives are then analysed by GC-FID. **Determination:** Separation on dual columns is employed to determine the qualification and quantification of the sterol derivatives. Determinations of Sterols are accomplished by quantitation against standards (also derivatised) of known concentration (where certain phytosterols are not available, elution order based on literature profiles are used to identify and quantitation by extrapolation to internal standard is employed).
Comments, limitations or known interferences	Sterols not NATA accredited
Equipment used	GC-FID
QA Protocols per batch	Multipoint calibrations One reagent blank per 10 samples 1 sample recoveries every 10 samples 1 sample in duplicate for every 10 samples
Mass of Sample required	Typically 10g of samples is required per determination.
Measurement Uncertainty	Typical Measurement Uncertainty for determination of Cholesterol in food is approximately 3% for samples falling mid-calibration range.

Method Summary of	VL 289	Australian Government National Measurement Institute
Summary Issued	October 2009	
Determination of Fatty Acid Profile in Foodstuffs by GC-FID		

Analysis Description	Fatty Acid Profile – including trans fatty acids
Matrix / Matrices	Foods
Reference Method(s)	Bligh & Dwyer, "A Rapid Method of Total Lipid Extraction and Purification", Can.J. Biochem. Physiol., 37, 911-917 Badings & Dejong (1983). J. Chrom., 279, 493-506. McCance & Widdowson (1991). The Composition of Foods. 5th Ed, p 9.
Limit of Reporting (LOR)	FAME's 0.1g/100g
NATA Accredited	Yes
Preparation & procedure	**Preparation:** The sample is homogenised and a sub sample taken (usually 1 to 10g, depending on sample type). Fat is extracted from the sample using either Chloroform/Methanol or Petroleum ether/iso-propyl alcohol. The extract is evaporated under nitrogen. A minimum extracted mass of 0.2g fat is required. The extracted fat is esterified using a methanolic sodium methoxide solution and treatment with sulphuric acid in methanol. The solution is neutralised and re-extracted using n-hexane. The hexane layer is removed, dried using anhydrous sodium sulphate and made to volume, with hexane. **Determination:** The relative proportion of each fatty acid methyl ester in the prepared sample is determined using gas chromatography with flame ionisation detection. Identification of the individual fatty acids is made by retention time against a standard of known fatty acid methyl esters including both cis and trans isomers. The amount of Conjugated Linoleic Acid (CLA) can be also determined from the FAME's chromatogram. **Calculation:** Integration and calculation of proportional methyl ester concentrations is made using instrument software. - CLA is quantitated using a six point external standard calibration. CLA is usually expressed as mg CLA/g fat.
Comments, limitations or known interferences	The results obtained are proportional only, as a percentage (or g/100g) of the FAME's present in the fat extracted from the sample. If a FAME is required to be determined as a proportion of the total sample then a total fat determination of the sample is also required. For most foods FAMES comprise over 95% of the total fat determined using standard mojonnier or soxhlet fat methods. The FAMES reported range from C4 (Butyric acid) to C24:1 chain lengths. Trans fatty acids are also determined using this method.
Equipment used	Vials and other glassware. Balance, Dionex ASE 200 and Dionex SE 500 Nitrogen gas evaporation manifold Gas Chromatograph equipped with a Flame Ionisation Detector. Software for interpretation/ calculation of results.
QA Protocols per batch	1 control plant oil and 1 control fat are run with each batch. Minimum of 1 duplicate analysis per batch – maximum batch size; 19 samples.
Mass of Sample required	10g
Comments	

Method Summary of	VL290_Thiamine & Riboflavin in Food by HPLC
Summary Issued	11th December 2009

Australian Government
National Measurement Institute

Determination of Thiamine & Riboflavin in Food by HPLC

Analysis Description	Thiamine & Riboflavin in Food by HPLC
Matrix / Matrices	Foods
Reference Method(s)	- European Committee for Standardisation, European Standard EN 14122:2003/AC, Foodstuffs – Determination of vitamin B1 by HPLC. - European Committee for Standardisation, European Standard I.S. EN 14152:2003, Foodstuffs – Determination of vitamin B2 by HPLC. - AOAC (1995) Thiamine Fluorometric Methods 942.23 Ch 45 pp. 6-8, 957 Ch 45 pp. 8-9. - Wehling, R. L. and Wetzel, D. L. (1984). J. Agric. Food Chem., 32, 1326-1331 - Wimalasiri, P. and Wills, R. B. H. (1985). J. Chromatography, 318, 412-416
Limit of Reporting (LOR)	**0.05 mg/100g**
NATA Accredited	Yes
Preparation & procedure	**Preparation & Extraction:** Thiamin (vitamin B1) and riboflavin (vitamin B2) are extracted from food by acid hydrolysis followed by enzymatic digestion using clarase (a-amylase). 17.5ml 0.05M sulphuric acid is added to approx. 1g, accurately weighed sample in a tube. Acid hydrolysis is then undertaken in a boiling water bath for 30 minutes. The sample is then rapidly cooled and 2% amylase solution added. The sample solution is then warmed at 55°C for 1 hour. The extract is filtered and ready for HPLC determination of riboflavin. **Determinations:** **Riboflavin:** Riboflavin in the sample filtrate is separated and determined by reverse phase HPLC on a C18 column using fluorescence detection. Separation is made using 88% acetonitrile and 12% 0.05M sodium acetate buffer and determined directly using an excitation wavelength of 450nm and an emission wavelength of 530nm. **Thiamin:** Thiamine is oxidised to thiochrome using potassium ferricyanide. Thiochrome is then separated on a C18 column using acetonitrile and sodium acetate buffer. Determination is by fluorescence detection using an excitation wavelength of 368nm an emission wavelength of 440nm. **Thiamin for samples containing Cocoa (e.g. Milo)** Cocoa containing samples (e.g. milo) may contain thiochrome-reaction inhibiting substances. "Clean up" step on ion exchange resin is required to remove those substances. Results are expressed to two significant figures in units of mg/100g.
Comments, limitations or known interferences	The method is generally quite sound with no particular known limitations.
Equipment used	Glassware, Balance, HPLC system with flourescence detection, Chemical Standards, Filters, tubes, water bath
QA Protocols per batch	One recovery per 10 samples, One duplicate per 10 samples, Control "FAPAS SRM" sample once per batch (10 samples).
Mass of Sample required	For solid and liquid samples approximately 1gram is normally taken, depending on expected concentration of analyte.

Method Summary of	VL291_Tocopherol Isomers in Food by HPLC – Version 6.0
Summary Issued	30th April 2009

Australian Government
National Measurement Institute

Determination of Tocopherols(α, β, γ, δ isomers) in Foods by HPLC.

Analysis Description	Tocopherol isomers in food by HPLC.
Matrix / Matrices	Foods and Beverages
Reference Method(s)	1. De Leenheer, A.P., Lambert, W.E. and De Ruyter, M. G. M. (eds) (1985). "Modern Chromatographic Analysis of the Vitamins", Marcel Dekker Inc. 2. Indyk, H.E. (1988). Analyst, 113, 1217-1221.
Limit of Reporting (LOR)	**0.1mg/100g**
NATA Accredited	Yes
Preparation & procedure	**Preparation & Saponification:** Approximately 2-3g of sample is accurately weighed into a 250ml flask and 30 ml of alcoholic KOH is added. The solution is then saponified by stirring constantly overnight at room temperature Note: For natural oil samples, 0.5-1 g of oil is diluted with heptane containing an antioxidant (eg BHT) and tocopherols are then determined by HPLC as indicated below. **Alternative:** Approximately 2-3g of sample is accurately weighed into a 250ml flask and 30ml alcoholic KOH is added. The solution is then placed in a water bath at 80c for 30 minutes. **Extraction:** The saponified sample is cooled. The solution is transferred to a 50ml volumetric flask. 10 ml of the solution is loaded onto a 'Chromobond XTR' column (i.e solid phase extraction) and eluted with petroleum ether. The petroleum ether extract is then reduced under rotary evaporation and then dried under a stream of nitrogen gas. The sample is then made up to a known volume in heptane prior to HPLC analysis. **Determination:** Tocopherol isomers within the extract are separated by Normal phase HPLC on a 5µm silica column using an iso-propanol in heptane mobile phase. Detection is made using fluorescence with excitation at 292nm and emission at 326nm. Quantitation is made against tocopherol isomer standards whose concentration is determined by absorbance measurements. Results are expressed to two significant figures in units of mg/100g.
Comments, limitations or known interferences	Tocopherol isomers are sensitive to degradation caused by exposure to oxygen, heat and light. Analyses should be conducted in such a way as to minimise exposure.
Equipment used	Glassware, Balance, HPLC system with fluorescence detection, Chemical Standards, Filters, funnels, rotary evaporator, water bath.
QA Protocols per batch	One recovery per batch (10 samples) One duplicate per batch
	One control determination per batch
Mass of Sample required	For solid and liquid samples approximately 2-3 grams is normally taken, depending on expected concentration of analyte.

Method Summary of	**VL292_alpha and beta Carotene in Foodstuffs**
Summary Issued	**18th April 2007**

Australian Government
National Measurement Institute

Determination of alpha and beta Carotene in Foodstuffs by HPLC

Analysis Description	Alpha & Beta Carotene Determination by HPLC
Matrix / Matrices	Foods and Liquids
Reference Method(s)	CRC Handbook of Chemistry and Physics, 56th Edition (1975-76), page C235 Ibid, page C251
Limit of Reporting (LOR)	5ug/100g
NATA Accredited	Yes
Preparation & procedure	**Preparation & Saponification:** Approximately 5g of sample is accurately weighed into a 250ml flask and 60ml alcoholic KOH is added. The solution is then placed in a water bath at 80c for 30 minutes. **Extraction:** The saponified sample is cooled. The solution is transferred to a 500ml separating funnel containing brine. Extraction is made using petroleum ether with 5 aqueous washes, each shake and wash followed by collection and combining of organic phases. The petroleum ether extract is then reduced under rotary evaporation followed by nitrogen. The sample is then made up to 10ml in a volumetric flask with methanol. **Determination:** α- and β- Carotene are separated by reverse phase HPLC on a C18 column using a 95:5 methanol:tetrahydrofuran mobile phase. Absorbance is measured by PDA detection at 450nm, the PDA spectra (250 to 650nm) is used as confirmation. Determination is made against a known β- Carotene standard, whose concentration is determined by absorbance measurements. Results are expressed to two significant figures in units of ug/100g.
Comments, limitations or known interferences	Carotenes are sensitive to degradation caused by exposure to oxygen, heat and light. Analyses should be conducted in such a way as to minimise exposure.
Equipment used	Glassware, Balance, HPLC system with PDA detection, Chemical Standards, Filters, funnels, rotary evaporator, water bath, and nitrogen gas evaporators.
QA Protocols per batch	One recovery per batch (10 samples), One duplicate per batch, and one sample blank.
Mass of Sample required	For solid and liquid samples approximately 5grams is normally taken, depending on expected concentration of analyte.

Method Summary of	VL293_Niacin in Food by HPLC
Summary Issued	4th March 2008
Niacin (Vitamin B3) Determination in Foodstuffs by HPLC	

Australian Government
National Measurement Institute

Analysis Description	Niacin (Vitamin B3) Determination in Foodstuffs by HPLC
Matrix / Matrices	Foods and Liquids
Reference Method(s)	AOAC Methods 13th Edition (1980), 43.045 "The determination of niacin in cereals, meat and selected foods by capillary electrophoresis and high performance liquid chromatography". C.M. Ward and V.C. Trenerry. Food Chemistry, 60 667 (1997). "The determination of total niacin in concentrated yeast spreads by capillary electrophoresis". C.M. Ward, V.C. Trenerry and I. Pant, Food Chem., 58 185 (1997).
Limit of Reporting (LOR)	**0.5mg/100g**
NATA Accredited	Yes
Preparation & procedure	**Sample Preparation and Extraction:** Approximately 1g of homogenised sample is accurately weighed into a tube and 0.75g $Ca(OH)_2$ is added in solid form followed by 20ml purified water. The tube is then microwaved for 2 hours at 121°c to digest the sample. Following digestion the solution is made to 50.0ml with purified water and centrifuged for 15minutes at 2500rpm. 15.0ml of centrifuged solution is taken and adjusted to pH 7 using oxalic acid and made to a final volume of 25.0ml using purified water. This solution is filtered prior to analysis by HPLC. If interferences are present then, the above sample solution is centrifuged at 2500rpm (0°c) and 10.0ml of supernatant taken. The supernatant is then passed through a 500 mg C18 SEP-PAK cartridge in combination with a 500mg SCX ion exchange cartridge, in series. Nicotinic acid is eluted from the SCX cartridge using 5ml of 2% ammonia in methanol solution. The methanol solution is then blown to dryness under N_2 and re-dissolved in purified water. This solution is filtered prior to analysis by HPLC. **Determination by HPLC:** Separation of niacin, in the treated solution, is by HPLC using a C18 column. Detection is conducted using Photo Diode Array detection (absorbance maximum approximately 260nm). Determination is conducted against known standards of nicotinic acid.
Comments, limitations or known interferences	Care must be taken to select the correct size SCX ion exchange and C18 clean-up columns to ensure all niacin is captured and eluted during the ion exchange process.
Equipment used	Glassware, Balance, CE system with UV detection, Chemical Standards, Filters, funnels, centrifuge, autoclave, C18 and SCX ion exchange columns.
QA Protocols per batch	One duplicate per 10 samples, Control "FAPAS SRM" sample once per batch (10 samples).
Mass of Sample required	For solid and liquid samples approximately 1 to 3 grams is normally taken, depending on expected concentration of analyte.

Method Summary of	VL295_Common Sugars
Summary Issued	17th February 2010
Determination of Common Sugars in Foods by HPLC	

Australian Government
National Measurement Institute

Analysis Description	**Determination of common Sugars in Foods**
Matrix / Matrices	**Foods**
Reference Method(s)	**AOAC 13th Ed. 31.138-31.142**
Limit of Reporting (LOR)	**0.2 g/100g with refractive index detector.** **0.05 g/100g with ELSD detector.**
NATA Accredited	Yes
Preparation & procedure	**Preparation:** Sample is homogenised and a sub sample is accurately weighed. Sugars are extracted with 25 ml water at 60°c for 30 minutes. The extract is clarified with 25 ml acetonitrile and filtered through a 0.45um filter into a 2ml vial, suitable for HPLC. **Determination for common sugars:** Filtered solution is analysed by HPLC using amino column with an acetonitrile/water mobile phase containing salt and refractive index detection. Quantitation is made against a standard solution containing known amounts of fructose, glucose, sucrose, maltose and lactose. **Determination for low level sugars:** Filtered solution is analysed by HPLC using carbohydrate ES column with an acetonitrile/water mobile phase and evaporative light scattering detector (ELSD). Quantitation is made against a standard solution containing known amounts of fructose, glucose, sucrose, maltose and lactose. **Calculation:** Result calculation is performed by HPLC software and a report generated.
Comments, limitations or known interferences	Sorbitol, galactose and other sugar alcohols may interfere with glucose or other sugars. When this occurs the glucose is determined using different mobile phase or separately using a Bio-Rad HPX column. The method uncertainty is relatively high at levels approaching the Limit of Reporting (0.2g/100g).
Equipment used	Flasks and glassware Balance Blender HPLC with RI or ELSD Detection and appropriate column(s) Software to perform integration and calculation of results
QA Protocols per batch	1 duplicate each batch (up to 15 samples usually) A standard is run every 5 samples A control reference is run each batch A recovery test in every batch
Mass of Sample required	15 g per sample, however more sample would be required for QA.

Method Summary of	VL298 Version 6.0
Summary Issued	27th October 2008
Moisture Determination in Food	

Australian Government
National Measurement Institute

Analysis Description	Moisture / Total Solids
Matrix / Matrices	Food
Reference Method(s)	AOAC 16th Ed. 934.06, 964.22, AS2300.1.1
Limit of Reporting (LOR)	0.2g/100g
NATA Accredited	Yes
Preparation & procedure	Samples are homogenised. Moisture determination is made, according to sample matrix type, using either, sand and vacuum drying (Method A) or no sand and conventional drying (Method B). ***Method A (Using Sand);*** A moisture dish with sand, lid and glass rod is oven dried at 102°c and cooled before all dried components are weighed together to the nearest 0.1mg. 2 to 5 gram of sample is weighed, to nearest 0.1mg, into the moisture dish. Water is added to the dish to aid mixing of the sample and sand. The moisture dish is placed on a steam bath until visible dryness of the sand/sample mix is achieved. The dish and components are placed in a vacuum oven and dried under vacuum (approx. 5kpa) at between 70 and 100°c, depending on sugar content of the sample. Drying time is a minimum of 4 hours depending on the sample matrix. After the required initial drying period the moisture dish and components are removed, cooled, re-weighed and returned for a further 1 hour drying. The weighing and drying process is repeated until constant weight is obtained. ***Calculation (Method A):*** Subtract the mass of the dish (plus components) from the mass of dried sample and dish (plus components). Divide the figure obtained by the sample mass and multiply by 100 to obtain a result as % moisture or g/100g. ***Method B (Without Sand)***; A moisture dish and lid is oven at 102°C dried and cooled. The dried components are weighed together to the nearest 0.1mg. A portion of sample (2 to 5 grams) is weighed, to nearest 0.1mg, into the dish. The sample in the dish is then placed in a conventional oven at 102°C for a minimum of 4 hours depending on the sample matrix. The dish and lid are then removed, cooled, re-weighed and returned for a further 1 hour drying. The weighing and drying process is repeated until a constant weight is obtained. ***Calculation (Method B):*** Subtract the mass of the dish (plus lid) from the mass of dried sample and dish (plus lid). Divide the figure obtained by the sample mass and multiply by 100 to obtain a result as % moisture or g/100g.
Comments, limitations or known interferences	These are internationally recognised techniques providing consistency and comparability with results obtained by laboratories worldwide. It is recognised that these techniques do not necessarily provide a true reflection of the total moisture contained in a sample. No real interferences in food samples.
Equipment used	Ovens – Vacuum and Conventional. Balances – Analytical – accurate to 0.1mg Moisture Dishes, sand and glass rods Steam bath
QA Protocols per batch	Flour control sample is determined each analysis batch. One duplicate analysis per batch – maximum batch size is 10 samples.
Mass of Sample required	10g per sample, however more sample would be required for QA.

Method Summary of	VL299_PROTEIN
Summary Issued	6th October 2006
Protein Determination in Food	

Australian Government
National Measurement Institute

Analysis Description	Protein determination based on Total Nitrogen content
Matrix / Matrices	Food
Reference Method(s)	**AOAC 16th Ed. 981.10, 920.152, 990.03, 920.87 AS2300.1.2.1**
Limit of Reporting (LOR)	0.2g/100g
NATA Accredited	Yes
Preparation & procedure	**Preparation:** Sample is homogenised and a sub sample (approx. 2g) is accurately weighed into a kjeldahl digestion tube. A digestion aid of potassium sulphate and a catalyst, copper sulphate is added to the sample, followed by 20ml of concentrated sulphuric acid. The tube is slowly heated to 400°C and then the temperature is maintained until the mixture in the tube is clear. The clear solution is digested for 1 hour and the tube allowed to cool. **Determination:** Once the tube has cooled 50ml distilled water is added. The tube is placed in a Kjeltec distillation unit and the mixture is steam distilled into a beaker containing 50ml of saturated boric acid solution. The distilled solution is titrated with standardised 0.1N sulphuric acid solution using a mixed indicator of bromcresol green and methyl red. **Calculations:** Total N (g/100g) = 0.14*(titre-blank) / sample mass Conversion from Total N to protein is made using a Factor related to the food matrix type. For most foods a factor of 6.25 applies.
Comments, limitations or known interferences	This is an internationally recognised reference method and provides comparability with measurements made worldwide. It is recognised that all Nitrogen compounds, except NO2 and NO3, are determined as being protein and the true factor which should be applied would, in reality, vary slightly with each different Food.
Equipment used	Digestion Tubes, beakers and other glassware Balance Kjeldahl digestion block – 20 place / up to 440c Kjeltec (Kjeldahl) steam distillation unit Auto-titration system
QA Protocols per batch	Reference Flour Control with each batch . Tyrosine recovery with each batch. Minimum of 1 duplicate analysis per batch – maximum batch size is 16 samples.
Mass of Sample required	10g per sample, however more sample would be required for QA.

Method Summary of	VL300_Fat by Soxhlet
Summary Issued	6th October 2005

Australian Government
National Measurement Institute

Fat Determination in Food by Soxhlet Extraction

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

Method Summary of	**VL320_B6 in Food by HPLC**
Summary Issued	**15th January 2008**
Determination of Vitamin B6 in Food by HPLC	

Australian Government
National Measurement Institute

Analysis Description	Vitamin B6 in Food by HPLC
Matrix / Matrices	Foods
Reference Method(s)	'Determination of Vitamin B6 in Food by HPLC' by M. Bergaentzle, F. Arella, J.B. Bourgnon & C. Hasslemann Food Chemistry, 1995, (52), 81-86.)
Limit of Reporting (LOR)	**0.02 mg/100g**
NATA Accredited	No
Preparation & procedure	**Preparation & Extraction:** Vitamin B6 is a group of water soluble compounds which includes pyridoxine. The B6 compounds are extracted from a homogenised sample using acetate buffer at pH 4.5. Acid phosphatase and glyoxilic acid are then used to convert the various B6 forms to pyridoxal. The converted extract is then made to volume, filtered and an aliquot reacted with borohydride to reduce pyridoxal to pyridoxol. All the vitamers are therefore converted to one form (i.e pyridoxol (Pyridoxine)). **Determinations:** Pyridoxine in the sample filtrate is determined by reverse phase HPLC on a C18 Nova-pak column using fluorescence detection. Separation is made using a mobile phase of 0.0005M hexanesulfonic acid (sodium salt)/0.05M potassium dihydrogen phosphate in 8% acetonitrile/92% water, pH 2.5. Detection is by fluorescence using an excitation wavelength of 295nm and an emission wavelength of 390nm. Results are expressed to two significant figures in units of mg/100g.
Comments, limitations or known interferences	Vitamin B6 forms are sensitive to degradation by light, heat and oxygen.
Equipment used	Glassware, Balance, HPLC system with flourescence detection, Chemical Standards, Filters, tubes, water bath
QA Protocols per batch	One recovery per 10 samples, One duplicate per 10 samples, Control "FAPAS SRM" sample once per batch (10 samples).
Mass of Sample required	For solid samples approximately 5gram is normally taken, depending on expected concentration of analyte.

Method Summary of	VL 392 _Vit.D & 25OH-Vit.D
Summary Issued	17th September 2009

Determination of Vitamin D2, D3 & 25-Hydroxyvitamin D2 & D3 in Meat Matrices by LC-MSMS

Australian Government
National Measurement Institute

Analysis Description	Determination of Vitamin D2, D3 and 25-Hydroxyvitamin D2 & D3 in Meat Matrices by LC-MSMS
Matrix / Matrices	Beef, Lamb, Pork, Chicken, Fish, Prawn and Mollusc
Reference Method(s)	A.P. De Leenheer, W.E. Lambert, and M.G.M. De Ruyter (eds) "Modern Chromatographic Analysis of the Vitamins", Marcel Dekker, Inc. (1985). Jetta Jakobsen, Ina Clausen, Torben Leth, Lars Ovesen *Journal of Food Composition and Analysis 17 (2004) 777-787* "A new method for the determination of vitamin D3 and 25-hydroxyvitamin D3 in meat". Olivier Heudi, Marie-José Trisconi, Christopher-John Blake *Journal of Chromatography A, 1022 (2004) 115-123* "Simultaneous quantification of Vitamins A, D3, and E in fortified infant formulae by liquid chromatography-mass spectrometry" *Department of Quality Assurance, Nestlé Research Centre, Nestec Ltd., Vers-chez-les-Blanc, 1000 Lausanne 26, Switzerland.*
Limit of Reporting (LOR)	0.1 ug/100g
NATA Accredited	Pending
Preparation & procedure	**Preparation & Saponification:** Approximately 7.5g of sample is accurately weighed into a 50ml falcon tube and 30 ml of alcoholic KOH is added. The solution is then saponified by stirring constantly overnight at room temperature **Extraction:** The saponified sample solution is loaded onto a 'Chromobond XTR' column (i.e solid phase extraction) and eluted with petroleum ether. The petroleum ether extract is then reduced under rotary evaporation and then dried under a stream of nitrogen gas. The extract is made up to a known volume in heptane centrifuged, decanted, dried under nitrogen and then made up to 400µL in heptane. **Determination:** The extract is then separated by normal phase LC and any vitamin D &/or 25-hydroxyvitamin D identified by Ion Trap MS-MS. The "D" vitamers are quantitated against individual calibration curves, with deuterated internal standards correcting for any extraction inefficiencies or instrument matrix enhancement or suppression effects. **Calculation:** Calculation of the vitamin D2 ,D3 and 25-hydroxyvitamin D2 & D3 content in the initial sample is determined in µg per 100g of sample.
Comments, limitations or known interferences	"D" vitamers – in particular the 25-hydroxy "D" vitamers, are sensitive to degradation caused by exposure to oxygen, heat and light. Analyses should be conducted in such a way as to minimise exposure.
Equipment used	Balance Rotary Evaporator Ion Trap LC-MS system Software for interpretation/ calculation of results.
QA Protocols per batch	1 duplicate and 1 recovery are run with each batch – Max batch size is 10.
Mass of Sample required	7.5g of sample per analysis (more sample will be required for QA).

Determination of Folate in Food
Triple enzyme Microbiological method

To be conducted by Royal Perth Hospital (Metropolitan Health Services)

ABN 13 993 250 709

A representative sample (in duplicate) of the food to be assayed is homogenised in a Phosphate buffer at pH 6.3(containing ascorbate)

Homogenates are treated with α- amylase and heat. (Optimal for the enzyme)

Then the homogenates are treated with protease and heat. (Optimal for the enzyme)

The sample is then heated in boiling water to inactivate the protease.

Sample is then centrifuged and the supernatant is collected.

A Phosphate buffer at pH 8.0 (containing ascorbate) is added and treated with polyglutamyl hydrolase.
Different concentrations of the enzyme are used to extract as much folate as possible.
It is then heated. (pH Optimal for the enzyme)
The polyglutamates are converted to di-glutamates by this step. (Chicken pancreas)

Samples are then diluted as required (this can mean up to ten dilutions) and assayed using a Chloramphenicol resistant strain of Lactobacillus Casei.
The organism does not respond to folates with a glutamyl chain length longer than three.

Results are calculated taking into account all the dilutions including buffer and enzyme additions.

All samples are run in duplicate.
A known food control is run with each batch. (Treated like a sample)
A known yeast control is run with each batch. (Treated like a sample)

A known enzyme control is run with each batch to monitor for enzyme activity.

All QC results should be within 1sd.
Duplicate results are accepted within CV of 10% giving an
Overall “uncertainty of measurement” of less than 15%

We participate in the FAPAS international food Quality control survey and are frequently amongst the top performers worldwide.
We also have a working relationship with the University of NSW and compare samples regularly.

METHOD DESCRIPTION SUMMARY PROFORMA	
Analysis description:	**Vitamin B12 (Cobalamin) Determination by Microbiological Assay**
Matrix:	**Foods**
Reference Method(s):	Anderson B.B. & Sourieal N.A., "Assay of Serum Cobalamin by Euglena Gracilis, Methods of Hematology – Cobalamins" CAO 1983.
LOR and units:	**0.1ug/100g**
NATA Accredited:	**Yes – NATA Accreditation No. 14671**

"Food" Vitamin Assay (Bioassay)

Preparation & Procedure: (Provided by Royal Perth Hospital)

Preparation:
The sample is mixed then diluted and homogenised with acetate buffer and acidified. Extraction is then conducted by autoclaving and collecting the supernatant, which contains the vitamin B12.

Assay:
The supernatant is then transferred into microbiological assay tubes.

Inoculation is made with *euglena gracilis* and the culture grown over a 5 day period.

Control and Standard tubes are also grown.

Determination:
Determination is made by measuring absorbance at 640nm.
The quantitation of the vitamin content in the samples analysed is determined by comparing the growth (Absorbance) of the sample tubes to those of the vitamin standards and then multiplying the result by any dilution factor.

Comments, limitations or known interferences:

Equipment used: Sample volume or weight required

Glassware.
Balance
Centrifuge
Spectrophotometer
Incubators
Software for interpretation/ calculation of results.

QA protocols per batch (APL Project)– maximum batch size is 12

All samples are run in duplicate.

A known food control is run with each batch.

A known enzyme control is run with each batch to monitor for enzyme activity.