8. Nutrients in Cattle offal

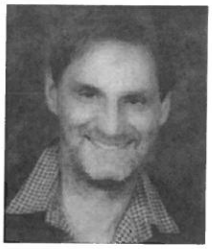
Researcher: Dr L Hoffman

Research Insitute: Animal Science

University of Stellenbosch

Total Funding: R 65 000

Final Approved: 2010



INTRODUCTION

It was found that the beef organs (thin intestine, tongue, rumen, liver, heart, lungs, spleen, and kidneys) differ from each other with regards to their proximate composition, cholesterol and fatty acid contents as well as their amino acid and mineral contents. However, it also appears that production system may also have an influence on these attributes which is most likely due to factors such as differences in diet, the age of the animals, exercise etc. The organs from the feedlot animals were on average more fat than that from the free range animals. The value derived in this investigation will be of value to human nutritionists who will be able to use the information when giving dietary advice to patients.

In South Africa, the so called fifth quarter of a carcass is traditionally seen as being of limited value. However, its value is on the increase with some offal products becoming delicacies in niche markets (particularly in restaurants). Currently, there is very limited scientific literature available on the nutritional values for offal, especially for animals reared in South Africa. Research findings reported in the public domain often only include selected chemical analyses of a few organs, for example proximate composition, cholesterol and fatty acids of brain, heart, liver and tongue of sheep. In this project funded by the RMRDT the nutritional value of cattle offal was determined. Another aspect that was also investigated was to determine whether the finishing off of the animals under feedlot or natural pastures would influence this composition.

Twenty animals (10 finished in a local feedlot and 10 finished on a free-range farm) of mixed breed were slaughtered at Groenland Meat Traders (PTY) LTD in Grabouw, Western Cape, South Africa. The thin intestine, tongue, rumen, liver, heart, lungs, spleen, and kidneys were removed for analysis immediately after slaughter. At the laboratory, the samples were defrosted and cooked inside a plastic bag within a water bath set at 60˚C for 60 minutes. It was decided to cook the organs as nutritional values of cooked organs/meat are of more value to dieticians than nutrient composition tables of raw organs/meat.

The moisture, protein, fat and ash content (g/100 g meat) of the organs were determined. For a more detailed profile of the fat, the individual fatty acids were also determined. Similarly, the amino acid content and mineral profile of the organs were also analysed.

Comparison of nutritional composition of foodstuffs between laboratories is always difficult due to differences in the method of sample preparation. In the present investigation, samples were cooked in a sealed bag thereby limiting the moisture loss that is normally experienced during the cooking, grilling or barbequing of the meat. This method was followed as it is frequently the practice in South Africa to cook organ meat in a pot as a stew thereby retaining most of the leached nutrients. It could thus be argued that the amounts of the nutrients reported may be closer to that of raw samples rather than cooked samples.

The proximate composition of the eight cooked organs is depicted in table 1. Similar moisture and fat values for raw cattle heart, liver and kidney have been noted by other scientists in other countries. In the present investigation, beef liver had the highest protein content. It is interesting to note that the free range beef tongue also had a much higher protein content than that from the feedlot animals. The highest fat levels were found in the small intestine. It is noteworthy that the organs originating from the feedlot cattle tended to have higher fat contents.

Table 1: The proximate composition (g/100 g as is) of eight organs from feedlot and free-range cattle

Origin	Proximate composition	Heart	Kidney	Liver	Lung	Small Intestine	Spleen	Stomach	Tongue
Feedlot	Moisture	76.1	76.9	72.4	77.7	74.2	77.2	76.2	77.5
	Protein	17.9	17.8	21.3	17.6	19.7	18.7	18.9	18.8
	Fat	2.4	1.7	1.6	2.3	3.8	2.0	2.4	1.9
	Ash	0.9	1.3	2.7	1.1	1.2	1.4	0.9	1.1
Free-range	Moisture	79.0	76.6	69.6	78.6	72.5	76.9	80.1	74.6
	Protein	16.7	17.5	21.9	15.8	19.1	19.8	17.8	23.4
	Fat	2.3	2.8	2.4	3.9	3.6	2.8	1.3	1.4
	Ash	1.3	1.3	3.1	1.2	1.1	1.5	1.0	1.0

The fatty acid profiles and cholesterol content of the different organs are depicted in table 2. The cholesterol content of the heart, liver, kidney and tongue are much lower than those normally reported. Cholesterol content differed between all the organs, with the lung having the highest content and the tongue having the lowest.

The small intestine also had the highest SFA content. Since SFA's and polyunsaturated PUFA's are consumed together, their ratio (the P:S ratio) is an important measure of the relative risk factor of the cholesterol content in foodstuff. The higher the P:S ratio, the healthier a foodstuff is considered with a recommended daily allowance of 0.45 or higher. The P:S ratio in the current investigation ranged from 0.02 to 0.59. It is known that the P:S ratio is inversely related to the fat level in

ruminant meat with similar findings being found in the current investigation (the fatter the organ, the more saturated the fat is and the lower the ratio).

The ratio of n-3: n-6 fatty acids is also considered important to human health since these represent two groups of essential fatty acids in the human diet. In the current investigation, organs from feedlot animals had consistently higher n-6:n-3 ratios than those from free-range animals, which is consistent with similar findings in meat derived from feedlots. The recommended value for the n-6:n-3 ratio of foodstuffs is less than 5, which is lower than any of the values found for the organs in this investigation.

Table 2: Fatty acid composition (%) and cholesterol content (mg/100g) of organs from free-range and feedlot cattle

Origin	Fatty acid	Heart	Kidney	Liver	Lung	Small Intestine	Spleen	Stomach	Tongue
Feedlot (Total)	SFA	51.30	53.13	53.99	50.53	65.12	58.59	60.90	45.46
	MUFA	23.40	21.16	13.49	25.34	25.30	18.23	27.44	31.26
	PUFA	23.43	23.30	31.68	22.70	6.98	21.88	8.70	21.89
	PUFA:SFA	0.46	0.44	0.59	0.45	0.11	0.37	0.14	0.48
	(n-6)/(n-3)	32.94	10.99	6.86	5.04	13.85	8.95	9.54	15.32
Feedlot	Cholesterol (mg/100g)	56.41	185.26	145.74	204.75	99.93	168.84	65.26	52.76
Free-range (Total)	SFA	55.06	65.26	62.12	59.26	81.81	61.33	55.98	45.77
	MUFA	25.80	21.85	16.66	23.20	15.73	17.73	31.16	31.05
	PUFA	17.44	10.99	20.46	16.33	1.69	19.82	11.55	21.98
	PUFA:SFA	0.32	0.17	0.33	0.28	0.02	0.32	0.21	0.48
	(n-6)/(n-3)	24.74	6.05	6.53	3.58	12.50	6.77	5.60	12.06
Free-range	Cholesterol (mg/100g)	50.92	147.88	113.78	178.95	102.06	166.84	78.55	39.29

The amino acid profiles of the different organs are given in table 3. Proline levels were the lowest and methionine levels the highest in the heart when compared to the other organs. The stomach had the highest levels of proline and glycine. The tongue had the highest levels of tyrosine, leucine and phenylalanine. As expected, those organs, especially the stomach, containing high levels of collagen also had the higher levels of proline.

The mineral compositions of the various organs are given in table 4. There is considerable variation between organs in the concentration of minerals. In general, sodium levels were higher than any other mineral, with the exception of iron, which was very high in the spleen. Calcium and magnesium levels were much lower than any of the other minerals, followed by phosphorous and potassium levels. Copper and zinc levels were much higher in the liver than any other organs.

Origin	Amino acid	Heart	Kidney	Liver	Lung	Small Intestine	Spleen	Stomach	Tongue
Feedlot	Threonine	2.55	3.08	3.07	2.57	3.12	2.91	2.77	3.86
	Valine	3.25	3.28	3.70	3.02	2.85	3.99	2.86	3.46
	Histidine	1.67	1.64	1.70	1.27	1.48	1.64	1.28	1.92
	Lysine	4.44	5.11	3.87	4.65	5.91	3.99	5.26	5.34
	Methionine	1.83	1.42	1.61	1.00	1.32	1.26	1.37	1.72
	Proline	3.19	3.57	3.48	4.19	4.81	4.25	5.32	4.17
	Tyrosine	2.68	2.92	2.81	2.26	2.85	2.54	2.63	3.34
	Isoleucine	2.83	2.66	2.95	2.01	2.64	4.55	2.59	3.92
	Phenylalanine	2.82	2.87	3.23	2.37	2.68	3.00	2.45	3.24
	Glycine	2.84	3.66	3.19	4.63	5.80	4.74	6.27	5.37
	Leucine	6.76	6.81	6.93	5.72	6.08	6.64	6.02	7.47
Free-range	Threonine	3.32	3.45	2.84	2.12	1.71	2.89	2.10	3.17
	Valine	2.90	3.72	3.12	2.91	2.52	3.44	2.64	2.89
	Histidine	1.61	1.66	1.52	1.35	0.80	1.87	1.17	1.68
	Lysine	4.97	4.11	4.09	3.92	2.93	4.63	4.29	5.60
	Methionine	2.02	1.50	1.55	1.05	0.98	1.38	1.45	1.62
	Proline	2.84	4.09	3.39	4.06	3.52	3.86	4.79	3.95
	Tyrosine	3.03	2.86	2.93	2.34	1.71	2.96	2.61	3.77
	Isoleucine	2.99	3.22	2.66	1.87	1.88	2.38	2.40	3.14
	Phenylalanine	2.98	3.14	3.17	2.49	1.83	3.10	2.53	3.32
	Glycine	3.03	4.45	2.77	4.35	4.55	3.88[a]	5.35	4.31
	Leucine	5.89	7.15	6.10	5.16	4.43	6.05	5.25	7.52

From the current investigation, it is evident that beef organs differ from each other with regards to their proximate composition, cholesterol and fatty acid contents as well as their amino acid and mineral contents. However, it also appears that production system may also have an influence on these attributes which is most likely due to factors such as differences in diet, the age of the animals, exercise etc. The value derived in this investigation will be of value to human nutritionists who will be able to use the information when giving dietary advice to patients

Origin	Mineral	Heart	Kidney	Liver	Lung	Small Intestine	Spleen	Stomach	Tongue
Feedlot	Phosphorous	0.014	0.020	0.025	0.019	0.020	0.019	0.009	0.013
	Potassium	0.012	0.014	0.020	0.016	0.021	0.020	0.013	0.016
	Calcium	0.001	0.002	0.001	0.001	0.002	0.001	0.001	0.001
	Magnesium	0.002	0.002	0.002	0.001	0.002	0.002	0.001	0.002
	Sodium	3.217	8.464	4.391	7.946	9.225	4.549	6.357	4.489
	Iron	4.096	6.313	2.881	10.409	3.062	31.225	3.538	2.262
	Copper	0.370	0.381	1.693	0.125	0.194	0.133	0.146	0.104
	Zinc	2.220	2.365	5.022	1.899	3.058	2.494	2.748	3.432
	Manganese	0.034	0.114	0.277	0.022	0.093	0.027	0.065	0.017
	Boron	0.016	0.008	0.021	0.020	0.025	0.024	0.012	0.011
	Aluminium	4.356	4.536	3.337	5.568	3.250	3.901	0.912	2.407
Free-range	Phosphorous	0.013	0.016	0.024	0.014	0.019	0.015	0.010	0.014
	Potassium	0.010	0.012	0.020	0.012	0.020	0.013	0.014	0.016
	Calcium	0.001	0.002	0.001	0.001	0.002	0.003	0.005	0.002
	Magnesium	0.002	0.002	0.002	0.001	0.002	0.002	0.001	0.002
	Sodium	2.594	7.190	4.073	7.809	7.922	3.308	6.702	4.506
	Iron	4.450	7.909	4.902	12.429	3.955	31.261	2.949	2.894
	Copper	0.285	0.270	0.977	0.140	0.198	0.103	0.111	0.154
	Zinc	2.005	2.033	4.398	1.718	2.527	2.315	2.526	3.740
	Manganese	0.038	0.097	0.260	0.025	0.104	0.033	0.631	0.031
	Boron	0.012	0.014	0.022	0.014	0.027	0.025	0.012	0.015
	Aluminium	2.189	2.641	2.417	3.879	8.219	1.079	0.537	2.773

9. Nutrients in Sheep offal

Researcher: Dr L Hoffman

Research Insitute: Animal Science

University of Stellenbosch

Total Funding: R 97 400

Final Approved: 2010

INTRODUCTION

Proximate composition differed between organs and breeds while very few differences were noted in total SFA and MUFA between organs and breed. Merino heart had significantly higher (7.27%) total PUFA than Dorper heart (1.78%). All the organs showed favourable P: S ratios, with the exception of the tongue, heart and stomach. Dorper and Merino brain, lungs and testicles had favourable (n-6)/(n-3) ratios below 5. Cholesterol content differed between both organs and breeds. Calcium (0.001-0.005 mg/100g) and magnesium (0.001-0.002 mg/100g) were found in the lowest concentrations while sodium (24.325-72.238 mg/100g) and iron (1.674-17.517 mg/100g) were found in the highest concentrations. Liver was found to be a good source of iron and zinc. These values will be of value to human dieticians during the formulation of human diets.

Proximate composition differed between organs and breeds while very few differences were noted in total SFA and MUFA between organs and breed. Merino heart had significantly higher (7.27%) total PUFA than Dorper heart (1.78%). All the organs showed favourable P: S ratios, with the exception of the tongue, heart and stomach. Dorper and Merino brain, lungs and testicles had favourable (n-6)/(n-3) ratios below 5. Cholesterol content differed between both organs and breeds. Calcium (0.001-0.005 mg/100g) and magnesium (0.001-0.002 mg/100g) were found in the lowest concentrations while sodium (24.325-72.238 mg/100g) and iron (1.674-17.517 mg/100g) were found in the highest concentrations. Liver was found to be a good source of iron and zinc.

In South Africa, the so called fifth quarter of a carcass is traditionally seen as being of limited value. However, its value is on the increase with some offal products becoming delicacies in niche markets (particularly in restaurants). Currently, there is very limited scientific literature available on the nutritional values for offal, especially for animals reared in South Africa. Research findings reported in the public domain often only include selected chemical analyses of a few organs, for example proximate composition, cholesterol and fatty acids of brain, heart, liver and tongue of sheep .

Twenty sheep (10 Dorper and 10 Merino) were reared in a free-range system in South Africa and slaughtered using standard South African techniques at LAV abattoir. The sheep sampled were all A2 or A3 carcass grades. The brain, tongue, stomach, liver, heart, lungs, spleen, kidneys and testicles were removed immediately after slaughter. Each of the organs were individually labeled, frozen and

transported to the Stellenbosch University meat laboratory for further analyses. At the laboratory, the samples were defrosted and cooked inside a plastic bag within a water bath set at 60°C for 60 minutes.

Proximate analysis was conducted on minced (three times through 2 mm sieve) organ samples of all the animals. The moisture, protein, fat and ash content (g/100 g meat) were determined according to standard laboratory procedures.

For fatty acid analysis, a lipid extraction was used whilst a sub-sample was used for cholesterol determination by Gas Liquid Chromatography. The amino acid composition (essential amino acids) and mineral profile were also determined.

The proximate compositions of the nine organs are given in table 1. Differences were noted between both organs and breeds. The moisture content of the brain, kidney and liver are similar to those reported in the literature for raw and cooked mutton brain, kidney and liver. However, lower moisture values for mutton tongue have been reported and it was also found that cooking significantly reduced the moisture content of mutton heart, which was reported as being 80.17% in raw heart and 67.94% in cooked heart. Similar moisture values (67.9% and 69.5%, respectively) have been reported for raw lamb tongue. Similar fat values to that reported in this investigation for brain have been reported overseas but the fat content of the heart, liver and kidney was much lower overseas than reported in this study. The fat content of raw and cooked tongue was reported as 26.23% and 22.76%, respectively, which is considerably higher than those found in the current study. In North Africa, similar protein and ash values to the current findings for sheep liver, spleen and heart have been reported. Similar moisture contents for liver, spleen, heart and kidney to that in the current study were also reported although considerably lower fat contents for sheep liver (3.20%) and heart (6.60%) were reported.

Table 1: Proximate composition (%) of Merino and Dorper organs

Breed	Proximate composition	Brain	Heart	Kidney	Liver	Lung	Spleen	Stomach	Testicle	Tongue
Dorper	Moisture	77.8	66.8	76.7	66.7	77.9	75.3	82.7	81.5	66.2
	Protein	10.1	15.2	16.2	18.8	15.6	20.4	14.8	12.9	15.2
	Fat	10.1	16.4	5.2	11.8	4.6	2.9	1.7	4.2	11.8
	Ash	2.0	0.9	1.7	1.9	1.1	1.7	0.9	1.1	0.9
Merino	Moisture	78.0	68.9	77.1	66.9	76.0	77.2	79.8	83.7	66.3
	Protein	8.7	13.5	14.9[b]	20.9	17.6	16.1	15.5	11.1	15.1
	Fat	11.9	16.4	6.2	9.7	4.6	4.3	3.1	3.8	16.0
	Ash	2.0	0.9	1.2	1.6	1.1	1.4	0.7	1.1	0.9

The fatty acid profiles and cholesterol contents of the different organs are shown in table 2. With the exception of the Dorper brain, heart and kidney, no differences between organs were found for total saturated fatty acids (SFA) or total monounsaturated fatty acids (MUFA). Total polyunsaturated fatty acids (PUFA) differed between organs with the tongue having the lowest level of PUFA. Total PUFA levels ranged between organs from 2.22% to 24.01%. Internationally, PUFA values of 28.5%, 23.0% and 26.9% for raw goat liver, kidney and heart, respectively have been reported which is higher than any of the values found in the current study. Although the international values were reported for raw samples, other researchers have found that cooking had a minimal effect on the fatty acid composition of meat and that drippings collected after cooking contained mainly triglycerides.

Table 2: Fatty acid composition (%) and cholesterol content (mg/100g) of Dorper and Merino organs

Breed	Fatty Acid	Brain	Heart	Kidney	Liver	Lung	Spleen	Stomach	Testicle	Tongue
Dorper	SFA	46.81	69.95	46.52	50.95	51.88	53.93	50.15	52.52	51.90
	MUFA	29.89	26.75	30.24	24.05	27.72	28.21	37.60	30.49	43.51
	PUFA	22.90	1.78	21.22	24.01	18.14	14.94	8.04	14.82	2.22
	PUFA:SFA	0.49	0.03	0.46	0.47	0.35	0.28	0.16	0.28	0.04
	(n-6)/(n-3)	0.43	9.00	11.44	5.95	4.10	7.44	9.50	1.13	7.83
	Cholesterol (mg/100g)	5238.29	56.47	226.19	168.19	201.84	188.19	30.90	89.15	46.63
Merino	SFA	45.52	68.24	45.37	47.16	47.68	52.33	51.54	48.16	44.52
	MUFA	32.51	21.09	31.75	32.97	28.68	30.56	38.86	31.79	50.57
	PUFA	21.35	7.27	20.22	18.87	21.50	14.62	8.38	18.06	3.65
	PUFA:SFA	0.47	0.11	0.45	0.40	0.45	0.28	0.16	0.38	0.08
	(n-6)/(n-3)	0.48	20.36	10.19	7.28	4.10	7.48	13.44	1.49	18.89
	Cholesterol (mg/100g)	5638.28	48.59	155.57	205.54	175.74	177.39	35.77	98.90	51.26

Since SFA's and polyunsaturated PUFA's are consumed together, their ratio (the P:S ratio) is an important measure of the relative risk factor of the cholesterol content in foodstuff. The higher the P:S ratio, the healthier a foodstuff is considered and the recommended daily allowance of P:S for humans is around 0.45. The P:S ratio of the Merino and Dorper organs showed considerable variation with Dorper hearts and tongues having the lowest ratio, 0.03 and 0.04 respectively. Merino and Dorper brains had the highest levels of 0.47 and 0.49, respectively.

The n-6 and n-3 fatty are considered essential fatty acids in the human diet since the human body is unable to synthesize these itself. The (n-6)/ (n-3) ratio is often used as a measure of the health value of foodstuff and a value of <5 is recommended. Only the heart and the testicles had ratios of <5 while the remaining organs, for both breeds, had values above 5. The (n-6)/ (n-3) ratio of lamb

muscle has been reported as ranging from 1.29 to 2.45, depending on diet. These values are lower than those found in the current investigation, suggesting that, with the exception of the heart and the testicles, Dorper and Merino organs have a less favourable (n-6)/ (n-3) ratio.

Table 3: Amino acid composition (mg/100g) of Dorper and Merino organs

Breed	Amino acid	Brain	Heart	Kidney	Liver	Lung	Spleen	Stomach	Testicle	Tongue
Dorper	Threonine	2.76	2.22	2.11	3.28	3.02	2.75	2.79	2.63	2.25
	Valine	2.74	2.14	3.26	3.74	3.57	3.52	2.79	2.48	2.50
	Histidine	1.60	1.25	1.58	2.19	2.09	2.29	1.27	1.18	1.17
	Lysine	4.73	3.47	4.34	5.60	5.57	5.29	5.08	4.75	4.85
	Proline	2.66	2.58	3.54	4.04	4.53	3.97	4.90	5.50	3.30
	Methionine	1.21	1.07	1.37	1.35	1.24	1.31	1.30	1.09	1.15
	Tyrosine	2.45	1.72	3.24	3.84	2.81	2.87	2.37	2.20	1.99
	Isoleucine	2.06	1.75	2.59	3.19	2.15	2.19	2.17	2.09	1.89
	Phenylalanine	2.81	1.93	3.06	4.08	3.10	3.28	2.44	2.36	2.14
	Leucine	5.84	4.70	6.92	8.22	7.43	7.29	5.83	5.58	5.18
	Glycine	2.70	2.65	2.63	3.29	4.70	4.07	6.05	6.12	4.18
Merino	Threonine	2.95	2.49	3.08	2.99	3.54	2.79	2.56	2.90	2.31
	Valine	3.01	2.37	3.57	3.40	3.91	3.38	2.58	2.71	2.32
	Histidine	1.59	1.37	2.03	2.10	2.49	2.14	1.23	1.40	1.15
	Lysine	4.68	4.01	4.96	5.32	5.87	5.42	5.01	5.40	5.12
	Proline	2.87	2.77	4.12	3.75	4.55	4.33	4.84	5.08	3.14
	Methionine	1.31	1.17	1.52	1.33	1.28	1.28	1.22	1.37	1.10
	Tyrosine	2.65	1.94	3.53	3.35	2.76	3.19	2.36	2.85	2.09
	Isoleucine	2.25	2.12	2.92	2.81	2.00	2.46	2.04	2.55	1.85
	Phenylalanine	3.03	2.09	3.51	3.65	3.43	3.40	2.42	2.85	2.25
	Leucine	6.19	5.32	7.72	7.43	8.15	7.26	5.76	6.43	5.18
	Glycine	3.10	2.80	3.79	3.16	4.70	4.36	6.08	5.33	3.75

Cholesterol levels were much higher in the heart than any of the other organs. This is in agreement with other findings where cholesterol contents of 1408.05 mg/100g in cooked mutton brain and 1352 mg/100g in lamb brain have been reported.

The amino acid compositions of the various organs are shown in table 3. Histidine and methionine levels are similar to those reported internationally for dried lamb organ samples. The liver showed high levels of leucine when compared to the other organs, which is in agreement with the findings of international reports.

Table 4: The mineral composition (mg/100g) of Dorper and Merino organs

Breed	Mineral	Brain	Heart	Kidney	Liver	Lung	Spleen	Stomach	Testicle	Tongue
Dorper	P	0.012	0.011	0.015	0.016	0.012	0.018	0.010	0.011	0.009
	K	0.010	0.012	0.010	0.013	0.010	0.015	0.009	0.010	0.009
	Ca	0.003	0.001	0.001	0.001	0.001	0.001	0.005	0.001	0.001
	Mg	0.002	0.002	0.002	0.002	0.001	0.002	0.002	0.001	0.002
	Na	34.516	44.286	59.703	24.325	71.613	32.933	35.686	39.662	26.115
	Fe	9.106	8.567	12.315	7.862	11.585	8.169	13.624	17.517	11.825
	Cu	0.443	0.193	0.318	3.493	0.355	0.080	0.255	1.161	0.197
	Zn	1.563	1.704	2.009	3.596	1.336	1.403	2.281	2.219	1.837
	Mn	0.243	0.121	0.378	0.439	0.054	0.064	0.701	0.458	0.407
	B	0.030	0.029	0.016	0.071	0.032	0.026	0.040	0.021	0.043
	Al	1.725	0.817	1.947	0.782	2.459	0.958	0.39	0.792	0.974
Merino	P	0.011	0.009	0.015	0.015	0.014	0.018	0.008	0.011	0.014
	K	0.015	0.010	0.010	0.011	0.010	0.015	0.009	0.011	0.015
	Ca	0.003	0.001	0.002	0.001	0.001	0.002	0.001	0.001	0.006
	Mg	0.002	0.002	0.002	0.001	0.001	0.002	0.001	0.001	0.002
	Na	62.637	38.037	64.027	25.245	72.238	33.626	41.056	39.370	69.130
	Fe	2.244	3.882	4.718	2.868	10.101	6.933	1.674	1.794	2.221
	Cu	0.254	0.152	0.292	10.163	0.172	0.060	0.112	0.076	0.067
	Zn	1.352	1.476	2.507	4.286	1.362	1.552	2.223	1.618	1.970
	Mn	0.047	0.024	0.098	0.242	0.008	0.017	0.060	0.022	0.032
	B	0.020	0.016	0.015	0.016	0.031	0.022	0.014	0.009	0.012
	Al	0.964	0.853	3.392	0.969	2.687	0.907	0.902	1.387	1.096

The mineral profiles of the various organs are shown in table 4. Calcium and magnesium were found in the lowest concentrations while sodium and iron were found in the highest concentrations. Liver had the highest concentration of copper and zinc. These are important since they are considered as

essential minerals. Lung had the highest sodium and aluminium concentrations but also the lowest zinc and manganese levels. The tongue had the lowest phosphor, sodium and copper levels. Both spleen and lung had lower levels of zinc and manganese when compared to the other organs.

The organs in this study all differed in proximate composition, fatty acid profiles, cholesterol content and mineral content. Breed differences were also noted. This can be expected since similar findings have been reported internationally. No differences between organs or breed were found for total saturated fatty acids (SFA) or total monounsaturated fatty acids (MUFA), while total polyunsaturated fatty acids (PUFA), differed between the two breeds with Merino hearts having a significantly higher PUFA level than Dorper hearts. All the organs showed favourable P: S ratios, with the exception of the tongue, heart and stomach. Both Dorper and Merino brain, lungs and testicles had favourable (n-6)/(n-3) ratios below five. Calcium and magnesium were found in the lowest concentrations in the organs while sodium and iron were found in the highest concentrations. Liver was found to be a good source of iron and zinc. It would be of interest to research the manipulation of this composition through various other factors such as nutrition and supplementation.