MUSCULAR FIBER ARCHITECTURE AND X-RAY MICROANALYSIS OF SHEEP OFFALS

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Abstract- The purpose of this study was to characterise the muscular fiber architecture and nutrient constituents in sheep offals using x-ray microanalysis. Offals from Dhone Merino ewes and castrates were fixed in 10% formalin and post-fixed in 1% sodium cacodylate-buffered uranly acetate before dehydration and critical point drying. Results revealed uniform fiber orientation (isotropy) in the lung, mouth muscle and fillet. The highest quantity of arsenic (8.14±0.21%) was found in the omasum of the ewes. Castrates contained maximum levels of 15.55±0.61% cadmium and 2.85±0.13% potassium in the lung with an average of 27.71 nitrogen-sulphur ratio in the large intestine and digestible protein of 61.95% in the rumen. It was concluded that the muscular orientations of most offals were not uniform (anisotropic) and that, omasum and lung contained most of the neurotoxic micro-nutrients.

Key Words – anisotropy, muscular fiber micrographs, omasum.

I. INTRODUCTION

Offals are a culinary term referring to the entrails, internal organs or the edible parts of slaughtered meat species that are excised from the carcass in the process of evisceration or dressing [1-3]. Anatomical parts such as liver, lung, heart, kidney, trachea, spleen, brain, pancreas, omasum, reticulum, rumen, fillet, tongue, tail, thymus glands and intestines are common offals that are widely consumed in a number of African countries. Due to affordability and unique taste, it guarantees food security for many rural dwellers and makes a frugal or essential part of animal protein for majority of the population in Southern Africa [3-5]. Similar to what is obtainable in China [6]; demand for nutritional balance, low fat intake and reduced risks of contamination have thus, elicited increased preference for mutton and offals from sheep. Muscular architecture which describes the geometric design of a muscle [7] is thus critical for determining the tenderness, functional properties of different sized muscles and the complex array of fibre orientations exhibited by the muscles [8]. A dearth of information however exists in this regard and also, on the multi-elemental constituents in offals from extensively raised and widely consumed indigenous sheep genotype. Against this background, this study was designed to examine the fiber architecture and x-ray micro analysis of offals from Dhone Merino sheep.

II. MATERIALS AND METHODS

Offals (liver, lung, rumen, omasum, abomasum, reticulum, small intestine, large intestine, kidney, spleen, trachea, mouth muscle, tongue, heart and fillet) from Dhone Merino ewes (n=69) and castrates (n=69) were used for this study. Representative sample of $\leq$ 5g from each offal was fixed in 10% formalin solution and re-fixed in 2.5% sodium cacodylate-buffered gluteraldehyde (pH7.2) at 4oC for 2 hours. Post-fixation was followed with 1% sodium cacodylate-buffered uranyl acetate for 2 hours. The offals were then washed in distilled water and dehydrated in ascending grades of ethanol from 10% to 100% respectively. The Hitachi critical point dryer (CPD) HCP-2 (Hitachi Koki Co Ltd, Tokyo Japan) was used for critical point drying. Each sample was mounted on aluminum stubs with double – sided carbon tape and then sputter coated with gold-palladium (Au-Pb) using the Eiko IB.3 Ion Coater (EIKO Engineering Co TD, Japan). The samples were finally observed under the JEOL JSM-6390LV scanning electron microscope (SEM) for the determination of electron micrographs and x-ray micro analysis of the offals. Data collected from SEM were x-ray nutrient constituents, the fiber length (micrometer, µm); fiber thickness (µm) and fiber orientation (anisotropy or isotropy) respectively.

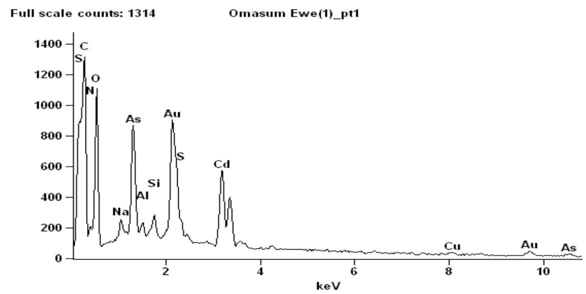
III. RESULTS AND DISCUSSION

A great variability of the muscular fibers was observed in the sheep offals with respect to fiber length, fiber thickness, fiber orientations and nutrient compositions. The longest fiber length of 201.21µm was obtained from the mouth muscle of the castrate. With the exception of the small intestine, other intestinal offals showed distinct fiber variations (anisotropy) as compared with isotropic arrangements in the lung, mouth muscle and fillet (Table 1). This result is consistent with the one reported by Gaige [8] where different muscles from various anatomical parts were diverse in terms of architecture.

Table 1 Fibre characteristics of Dhone Merino offals

Offals	Source	Fibre length (µ)	Fibre thickness(µ)	Nature of fibre orientation
Intestinal offals				
Abomasum	Castrate	54.24	4.6	Anisotropy
	Ewe	63.9	5.8	
Large intestine	Castrate	80.32	8.76	Anisotropy
	Ewe	74.07	6.72	
Omasum	Castrate	87.97	8.92	Anisotropy
	Ewe	99.50	21.12	
Reticulum	Castrate	42.11	17.65	Isotropy
	Ewe	40.43	22.40	
Rumen	Castrate	76.40	24.17	Anisotropy
	Ewe	67.18	18.62	
Small intestine	Castrate	54.21	23.00	Isotropy
	Ewe	112.30	40.18	
Non-intestinal offals				
Lung	Castrate	234.67	72.97	Isotropy (circular)
	Ewe	59.62	46.28	
Spleen	Castrate	46.00	13.54	Anisotropy
	Ewe	44.17	13.44	
Heart	Castrate	47.97	11.41	Anisotropy
	Ewe	155.35	22.37	
Liver	Castrate	43.85	09.11	Anisotropy
	Ewe	38.76	21.00	
Trachea	Castrate	16.17	5.10	Anisotropy
	Ewe	13.35	3.82	
Mouth	Castrate	201.21	23.53	Isotropy
	Ewe	198	18.89	
Tongue	Castrate	91.13	10.36	Anisotropy
	Ewe	111.71	14.67	
Fillet	Castrate	86.76	24.22	Isotropy
	Ewe	71.5	18.71	
Kidney	Castrate	38.18	26	Anisotropy
	Ewe	30.88	26.17	

Although multi-elemental compositions were found in all the offals, the arsenic content was most abundant in the omasum of Dhone Merino ewes (Figure 1). Since the wall of omasum is highly folded, it provides a large surface area for efficient absorption of water, salts, residual volatile acids, bicarbonates and trace elements such as arsenic and cadmium.



Weight %

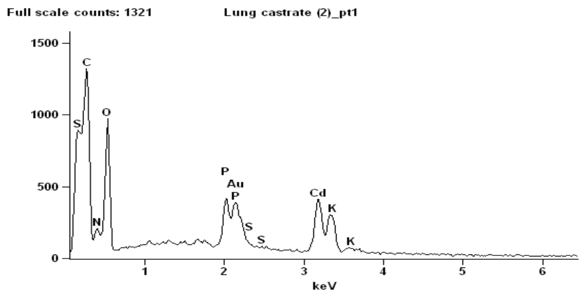
	C-K	N-K	O-K	Na-K	Al-K	Si-K	S-K	Cu-K	As-L	Cd-L	Au-L
Omasum Ewe(1)_pt1	15.91	5.41	21.88	0.90	0.51	0.80	0.75	1.82	8.14	12.00	31.86

Weight % Error (+/- 1 Sigma)

	C-K	N-K	O-K	Na-K	Al-K	Si-K	S-K	Cu-K	As-L	Cd-L	Au-L
Omasum Ewe(1)_pt1	+/-0.36	+/-0.94	+/-0.51	+/-0.06	+/-0.07	+/-0.08	+/-0.10	+/-0.38	+/-0.21	+/-0.49	+/-4.01

Figure1. X-ray micro analysis showing maximum level of arsenic in the omasum of Dhone Merino ewe.

The maximum level of cadmium accounting for 15.55% was found in the lung of Dhone Merino castrate (Figure 2). This value, which corresponds to 0.109 µg/kg body weight per week is lower than the FAO/WHO Provisional Tolerable Weekly Intake (PTWI) of 0.20-0.42 µg/kg body weight per week [9, 10] but within the Average Weekly Dietary Intake (AWDI) of 0.95-3.06 µ/kg-bw/week (13.7-43.8%) cadmium [11]. The potassium level of 2.89% (20.23×10^{-3} µg/kg body weight per week) in castrate lung will be ideal to boost normal heart beat, nerve transmission and acid-base balance if lung from castrate sheep is consumed.



Weight %

	C-K	N-K	O-K	P-K	S-K	K-K	Cd-L	Au-L
Lung castrate (2)_pt1	18.33	6.93	28.41	2.97	0.36	2.89	15.55	24.55

Weight % Error (+/- 1 Sigma)

	C-K	N-K	O-K	P-K	S-K	K-K	Cd-L	Au-L
Lung castrate (2)_pt1	+/- 0.39	+/- 0.87	+/- 0.70	+/- 0.09	+/- 0.10	+/- 0.13	+/- 0.61	+/- 4.18

Figure 2. X-ray microanalysis showing maximum levels of cadmium and potassium in the lung of Dhone Merino castrate.

The ratio (N/S) in the large intestine (Table 2) was indicative of inherently low retention of both nutrients in the intestinal wall of sheep. Highest digestible protein value of 61.95% for the rumen castrate serves as a predictor for its better digestibility per unit of crude protein [12].

IV. CONCLUSION

This study showed dissimilar orientations of the muscular fibers in Dhone Merino sheep. The x-ray micro analysis also revealed the presence of various nutrients in the offals. Meat consumers may therefore consider sheep offals as a protein source by choosing offals with desirable fiber orientation and preferred nutrient contents.

ACKNOWLEDGEMENTS

This work was funded by the National Research Foundation (Project T079) and Govan Mbeki Research and Development Center (GMRDC). The authors are therefore grateful for this support.

Table 2 Protein components and mineral ratios of offals from Dhone Merino

Offals	Meat Source	Nitrogen (%)	Sulphur (%)	N/S Ratio	Crude Protein (%)	Digestible Protein
Intestinal offals						
Abomasum	Castrate	6.45	0.95	6.78	40.33	32.85
	Ewe	4.41	0.71	6.21	27.59	21.28
Large intestine	Castrate	5.82	0.21	27.71	36.38	29.26
	Ewe	8.64	0.83	10.41	54	45.26
Omasum	Castrate	7.36	0.92	8.00	45.98	37.99
	Ewe	5.41	0.75	0.68	33.81	26.93
Reticulum	Castrate	9.24	1.06	8.72	57.77	48.69
	Ewe	18.39	1.84	3.62	41.63	34.03
Rumen	Castrate	11.58	1.02	6.39	72.38	61.95
	Ewe	8.34	1.23	6.78	52.11	52.63
Small intestine	Castrate	6.80	0.97	7.01	42.51	37.55
	Ewe	5.61	0.63		35.06	28.06
Non-intestinal offals						
Fillet	Castrate	11.20	1.31	8.54	70.00	59.79
	Ewe	8.92	1.00	5.74	55.73	46.83
Heart	Castrate	6.57	0.89	7.38	41.06	23.82
	Ewe	4.86	0.74	6.57	25.64	19.51
Kidney	Castrate	8.86	1.66	5.34	55.38	46.52
	Ewe	9.40	1.08	4.82	58.75	49.58
Liver	Castrate	9.67	1.22	4.49	60.44	51.11
	Ewe	3.88	0.34	11.41	46.85	38.77
Lung	Castrate	14.00	1.41	9.93	87.5	75.68
	Ewe	29.89	2.34	8.17	72.00	61.61
Mouth	Castrate	7.11	0.83	3.95	44.44	36.58
	Ewe	4.99	0.45	11.08	31.23	24.59
Tongue	Castrate	10.30	1.33	6.32	64.38	54.69
	Ewe	7.72	0.76	3.43	48.25	40.04
Trachea	Castrate	7.48	0.88	2.51	46.81	38.73
	Ewe	5.17	0.45	11.48	32.31	25.57

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