HOW HEALTHY IS ZEBRA MEAT?

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Abstract – Zebra is regularly harvested for export in South Africa. Although the meat is exported and consumed locally, little information exists on the meat composition of zebra. The study investigates the proximate and fatty acid composition of zebra meat. Zebra *longissimus lumborum* muscle was shown to be a protein dense meat with a low intramuscular fat content. Similarly, both this muscle as well as the subcutaneous fat has a very healthy composition with high levels of linolenic acid. However, further research is required to evaluate and quantify the effects of extrinsic (age, season, nutrition, gender) and intrinsic (muscle type, fat depot) factors on the lipid composition.

I. INTRODUCTION

Zebra are almost completely grazers that manage to survive on lower quality forage. Zebra furthermore consume the older grass growth ahead of the other grazing species, so as to enable the selective grazing by other grazers [1]. South Africa regularly harvests zebra for export. In 2011, the meat from 745 carcasses was exported. Since zebra are classified as equine and not as cloven hoofed animals, they do not fall under the regulations that apply to foot-and-mouth disease controls. Consequently, the industry can export zebra meat when there are outbreaks of this disease. The meat from zebra is also sought after for the making of salami, in addition to the high value of the zebra skin (33 – 37% of the total value) [2]. Although the meat is exported and consumed locally, little information exists on the meat composition of zebra. This report discusses the proximate and fatty acid composition of zebra meat harvested for export.

II. MATERIALS AND METHODS

Harvesting

Twenty zebra (*Equus burchelli*) were harvested from the northern Bushveld, Limpopo Province, South Africa. Harvesting was in the middle of winter (July) in a summer rainfall region.

Sample preparation

After skinning, the *longissimus lumborum* (LL) muscle and adjacent subcutaneous fat (SCF) layer of each zebra carcass (Mean weight = 138.2 kg; Standard Deviation (SD) = 23.50; Minimum (Min) = 106.0 kg; Maximum (Max) = 190.6 kg) was removed from the last rib to the caudal end of the *longissimus thoracis et lumborum* (LTL). The muscles samples were vacuum packed and frozen. The samples were thawed at ± 4˚C for 24 h prior to processing. The SCF was removed from the thawed samples prior to homogenising the muscle. Both the muscle and SCF was individually vacuum packed and frozen at -18˚C until chemical analyses. Prior to chemical analyses, the frozen, homogenised SCF and muscle samples were thawed at ± 4˚C for 24 h.

Proximate analysis

The moisture contents (% wet weight) of 2.5 g homogenised meat samples were determined for all samples in duplicate by drying for 24 h at 100°C as described in the official method of the Association of Official Analytical Chemists [3].

The total crude protein content (% wet weight) of the defatted, dried and ground meat samples was analysed in duplicate by means of the Dumas combustion method 992.15 [4]. The samples (0.1 g) were analysed in a Leco Nitrogen/Protein Analyser (FP – 528, Leco Corporation). The Leco analyser was calibrated with ethylene-diamine-tetra-acetic acid (EDTA) before each batch of samples were analysed. The results were obtained as percentage nitrogen (N), which was then converted to percentage protein per gram of meat sample. The total lipid content (% wet weight) of 5 g homogenised meat samples was determined in duplicate using the chloroform/methanol extraction gravimetric method [5]. A chloroform/methanol solution concentration of 1:2 (v/v) was used where the samples were expected to contain less than 5% fat. The ash content (% wet weight) of the moisture free samples was determined in duplicate using the official AOAC method

942.05 by ashing the samples for 6 h at 500°C [6].

Fatty acid analysis

After thawing, the fat from a 2 g sample was extracted with a chloroform:methanol (2:1; v/v) solution [7]. The fatty acid methyl esters (FAMEs) were extracted and analysed using the method described in van Schalkwyk *et al.* [8]. Values were recorded as % of total fatty acids in each meat sample.

III. RESULTS AND DISCUSSION

Proximate composition

The proximate composition (%) of the meat from 20 zebra harvested from the same region and season is presented in Table 1.

Table 1 The proximate composition (%) of zebra (n = 20) *longissimus lumborum* muscle

	Mean	SD	Min	Max
Moisture	76.4	0.81	74.4	77.9
Protein	22.3	0.53	21.4	23.3
Fat	1.4	0.48	1.0	3.1
Ash	1.1	0.07	1.0	1.3

Table abbreviations: Standard Deviation (SD); Minimum (Min); Maximum (Max).

Meat generally consists of ~75% moisture, ~19% protein, ~2.5% fat and smaller quantities of other components [9]. Zebra meat can be classified as a protein dense foodstuff due to its high protein content (22.3%). Additionally, the meat from zebra has a low mean total fat content with a minimum of 1.0% and a maximum of 3.1%. Zebra meat with a mean total intramuscular fat (IMF) content of 1.5% (Table 1) can be marketed as being low in fat, since this is less than 3% [10]. Onyango *et al*. [11] reported more or less similar proximate composition values for zebra loin muscles at 75.2% moisture content, 22.8% crude protein content, 0.3% crude fat content and 1.5% ash content. Zebra meat is therefore high in protein and low in fat.

The mean moisture and protein contents of horse meat varied from the values of this study [12,13], whilst the horse fat content showed much higher (6.6%) values [12]. However, in the latter review the intermuscular fat (IMF) in horse meat was similar to that in zebra meat and varied from as low as 0.12% to as high as 6.63% [13]. The ash content of the zebra was also within the range reported for horse meat [13], but significantly lower than the 5.1-8.2% reported in donkey [14] but similar to the 1.0% reported in the *longissimus dorsi* muscle of 15-month old donkeys [15]. It is postulated that the proximate composition of zebra meat will also be influenced by the same factors that influence that of horse meat [13] such as age, gender, etc., although the effect of diet will be less pronounced as zebra are presently not fed artificial formulated diets but their composition should be influenced by season. This aspect warrants further research.

Fatty acid profile

The fatty acid profile (% of fatty acids present) of the LL muscle and SCF of zebra is presented in Table 2. The four fatty acids present at the greatest quantities in zebra meat and SCF were palmitic acid (C16:0), stearic acid (C18:0), oleic acid (C18:1ω9) and linoleic acid (C18:2ω6c) (Table 2).

Zebra are grazing animals and similar to horses and donkeys, are hind-gut fermenters. Lorenzo *et al*. [13] showed that diet has an influence on the fatty acid profile of horse meat with extensively raised horses (mainly feeding on pastures) having a higher concentration of polyunsaturated fatty acids (PUFA) than concentrate fed horses. It is theorised that zebra should therefore also follow a similar trend. The fatty acid contents of grass is quite low [16], nonetheless the primary fatty acid present is C18:3ω3 (alpha-linolenic acid, ALA) and smaller quantities of C18:2ω6 and C16:0 [16,17]. Since zebra are not ruminants, it is expected that the fatty acid profile in the meat will more or less be a representation of the composition of the fatty acids in the diet [13]. The linoleic acid content was indeed high in the LD muscle (23.4%) but lower (9.5%) in the SCF (Table 2). However, the ALA was lower in the muscle (11.8%) than in the SCF (25.5%). The LD muscle and SCF of zebra both have high palmitic acid contents (24.0% and 25.7%, respectively) and stearic acid contents (14.0% and 7.9%, respectively). Of the long chained fatty acids, both the C20:3ω6 and C22:5ω3 were ≈1.5% and higher in the IMF than the SCF.

Table 2 The fatty acid profile (% of fatty acids present) of the *Longissimus lumborum* muscle and subcutaneous fat of zebra (n = 20)

Fatty acid	*Longissimus lumborum* muscle (IMF)				Subcutaneous fat (SCF)			
	Mean	SD	Min	Max	Mean	SD	Min	Max
C14:0	0.76	0.28	0.33	1.41	1.04	0.74	0.00	2.99
C15:0	0.18	0.04	0.11	0.28	0.17	0.15	0.00	0.53
C16:0	24.03	1.56	21.27	27.36	25.71	9.43	11.00	51.71
C18:0	14.06	2.35	7.77	18.58	7.94	6.52	1.47	23.77
C20:0	0.14	0.03	0.06	0.17	0.12	0.15	0.01	0.53
C21:0	0.40	0.08	0.22	0.64	0.22	0.22	0.04	0.93
C22:0	1.46	0.63	0.49	3.21	0.38	0.99	0.01	4.17
C24:0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C14:1	0.00	0.00	0.00	0.00	0.06	0.09	0.00	0.42
C15:1	0.00	0.00	0.00	0.00	0.06	0.05	0.00	0.16
C16:1ω9	1.54	0.68	0.00	3.42	1.89	1.19	0.49	4.29
C18:1ω9c	15.88	4.63	10.24	30.97	24.12	9.93	7.92	48.13
C18:1ω9t	0.17	0.04	0.13	0.27	0.20	0.14	0.05	0.51
C20:1ω9	0.25	0.04	0.17	0.33	0.24	0.21	0.05	0.79
C22:1ω9	0.00	0.00	0.00	0.00	0.12	0.20	0.00	0.64
C24:1ω9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C18:2ω6c	23.41	4.16	11.91	29.25	9.47	6.48	1.82	23.45
C18:2ω6t	0.17	0.07	0.06	0.35	0.11	0.12	0.02	0.41
C18:3ω6	0.57	0.12	0.37	0.81	0.43	0.28	0.11	1.11
C18:3ω3	11.78	4.33	4.60	20.06	25.48	17.19	4.56	66.88
C20:2	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.08
C20:3ω6	1.57	0.59	0.39	3.06	0.48	0.98	0.01	3.72
C20:3ω3	0.24	0.12	0.05	0.52	0.38	0.99	0.00	4.17
C20:4ω6	0.61	0.12	0.45	0.85	0.38	0.25	0.09	0.86
C20:5ω3	0.74	0.32	0.24	1.53	0.34	0.68	0.01	2.27
C22:2ω6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C22:5ω3	1.47	0.51	0.554	2.48	0.46	0.93	0.02	3.80
C22:6ω3	0.60	0.24	0.16	1.20	0.16	0.36	0.01	1.51
SFA	41.01	3.06	3.91	45.732	35.59	8.62	16.17	55.89
MUFA	17.84	5.17	11.37	34.70	26.70	9.81	9.31	49.04
PUFA	41.15	3.37	31.40	46.67	37.71	14.86	14.27	73.26
ω6 PUFA	26.33	4.72	13.32	33.78	10.87	7.82	2.09	29.36
ω3 PUFA	14.82	3.68	9.20	22.57	26.82	16.09	8.19	67.01
PUFA:SFA	1.01	0.09	0.85	1.21	1.26	1.04	0.26	4.53
ω6:ω3	1.95	0.80	0.747	3.67	0.59	0.58	0.07	2.25

Standard Deviation (SD); Minimum (Min); Maximum (Max); Total Saturated Fatty Acids (SFA); Total Monounsaturated Fatty Acids (MUFA); Total Polyunsaturated Fatty Acids (PUFA); Total Omega-3 Polyunsaturated Fatty Acids (ω3 PUFA); Total Omega-6 Polyunsaturated Fatty Acids (ω6 PUFA); Polyunsaturated to Saturated Fatty Acids Ratio (PUFA:SFA); Omega-6 to Omega-3 Polyunsaturated Fatty Acids Ratio (ω6:ω3). SFA = sum of C14:0, C15:0, C16:0, C18:0, C20:0, C21:0 and C22:0; MUFA = sum of C14:1, C15:1, C16:1ω9, C18:1ω9c, C18:1ω9t, C20:1ω9, C22:1ω9 and C24:1ω9; PUFA = sum of C18:2ω6c, C18:2ω6t, C18:3ω3, C18:3ω6, C20:2, C20:3ω3, C20:3ω6, C20:4ω6, C20:5ω3, C22:2ω6, C22:5ω3 and C22:6ω3; ω3 PUFA = sum of C18:3ω3, C20:3ω3, C20:5ω3, C22:5ω3 and C22:6ω3; ω6 PUFA = sum of C18:2ω6c, C18:3ω6, C20:3ω6 and C20:4ω6; PUFA:SFA = [(sum of C18:2ω6c, C18:2ω6t, C18:3ω3, C18:3ω6, C20:2, C20:3ω3, C20:3ω6, C20:4ω6, C20:5ω3, C22:2, C22:5ω3 and C22:6ω3)/(sum of C14:0, C15:0, C16:0, C18:0, C20:0, C21:0 and C22:0)]; ω6:ω3 = [(sum of C18:2ω6c, C18:3ω6, C20:3ω6 and C20:4ω6)/(sum of C18:3ω3, C20:3ω3, C20:5ω3, C22:5ω3 and C22:6ω3)]

Zebra has similar saturated fatty acid (SFA) and PUFA concentrations (≈40% of each) in the IMF but lower levels of these in the SCF, resulting in a polyunsaturated to saturated fatty acid ratio (PUFA:SFA) of ≈1.0 in the muscle and 1.3 in the SCF. In comparison with the SFA, monounsaturated fatty acid (MUFA) and PUFA contents in horse meat (35%, 47%, and 19% of total fatty acids, respectively) [18] and in donkey meat (41%, 34% and 25%, respectively) [19], zebra meat has somewhat higher SFA (41.1%), slightly lower MUFA (18.6%) and more than double the PUFA contents (39.6%) (Table 2). The latter is due to the high levels of linoleic and linolenic acids.

The omega-6 to omega-3 fatty acid ratio (ω6:ω3) of the LL muscle was higher (1.95) than that of the SCF (0.59). The low ω6:ω3 value of the latter being due to the low levels of ω6 PUFA (10.9%) and high levels of ω3 PUFA (26.8%) present in zebra SCF (Table 2). Some researchers suggest a PUFA:SFA of ≥0.70 and ω6:ω3 of ≤5.0 for red meat to be seen as healthy for human consumption [20]. Therefore, the IMF of the LL muscle and SCF of zebra both had favourable mean PUFA:SFA values (1.01 and 1.26, respectively) and ω6:ω3 values.

IV. CONCLUSION

Zebra LL was shown to be a protein dense meat with a low IMF content. Similarly, both the LL muscle as well as the SCF has a very healthy fatty acid composition with high levels of linolenic acid. However, further research is required to evaluate and quantify the effects of extrinsic (age, season, nutrition, gender) and intrinsic (muscle type, fat depot) factors on the lipid composition. Presently, all indications are that zebra meat is also an ideal meat for further processing (salami, etc.) although more research is also required to verify this. Another aspect that warrants more research is the dynamics of lipid digestion in the stomach of hind gut fermenters such as zebra. Presently, zebra are not farmed as such and all harvested animals are surplus animals, however the possibility of this species becoming more popular should not be underestimated as its skin also has value.

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