NUTRITIONALLY RELEVANT COMPONENTS IN MEAT OF FARMED FALLOW DEER (*DAMA DAMA L.*) AND RED DEER (*CERVUS ELAPHUS L.*) AS COMPARED WITH BEEF

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Abstract – Game represents only a minor part of total meat consumption, and a comparison with beef may help to improve the position of game on the market. A total of 36 meat samples, M. *longissimus*, from 12 fallow deer, 6 red deer and 8 bullocks and 10 steers (Limousin x Simmental crossbreed) was analysed for nutritionally relevant compounds. The steers´ meat contained twice as much fat (IMF) as that of the bullocks (19.7 vs 10.9 g/kg) whereas game represented intermediate IMF content (14.6 and 15.5 g/kg in fallow deer and red deer, respectively). Game had a higher Fe concentration than beef. The game IMF showed significantly more polyunsaturated fatty acids (PUFA) than bullocks and steers, particularly, the very long-chain (VLC) n-3 PUFA which contribute to prevention of coronary heart disease. VLC n-3 PUFA, with sea fish as the main source, are limited in Western food and game could be an alternative for people with aversions against fish.

I. INTRODUCTION

Game represents only a minor part of total meat consumption, and studies of nutritionally relevant constituents by comparison with beef may help to improve the position of game on the market. Besides the favourable pattern of indispensable amino acids and vitamin B12 (1), the trace elements, mainly the highly bioavailable Fe, and the fat determine the nutritional quality. Among the polyunsaturated fatty acids (PUFA) these of the omega-3-type, also n-3-type, are in the focus and here especially the very-long-chain polyunsaturated fatty acids (VLC-PUFA) - the eicosapentaenoic acid (EPA; 20:5, n-3), docosapentaenoic acid (DPA; 22:5, n-3) and docosahexaenoic acid (DHA; 22:6, n-3). These three VLC-PUFA from n-3-type act as precursors for the n-3 eicosanoids, which reduce the risk of suffering and dying from coronary heart diseases (CHD). However, the synthesis of n-3-VLC-PUFA is limited (2) and, therefore, food with higher contents in these FA should be preferred. Fish from the sea is the best source of VLC n-3 PUFA, but fishing and aquaculture are limited. There are high expectations for the use of meat as alternative VLC n-3 PUFA source resulting in a need for checking different animal species including the game. Objectives of the present study were to characterize the nutritional status of the meat of fallow deer and red deer in comparison to beef cattle. According to the big role of steers for beef production in many parts of the world and in a particular German market segment the samples from bullocks and steers had to be considered. Besides the main nutrients, the study focused on the content of Fe, Zn, Mn, Cu, Se and I and on the FA in the IMF of the *M. longissismus.* The analysed concentrations of trace elements and FA should be discussed in relation to the recommendations of Societies of Nutrition Germany, Austria, Switzerland (3)

II. MATERIALS AND METHODS

The investigated 36 meat samples, *M. longissimus*, transition lumbar-breast region, represented fallow deer (12 bucks, 16 month old, 24.6 kg carcass weigt, CW), red deer (6 calves, 7 month old, 31.1 kg CW), 8 bullocks (18 month old, 351 kg CW) and 10 steers (22.5 month old, 296 kg CW), all beef from Limousin x Simmental crossbreed. Game originated from farms in the foothills of the Thuringian Forest, cattle from a farm in the Thuringian Forest. The lyophilized and ground samples were analysed for water, protein, intramuscular fat (IMF), Fe, Zn, Mn, Cu, Se and I and fatty acids (FA). For the analysis of trace elements matrix disintegration was made via pressure digestion of 0.5 g lyophilized finely ground sample mixed with 3 ml concentrated nitric acid and 1 ml hydrogen peroxide. Fe, Zn, Cu and Mn were detected by inductively coupled plasma atomic emission spectrometry (ICP-AES, Optima 3000, Perkin_Elmer, Waltham, Massachusetts, USA). Se content was analyzed by flow-injection hydride atomic absorption spectrometry (AAnalyst 100/FIA 400, Perkin_Elmer, Waltham, Massachusetts, USA). The iodine content was analysed using inductively coupled plasma-mass spectrometry (ICP-MS, ELAN 6000, Perkin_Elmer, Waltham, Massachusetts, USA) after matrix disintegration and solution with tetramethylammoniumhydroxide, TMAH (4). Neutral and polar lipids were extracted from 10 g lyophilized finely ground sample using extraction with (1:2 v/v) chloroform-methanol. FA were determined after methylation by GC (Shimadzu GC 17a V3, Duisburg, Germany) using, in first run, a medium polar column to separate C 4 to C 25 inclusive branched-chain FA. In a second run, the positional and geometric isomers of C18:1 were resolved using a 200 m high-polarity column (for details see Ref 5). The data from the two game and two cattle groups were subjected to ANOVA and the Student-Newman-Keuls' test (SPSS Inc,Chicago, IL, USA). Despite the depiction of significances in the Tables only for the two game or beef groups, the text also gives the significances between game and beef.

III. RESULTS AND DISCUSSION

At a similar protein content in meat of the investigated species in a range from 21-22%, the fat content differed (Tables 1 and 2). Bullocks contained only about a half of the IMF than the steers whereby the IMF in the game was "between" that of the bullocks and steers. The game meat had a significantly higher content of Fe, Mn and Cu (Mn and Cu not shown) than the beef, whereas the beef dominated for the contents of Zn and Se. Se and Zn are part of mineral feed which is obligatorily administered in cattle feeding. For farmed game, lick-stones are used with lower mineral offer. The 2.5-times meat Se content in the steers compared with the bullocks may result from longer steer fattening in the barn at a later growth stage with a higher Se intake by more daily mineral feed.
According to US food tables (6) game´s content of 3.4 mg Fe/100 g, is lower than the present values, however, the Zn content of 5.2 mg/100 g and the Se content of 10 µg/100 g represent the three- and six-fold content than in Table 1. Also in farmed red deer, aged about 20 months, from New Zealand, with 32 mg Fe/kg meat, a lower content of Fe was analysed (7) than in the present investigation (Table 1). Regarding Se, game content is half of the meat from hunted red deer in Poland (8).

The iodine content was very low in all investigated meat (between 3 and 15 µg I /kg in red deer and steers, respectively) which confirmed results of former investigations in pigs (4). Regarding a recommendation of 200 µg I per adult and day (3) meat may not substantially contribute to the supply with I.

The SFA represented the dominating FA group with more than a half of total FA in the IMF of fallow deer and this exceeded significantly the SFA in the IMF of red deer and beef (Tables 1 and 2). The MUFA showed significant differences between beef and game in favour of beef IMF. Oleic acid (18:1, c 9) is the main representative of the MUFA (not shown), however, also the *trans* isomeric FA, represented mainly by 18:1 FA, occurred at a higher level in beef IMF.

Table 1 Selected constituents of game meat and intramuscular fat (IMF), mean±SD

Item	Fallow deer bucks (n=12)	Red deer calves (n=6)
Protein, g/kg meat	213 ± 6	210 ± 3
IMF, g/kg meat	14.6 ± 2.4	15.5 ± 2.1
Fe, mg/kg meat	38.4 ± 5.4	42.4 ± 4.7
Zn, mg/kg meat	17.8 ± 2.6	17.8 ± 3.0
Se, µg/kg meat	17 ± 10	16 ± 6
SFA, g/100g IMF	53.4[a] ± 4.0	41.8[b] ± 3.2
MUFA[1)], g/100 g IMF	18.4[b] ± 1.7	22.5[a] ± 4.0
TFA, g/100 g	1.90 ± 0.35	1.87 ± 0.46
PUFA[1)], g/100 g IMF	25.8[b] ± 5.3	33.0[a] ± 6.9
n-3, g/100 g IMF	8.06 ± 1.11	9.03 ± 2.15
n-6, g/100 g IMF	17.78[b] ± 4.45	24.01[a] ± 5.74
EPA, g/100 g IMF	1.52[b] ± 0.25	2.36[a] ± 0.64
DPA, g/100 g IMF	2.81 ± 0.52	2.52 ± 0.56
DHA, g/100 g IMF	0.22[b] ± 0.06	0.53[a] ± 0.16
VLC-FA, n-3	4.66 ± 0.78	5.55 ± 1.36
CLA	0.31[b] ± 0.07	0.54[a] ± 0.15

[1)]only cis isomers [ab] different indices in the same row characterize significant differences.
Abbreviations: SAFA = Saturated Fatty Acids, MUFA = Monounsaturated Fatty Acids, TFA = *trans* isomeric FA, mainly of 18:1, PUFA = Polyunsaturated Fatty Acids,
EPA = eicosapentaenoic acid - 20:5, n-3;
DPA = docosapentaenoic acid - 22:5, n-3;
DHA = docosahexaenoic acid - 22:6, n-3;
VLC-FA = Very-Long-Chain Fatty Acids;
CLA = Conjugated Linoleic Acids.

The IMF of game had a significantly higher content of *cis* PUFA than that of beef. There are also significant differences in favour of the fallow deer compared with red deer as well as in favour of the bullocks compared with steers. In accordance with the total PUFA, IMF of game had higher contents in n-3 and n-6 FA than that of beef. The content of EPA and DHA in red deer IMF was higher than in fallow deer IMF whereas the DPA percentage hardly differed between the "deer species". The n-6/n-3 ratios of 2.2:1 for fallow deer and 2.7:1 for red deer were in a similar magnitude. In bullocks and steers, at 5.5 and 3.0:1 broader n-6:n-3 relations were realized.

Table 2 Selected constituents in beef (Limosin x Simmental breed) and in the intramuscular fat (IMF), mean±SD

Item	Bullocks (n=8)	Steers (n=10)
Protein, g/kg meat	223± 6	218 ± 4
IMF, g/kg meat	10.9^b ± 4.9	19.7^a ± 8.1
Fe, mg/kg meat	13.6 ± 1.6	17.5 ± 3.3
Zn, mg/kg meat	32.5 ± 3.0	30.2 ± 5.0
Se, µg/kg meat	52^b ± 9	127^a ± 8
SFA, g/100g IMF	42.2^b ± 1.4	45.4^a ± 2.1
MUFA[1)], g/100g IMF	37.6^b ± 2.3	41.2^a ± 2.3
TFA, g/100 g	2.52 ± 0.47	2.65 ± 0.40
PUFA[1)], g/100g IMF	17.1^a ± 3.4	9.9^b ± 1.4
n-3, g/100g IMF	2.61 ± 0.33	2.43 ± 0.37
n-6, g/100g IMF	14.51^a ± 3.18	7.27^b ± 1.06
EPA, g/100g IMF	0.59 ± 0.08	0.49 ± 0.13
DPA, g/100g IMF	0.98 ± 0.14	0.78 ± 0.14
DHA, g/100g IMF	0.08 ± 0.01	0.09 ± 0.03
VLC-FA, n-3	1.63 ± 0.24	1.37 ± 0.30
CLA	0.58^b ± 0.08	0.75^a ± 0.14

[1)]only cis isomers [ab] different indices in the same row characterize significant differences.
For abbreviations see footnote Table 1

Fallow deer and red deer VLC n-3 PUFA and VLC n-6 PUFA were with a percentage of ca. 5% clearly better (Table 1) than the beef IMF with ca. 1.5% of VLC n-3 PUFA and 2-4% of VLC n-6 PUFA level (Table 2). In the literature, VLC n-3 FA ranged in fallow deer IMF from 5.2-8.6% (9, 10), in red deer IMF from 2.3-9.9% (11, 7), in beef IMF only from 0.4-2.5% VLC n-3 FA (12, 13). VLC n-6 FA ranged in fallow deer IMF from 11-16% (9, 10), in red deer IMF from 4.5-10.4% (7, 11). The few studies with the high variance point to the necessity of further investigations.

The conjugated linoleic acid (CLA) isomers represented the highest values in IMF of steers and the lowest in that of fallow deer whereas red deer and bullocks had similar IMF contents in these minor FA. CLA *c*9, *t*11 (not shown) is the main representative of CLA group in all species. However, it ranged from almost a third of total CLA in fallow deer and bullock´s IMF up to about 4/5 in red deer and steer´s IMF. Differences of CLA, 18:1*t* isomers and also in branched-chain and odd-chain (BCOC) FA (not shown) have a low relevance for human nutrition, however, point to species differences in feed fat degradation and fat synthesis by rumen microbes.

Considering nutrition facts for consulting and nutrition education, MUFA and n-6 PUFA of the minor fat part in a game portion may not contribute substantially to a daily offer of 20-30 g MUFA and 10-15 g PUFA (as part of totally 60-80 g food fat per adult and day, ref. 3). However, for n-3 PUFA and the respective VLC representatives the supply via a game portion may be significant. Regarding a daily recommendation of at least 0.5% n-3 PUFA from total food-energy (3), an adult at 1800 kcal gross energy per day should consume 9 kcal via 1 g n-3 PUFA.

Table 3 For nutrition information relevant fatty acids (FA) of game as mg per 100g meat, mean±SD

Item	Fallow deer bucks (n=12)	Red deer calves (n=6)
MUFA[1)]	270 ± 62	353 ± 98
PUFA[1)]	367^b ± 45	502^a ± 65
n-3	115 ± 14	138 ± 28
n-6	251^b ± 41	364^a ± 63
EPA	21.7^b ± 3.0	35.9^a ± 7.3
DPA	40.1 ± 6.2	38.3 ± 6.2
DHA	3.3^b ± 1.2	8.0^a ± 2.0
VLC-FA, n-3	66.7^b ± 9.6	84.4^a ± 15.4
CLA	4.5^b ± 1.2	8.4^a ± 3.7

[1)]only cis isomers [ab] different indices in the same row characterize significant differences.
For abbreviations see footnote Table 1

A steak prepared from 150 g lean meat would contribute roughly 40–70 mg n-3 PUFA in the case of beef (5), however, in the case of game 170 mg for fallow deer, even about 200 mg for red deer. This n-3 PUFA intake exceeds 120 mg via a 150 g-steak from beef representing the pasture-fed Highland cattle as "best case" in the cattle breed comparison of Kraft et al. (5).

For coronary heart disease prevention, there is the recommendation of a mean daily consumption per adult at 250 mg VLC n-3 PUFA (EPA, DPA+DHA; ref. 2). The previously mentioned steak prepared from 150 g lean meat would contribute roughly 25–35 mg VLC n-3 PUFA in the case of beef, however, in the case of game 100 mg for fallow deer, even about 130 mg for red deer.

IV. CONCLUSION

Lean meat (*M. longissimus*) from investigated game had a higher Fe content and the better fat quality than beef (Limousin x Simmental crossbreed). In comparison with beef IMF, the IMF in fallow deer and red deer represented twice the content of PUFA and n-3 PUFA and the threefold content of VLC n-3 PUFA. Meat from fallow deer and red deer seems to be a good source for VLC n-3 PUFA and a possible alternative for people with aversion against seafish. Furthermore, because of an increasing lack of seafood, alternative LC n-3 PUFA sources are of worldwide interest.

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