FOOD ADDITIVES & CONTAMINANTS: PART B, 2016
http://dx.doi.org/10.1080/19393210.2016.1151464

Elemental composition of game meat from Austria

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ABSTRACT

Concentrations of 26 elements (B, Na, Mg, P, S, K, Ca, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Se, Rb, Sr, Mo, Cd, Sb, Ba, Hg, Pb, U) in wild game meat from Austria were analysed using an inductively coupled plasma mass spectrometer. All investigated animals were culled during the hunting season 2012/2013, including 10 chamois (*Rupicapra rupicapra*), 9 hare (*Lepus europaeus*), 10 pheasant (*Phasianus colchicus*), 10 red deer (*Cervus elaphus*), 12 roe deer (*Capreolus capreolus*) and 10 wild boar (*Sus scrofa*). In 19 out of 61 meat samples lead concentrations were higher than 0.1 mg/kg, the maximum limit in meat as set by the European Commission (Regulation EC No 1881/2006), which is most likely caused by ammunition residues. Especially, pellet shot animals and chamois show a high risk for lead contamination. Despite ammunition residues all investigated muscle samples show no further health risk with respect to metal contamination.

ARTICLE HISTORY
Received 27 November 2015
Accepted 3 February 2016

KEYWORDS
Elements; heavy metals; wild game meat; ICP-MS

Introduction

The importance of adequate intakes of essential elements is widely recognised. On the other hand, also heavy metal concentrations attracted much attention from governmental and regulatory bodies who are concerned to reduce the human health risks through food consumption. To give a broad picture both aspects should be covered and also less consumed food types should be of interest. The consumption of game meat is only 0.7 kg per capita and compared to pork, beef and poultry meat (39.2, 11.5 and 12.6 kg per capita, respectively) in Austria (Statistik Austria 2015a) as well as in other European countries rather low. Nevertheless, game meat has a certain tradition in Austria, Germany and especially the eastern parts of Europe and is commonly thought to be nutritious and tasty. Approximately, 550,000 heads of chamois, hare, pheasant, red deer, roe deer and wild boar together are culled per year in Austria (Statistik Austria 2015b). In Germany, more than 2 million culls per year are counted (Deutscher Jagdverband 2015). But information concerning the elemental composition of game meat from Austria is very scarce and also in other European countries only limited data for certain elements are available (summarised in Tables 1 and 2). Literature that covers essential elements and heavy metals in one and the same sample is even harder to obtain. The aim of the current paper is to provide this basic knowledge on the concentrations of B, Na, Mg, P, S, K, Ca, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Se, Rb, Sr, Mo, Cd, Sb, Ba, Hg, Pb and U in game meat and highlight the possible contamination through lead bullets. It reports results of a survey wherein 26 elemental concentrations in chamois, hare, pheasant, red deer, roe deer and wild boar samples were measured in one single inductively coupled plasma mass spectrometry (ICP-MS) run, as summarised in Table 3.

Materials and methods

Ultrapure water, supplied by a Milli-Q purification system (Merck Millipore, Darmstadt, Germany) and nitric acid Rotipuran p.a. ≥ 65% (Carl Roth, Karlsruhe, Germany) further purified via a quartz sub-boiling distillation were used throughout. Calibration standards and internal standard solution were prepared via dilution from Peak Performance Single-Element Standards (CPI International, Santa Rosa, USA) suitable for ICP-MS. Reference material RM 8414 (NRC RM 8414 – Bovine Muscle Powder, National Research Council Canada, Ottawa, Canada) was used to ensure accuracy of the results.

In total, 61 muscle tissue samples and additional 42 corresponding bullet wound samples were collected from chamois, hare, pheasant, red deer, roe deer and wild boar during the hunting season 2012/2013 in Austria (Figure 1). Detailed information about the samples is given in Table 4. All samples were taken in the same way as meat prepared for sale and consumption.

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Table 1. Comparable studies on Na, Mg, P, K and Ca concentrations (g/kg wet mass) in Europe.

	Reference	Country	Na	Mg	P	K	Ca
Hare	Strmisková and Strmiska (1992)	Slovakia	0.44	0.24	2.1	2.6	0.15
Pheasant	Straková et al. (2011)	Czech Republic		0.41	2.6		0.17
	Strmisková and Strmiska (1992)	Slovakia	0.32	0.27	2.4	3.2	0.19
Red deer	Sager (2005)	Austria	0.63	0.22	1.9	3.2	0.05
Wild boar	Sager (2005)	Austria	0.70	0.20		3.1	0.05
	Strmisková and Strmiska (1992)	Slovakia	0.61	0.27	2.2	3.3	0.10

In case of animals culled with a bullet, one muscle tissue sample was collected at least 10 cm away from the identified bullet wound and one was collected in the vicinity of the bullet wound area. For hare and pheasant samples, the pellets were removed by sight and only one sample per animal was taken. Samples (50–150 g wet mass) were collected at the meat processing company Ager (Söll, Tirol) except for hare and pheasant samples which were cut up at the Lehr- und Forschungszentrums Raumberg-Gumpenstein (Irdning, Styria, Austria). The samples were homogenised and frozen until further preparation was performed at the Institute of Chemistry (University of Graz, Styria, Austria). First, the samples were freeze-dried for about 5 days (Christ Beta 2–16, LMC-1, Fa. Christ, Osterode, Germany) and afterwards mineralised with nitric acid using a microwave-heated autoclave (Ultra Clave, MLS GmbH, Leutkirch, Germany). Therefore, each freeze-dried sample was weighed three times (about 0.5 g weighed to 0.1 mg) in a 12 cm^3 quartz tube and filled with 5 ml of nitric acid. After finishing the microwave heating, the solutions were transferred into 50 ml Cellstar PP-Test tubes (Greiner Bio-One International AG, Kremsmünster, Austria) and filled up with ultrapure water. In each run, three times the certified reference material RM 8414 and three blanks were included.

Elemental analysis was carried out with an ICP-MS (Agilent 7500ce, Agilent Technologies, Waldbronn, Germany). To control instrument stability a solution of Be, In, Ge and Lu was continuously added online as internal standard.

All obtained data were statistically treated including analysis of variance (ANOVA) and significance (Tukey HSD) using Statgraphics Centurion XVI software package.

Results and discussion

Analysis of the certified reference material RM 8414 "Bovine muscle powder" found all elements in good agreement with the given estimate and information values (Table 5). All results are expressed on a wet mass basis. Limits of detection (LOD) were calculated as the signal response of the blank solutions plus three times the standard deviation of the blank signals divided by the slope of the calibration curve. The lowest limit was set at 1 µg/kg (based on wet mass). The given values for measurement uncertainty as given in the database were calculated as relative standard deviations out of triplicate determinations for every sample.

Na, Mg, P, S, K, Ca

Sodium concentrations for all specimens range between 0.32 and 0.92 g/kg. Highest sodium concentrations are found in roe deer and wild boar with mean values of 0.74 g/kg and 0.67 g/kg, respectively. Sodium is an essential element, but high intakes are discussed to be responsible for high blood pressure (Mozaffarian et al. 2014). In general, obtained sodium concentration for red deer is with 0.55 g/kg lower than 0.63 g/kg reported by Sager (2005), but results for hare, pheasant and wild boar are higher than other literature values (Table 1).

Magnesium concentrations range from 0.20 (chamois, red deer) to 0.26 g/kg (hare and pheasant) and is comparable with results reported in literature (Table 1). Only Straková et al. (2011) reported higher magnesium concentrations in pheasant (0.41 g/kg). Magnesium is an essential bulk element and is necessary for more than 300 biochemical reactions in the human body. Same as calcium and phosphorus, magnesium is, for example, very important for bone formation (Adam & Biesalski 2004).

Phosphorus and sulphur mean concentrations show no significant difference within one animal group (*t*-test, $p \le 0.01$) with the exception of pheasant. The sulphur concentration in pheasant samples is at least 19% higher than the phosphorus concentration. In general, obtained phosphorus values (range between 1.2 and 2.2 g/kg) tend to be lower than literature values. Phosphorus is involved in energy transfers, part of several enzymes and used as building material for bones and teeth (Calvo & Uribarri 2013).

Potassium is among the investigated elements the most prominent in all specimens, with an overall range between 2.2 and 4.4 g/kg. Roe deer and wild boar are especially rich in potassium and show significant difference ($p \le 0.01$) to all other groups with the exception of pheasant. Mean values for pheasant (3.2 g/kg) and red deer (3.0 g/kg) are in good agreement with literature values (Table 1), whereas hare (3.1 g/kg) was slightly higher than 2.6 g/kg reported by Strmisková and Strmiska (1992). Main function of potassium in the

Table 2. Comparable studies on V, Cr, Mn, Fe, Co, Cu, Zn, As, Se, Rb, Sr, Mo, Cd, Sb, Ba, Pb and Hg concentrations (mg/kg wet mass) in Europe.

	Reference	Country	V	Cr	Mn	Fe	Co	Cu	Zn	As	Se	Rb	Sr	Mo	Cd	Sb	Ba	Pb	Hg
Hare	Strmisková and Strmiska (1992)	Slovakia			0.44	29		2.3	23										
Pheasant	Strmisková and Strmiska (1992)	Slovakia			0.16	22		0.96	16										
	Szmczyk and Zalewski (2003)	Poland						4.77	16									0.075	
Red deer	Bilandžić et al. (2009)	Croatia													0.038			0.185	
	Falandysz et al. (2005)	Poland						3.3	39						0.1			0.22	
	Falandysz and Jarzyńska (2011)[a]	Poland	0.009	0.17	0.76		0.006	3.6	50		0.046	6.3	0.043	0.056	0.073	0.007	0.053	0.059	
	Kursa et al. (2010)	Czech Rep.									0.016								
	Lazarus et al. (2008)	Croatia				74		3.5	43		0.53							0.148	0.006
	Sager (2005)	Austria			0.24	35	<0.006	1.6	49					<0.006					
	Srebočan et al. (2012)	Croatia													0.0002			0.0024	0.0011
Roe deer	Dannenberger et al. (2013)	Germany				32		2.8	24		0.04								
	Falandysz (1994)	Poland				24		1.6	34						0.010			0.097	0.0034
	Gašparik et al. (2004)	Slovakia		0.25	2.03			2.49	55						0.232			6.478	
	Kursa et al. (2010)	Czech Rep.									0.036								
	Pérez López et al. (2011)[b]	Spain							1.6						0.002			0.057	
	Pokorny and Ribarič-Lasnik (2000)	Slovenia													0.04			0.05	
	Pompe-Gotal and Prevendar Crinić (2002)	Croatia													0.018				
	Srebočan et al. (2011)	Croatia													0.0008–0.006			0.0012–0.0014	0.001–0.034
Wild boar	Amici et al. (2012)	Italy		0.14				12.2	53						0.079			0.126	
	Bilandžić et al. (2009)	Croatia													0.083			1.106	
	Dannenberger et al. (2013)	Germany				19		1.7	24		0.13								
	Falandysz (1994)	Poland				54		4.5	47						0.010			0.210	0.015
	Kursa et al. (2010)	Czech Rep.									0.028								
	Rudy (2010)	Poland								<0.001					0.013			0.059	0.006
	Sager (2005)	Austria												<0.006					
	Srebočan et al. (2011)	Croatia													0.0007–0.0026			0.002–0.015	0.007–0.012
	Strmisková and Strmiska (1992)	Slovakia			0.61	27		0.56	44										

[a]Wet mass calculated with 67% water. [b]Wet mass calculated with 74% water.

Table 3. Data on element concentrations (on wet mass) in game meat from Austria.

	Chamois			Hare			Pheasant			Red deer			Roe deer			Wild boar		
	x	±	σ	x	±	σ	x	±	σ	x	±	σ	x	±	σ	x	±	σ
B [mg/kg]	0.090	±	0.067	0.10	±	0.04	0.037	±	0.011	0.17	±	0.06	0.27	±	0.04	0.057	±	0.037
Na [g/kg]	0.62	±	0.12	0.54	±	0.03	0.51	±	0.16	0.55	±	0.10	0.74	±	0.05	0.67	±	0.19
Mg [g/kg]	0.20	±	0.04	0.26	±	0.01	0.26	±	0.02	0.20	±	0.01	0.24	±	0.01	0.22	±	0.04
P [g/kg]	1.7	±	0.4	2.2	±	0.1	2.0	±	0.1	1.7	±	0.1	2.0	±	0.1	1.9	±	0.3
S [g/kg]	2.0	±	0.5	2.2	±	0.1	2.5	±	0.1	1.7	±	0.1	2.1	±	0.1	2.0	±	0.3
K [g/kg]	3.0	±	0.7	3.1	±	0.1	3.2	±	0.3	3.0	±	0.1	3.7	±	0.2	3.6	±	0.6
Ca [mg/kg]	82	±	34	75	±	10	122	±	16	108	±	41	125	±	28	121	±	32
V [mg/kg]		<0.002			<0.002		0.002	±	0.001		<0.002			<0.002			<0.002	
Cr [mg/kg]	0.012	±	0.012	0.007	±	0.004	0.008	±	0.005	0.005	±	0.002	0.007	±	0.004	0.007	±	0.006
Mn [mg/kg]	0.12	±	0.04	0.18	±	0.04	0.21	±	0.14	0.13	±	0.02	0.21	±	0.04	0.10	±	0.02
Fe [mg/kg]	25	±	9	33	±	4	11	±	2	25	±	3	30	±	3	17	±	6
Co [mg/kg]	0.002	±	0.001	0.002	±	0.001	0.004	±	0.004	0.002	±	0.001	0.002	±	0.001	0.002	±	0.001
Ni [mg/kg]	0.007	±	0.005	0.005	±	0.002	0.008	±	0.006	0.004	±	0.001	0.007	±	0.003	0.005	±	0.002
Cu [mg/kg]	1.2	±	0.4	2.7	±	0.3	0.77	±	0.07	1.3	±	0.2	1.6	±	0.2	0.79	±	0.12
Zn [mg/kg]	65	±	13	17	±	2	14	±	6	27	±	9	29	±	3	27	±	7
As* [mg/kg]	0.005	±	0.006	0.026	±	0.068	0.12	±	0.30	0.003	±	0.005	0.002	±	0.001	0.012	±	0.011
Se [mg/kg]	0.074	±	0.024	0.10	±	0.05	0.22	±	0.06	0.040	±	0.015	0.083	±	0.026	0.15	±	0.06
Rb [mg/kg]	11	±	6	0.70	±	0.23	3.3	±	0.8	7.5	±	5.9	6.4	±	13.3	2.0	±	0.8
Sr [mg/kg]	0.029	±	0.014	0.033	±	0.017	0.071	±	0.041	0.046	±	0.028	0.050	±	0.011	0.050	±	0.018
Mo [mg/kg]	0.004	±	0.002	0.006	±	0.003	0.016	±	0.004	0.001	±	0.001	0.003	±	0.001	0.013	±	0.008
Cd [mg/kg]	0.002	±	0.001	0.002	±	0.001	0.002	±	0.003	0.001	±	0.001	0.001	±	0.001	0.002	±	0.001
Sb* [mg/kg]	0.82	±	2.56	0.26	±	0.75	0.76	±	2.02	0.001	±	0.001	0.005	±	0.012	0.001	±	0.001
Ba [mg/kg]	0.037	±	0.018	0.013	±	0.003	0.023	±	0.014	0.070	±	0.045	0.044	±	0.018	0.014	±	0.006
Hg [mg/kg]	0.004	±	0.001		<0.004			<0.004			<0.004			<0.004		0.008	±	0.005
Pb* [mg/kg]	77	±	241	9.0	±	26	125	±	335	0.006	±	0.008	0.14	±	0.43	0.015	±	0.017
U [mg/kg]		<0.001			<0.001			<0.001			<0.001			<0.001			<0.001	

*High mean values and standard deviations are due to munition residues.

Figure 1. Map of Austria with location of all hunting grounds.

human body is to maintain the osmotic pressure (Chen et al. 2015), but it also acts as cofactor in several enzymes or maintains the ionic balance between potassium, sodium, calcium and magnesium (Anke et al. 2004).

Calcium has the lowest concentration of all macro elements with an overall range between 36 and 186 mg/kg. Compared to previously reported calcium levels in Austria (0.05 g/kg by Sager 2005) obtained results for red deer (0.11 g/kg) and wild boar (0.12 g/kg) are more than twice as high, whereas other values seem to be rather low compared to concentrations found in other European countries (Table 1). Calcium is necessary for bone formation, blood clotting as well as nervous and muscle functions (Kasper 2004).

V, Mn, Fe, Co, Cu, Zn, Se, Mo

Only two samples showed vanadium concentrations above the limit of detection (0.002 mg/kg) but both samples did not exceed 0.004 mg/kg.

Manganese concentrations range between 0.062 and 0.53 mg/kg and are rather low compared to the literature (Table 2). Especially, roe deer results published by

Table 4. Game meat samples, with English name, scientific name, number of samples and water content [%].

			Water content [%]		
English name	English name	*n*	*x*	±	*σ*
Chamois	*Rupicapra rupicapra*	10	70	±	4
Hare	*Lepus europaeus*	9	74	±	1
Pheasant	*Phasianus colchicus*	10	74	±	1
Red deer	*Cervus elaphus*	10	74	±	1
Roe deer	*Capreolus capreolus*	12	74	±	1
Wild boar	*Sus scrofa*	10	70	±	4

Table 5. Certified and measured values (in dry mass) for RM 8414 Bovine muscle powder.

Element	Certified			Measured (*n* = 36)		
K [g/kg]	15.2	±	0.4	15	±	1
P [g/kg]	8.4	±	0.5	8.0	±	0.2
S [g/kg]	8.0	±	0.4	8.4	±	0.3
Na [g/kg]	2.1	±	0.1	2.0	±	0.1
Mg [g/kg]	0.96	±	0.10	0.93	±	0.16
Ca [mg/kg]	145	±	20	138	±	9
Zn [mg/kg]	142	±	14	160	±	8
Fe [mg/kg]	71.2	±	9.2	67	±	2
Rb [mg/kg]	28.7	±	3.5	26	±	1
Cu [mg/kg]	2.84	±	0.45	2.7	±	0.1
B [mg/kg]	0.6	±	0.4	0.18	±	0.01
Pb [mg/kg]	0.38	±	0.24	0.46	±	0.21
Mn [mg/kg]		0.37[a]		0.33	±	0.06
Mo [mg/kg]	0.08	±	0.06	0.059	±	0.007
Se [mg/kg]	0.076	±	0.01	0.098	±	0.011
Cr [mg/kg]	0.071	±	0.038	0.094	±	0.039
Sr [mg/kg]	0.052	±	0.015	0.058	±	0.006
Ni [mg/kg]	0.05	±	0.04	0.046	±	0.038
Ba [mg/kg]		0.05[a]		0.027	±	0.006
Cd [mg/kg]	0.013	±	0.011	0.015	±	0.008
Sb [mg/kg]		0.01[a]		0.003	±	0.003
As [mg/kg]	0.009	±	0.003	0.009	±	0.003
Co [mg/kg]	0.007	±	0.003	0.006	±	0.001
V [mg/kg]		0.005[a]			<0.008	
Hg [mg/kg]	0.005	±	0.003		<0.015	

[a]Information value.

Gašparik et al. (2004) are with 2.03 mg/kg 10 times higher than 0.21 mg/kg obtained in this study.

Besides zinc, iron has the highest concentrations trace elements with a range from 11 mg/kg (pheasant) up to 33 mg/kg (hare). Obtained results are in close agreement with most literature values (Table 2). Only Lazarus et al. (2008) and Falandysz (1994) reported higher concentrations for red deer (74 mg/kg) and wild boar (54 mg/kg). The most important function of iron is the utilisation and distribution of oxygen as part of haemoglobin. Especially, woman of childbearing age and children are likely to suffer from iron deficiency (Ebermann & Elmadfa 2008).

Cobalt values are, as previously reported by Sager (2005) and Falandysz and Jarzyńska (2011), really low and range between 0.001 and 0.015 mg/kg. As part of vitamin B12 cobalt is essential to humans.

Hare samples show, with 2.7 mg/kg, the highest mean value for copper. This concentration is in good agreement with 2.3 mg/kg published by Strmisková and Strmiska (1992). All other copper concentrations tend to be lower than values reported in the literature (Table 2). Lowest mean values, and with that significantly different ($p \leq 0.01$) from all other mean values, show with 0.77 mg/kg and 0.79 mg/kg pheasant and wild boar samples, respectively. In the human body, copper acts mainly as part of more than two dozen different copper proteins (Anke et al. 2004).

Zinc as a part of metalloenzymes is essential for human beings and after Na, Mg, P, S and Ca the element with the highest observed concentration. The overall range for all specimens ranges from 9.2 up to 87 mg/kg. The chamois mean value is 65 mg/kg and significantly higher ($p \leq 0.01$) than all other mean values. Hare and pheasant samples show with 17 mg/kg and 14 mg/kg, respectively the lowest mean values. Obtained values are within previously reported zinc concentration (Table 2). For selenium, most samples are below 0.15 mg/kg. Only the pheasant mean value is 0.22 mg/kg and higher and significantly different ($p \leq 0.01$). Most literature values range between 0.016 (Kursa et al. 2010) and 0.13 mg/kg (Dannenberger et al. 2013). Lazarus et al. (2008) reported with 0.58 mg/kg the highest value. Selenium functions as antioxidant as well as protecting agent against toxicants and carcinogens. Additionally, it can replace sulphur in amino acids (Leitzmann 2009).

Total 8 samples out of 61 show molybdenum concentrations below the limit of detection (0.001 mg/kg). Also, all other specimens show really low molybdenum concentrations and do not exceed 0.027 mg/kg which is lower than previously reported 0.53 mg/kg by Falandysz and Jarzyńska (2011) but in good agreement with <0.006 mg/kg published by Sager (2005). As part of the animal enzymes, aldehyde-, sulfite- and xanthine-oxidase molybdenum is essential to animals and humans. A molybdenum deficiency can lead to tachycardia, tachypnoea or night blindness (Adam et al. 2002).

B, Cr, Ni, Rb, Sr, Cd, Ba, Hg

Lowest and highest boron concentrations are 0.014 mg/kg and 0.34 mg/kg, respectively. Roe deer samples show with 0.27 mg/kg the highest mean concentration which is significantly different ($p \leq 0.01$) to the others.

About 1/3 of all chromium concentrations are below the limit of detection (0.004 mg/kg) and even the highest sample is with 0.043 mg/kg below all reported literature values (Table 2).

Total 36 out of 61 game meat samples show a nickel concentration below the limit of detection (0.004 mg/

kg). But also the other determined concentrations are rather low and do not exceed 0.023 mg/kg. Nickel activates many different enzymes (Belitz et al. 2008) but long-time exposure via the food chain can lead to chronic diseases (Anke et al. 2004).

Rubidium concentrations range from 0.30 up to 47 mg/kg. Literature values are very scarce, but the mean value of 6.3 mg/kg for red deer provided by Falandysz and Jarzyńska (2011) is in good agreement with 7.5 mg/kg found in this study. Rubidium acts in the human body similar to potassium, but replacement of 10–15% of potassium through rubidium can take place without any negative effects (Adam & Biesalski 2004).

Obtained strontium concentrations are all above the limit of detection (0.003 mg/kg) but generally low and do not exceed 0.11 mg/kg. Strontium is not essential to humans but should be monitored since excess could cause health problems.

Cadmium concentrations are really low, as 32 samples are below the limit of detection (0.001 mg/kg) and also the highest obtained concentration is with 0.010 mg/kg far below the maximum level of 0.05 mg/kg for different meat types as given by the European Commission (2006).

Barium values range between 0.006 and 0.16 mg/kg with mean values below 0.070 mg/kg.

For mercury, 53 out of 61 samples are below the limit of detection (0.004 mg/kg), but also the other samples do not exceed 0.018 mg/kg. Mercury is a toxic element, but with varying impacts due to the chemical form.

All uranium concentrations are below the limit of detection (0.001 mg/kg).

As, Sb, Pb

Lead, antimony and arsenic concentrations are generally low but suffer, in some specimens, from contaminations caused by the ammunition. Obtained lead concentrations are visualised in Figure 2. Total 19 out of 61 samples show lead concentrations higher than 0.1 mg/kg, the maximum level for different meat types given by the European Commission (2006). This contamination is thought to be caused by ammunition residues, which is supported by the fact that the corresponding bullet wound sample always confirms the use of lead bullets. This phenomenon was also previously reported, for example, by Falandysz et al. (2005). Highest observed lead concentration occurred in one chamois sample with about 760 mg/kg. Also two hare samples show really high lead concentrations with about 280 mg/kg and 44 mg/kg. Four more samples show concentrations higher than 1 mg/kg. For the remaining 12 contaminated samples, lead concentrations between 0.1 and 1 mg/kg could be observed. Lead can inhibit several enzymes of haem synthesis and, furthermore, can cause damage to the nervous system and kidneys (Anke et al. 2004).

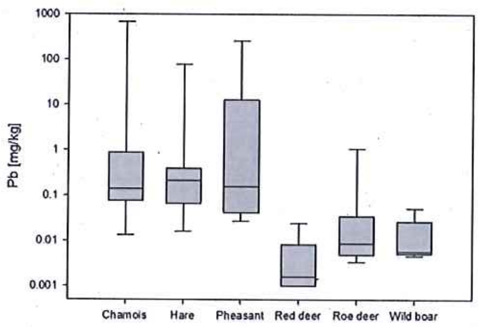

Figure 2. Box plot with measured lead concentrations.

Lead-antimony alloys, so-called hard lead is quite common as bullet material (projectile). Hard lead can contain up to 9% antimony, according to DIN17641 (DIN 17641:1962-10). Therefore, it does not surprise that in all seven samples with lead concentrations higher than 1 mg/kg, also antimony values are elevated to a certain extent. Without the contaminated samples no specimen exceeds the concentration of 0.008 mg/kg. For pellet shot animals, with lead contamination, also an elevation of the arsenic concentrations could be observed. That's why arsenic concentrations up to 0.96 mg/kg occur, whereas most other specimens show concentrations near the limit of detection (0.001 mg/kg). The arsenic contamination due to pellet residues is not unexpected because pellet lead can contain up to 1.7% arsenic (Hasse 2007). Only wild boar samples tend to show higher arsenic concentrations due to environmental influences, but do not exceed 0.035 mg/kg.

Conclusion

Investigated game meat samples showed no contamination due to environmental impacts. However, they can suffer from residues caused by lead ammunition. Unfortunately, too little information about the animals and the bullet wounds were available. Therefore, it is hard to assess the actual risk for game meat consumers. To be on the safe side, hunters could use lead free ammunition.

Acknowledgement

This work was supported by the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management [grant number 100905/2].

Disclosure statement

No potential conflict of interest was reported by the authors.

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