A significant dietary source of lead to Nunavik Inuit: Ptarmigan hunting

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Abstract

Lead concentration in ptarmigans is extremely low. However, lead fragments from lead projectiles used in small caliber rifles for harvesting ptarmigans in Nunavik can significantly increase the lead concentration in the edible parts of the bird. The geometric mean lead concentration in 180 samples of edible parts from 36 ptarmigans is 1.90 µg /g w.w. which is 19 times above the European Union Maximum Level (0.1 µg /g w.w.) for commercial meat destined for human consumption; or 3.8 times the Canadian lead residue guideline for fish protein (0.5 µg /g w.w.) Consumption of more than three ptarmigans per week by an adult might exceed the Provisional Tolerable Weekly Intake (PTWI) for lead (25 µg /kg body weight/ week for both adults and children) set by the World Health Organization. It might take no more than two birds per week for children to exceed the PTWI because of their smaller size. In view of the large quantities of ptarmigans consumed in all Nunavik communities, ptarmigan hunting is a very significant dietary source of lead to Nunavik Inuit.

Introduction

Despite the ban of lead pellets in shotgun cartridges used in Nunavik, blood lead concentrations in Nunavik Inuit remain higher than that in southern populations. Lead exposure sources have not been fully identified in the region. Hundreds to thousands of ptarmigans are being harvested for food in each Nunavik community for as long as eight to ten months yearly. Ptarmigan are one of the most widely consumed traditional foods in the fall through spring period in the region. Ptarmigans are harvested almost exclusively by using small caliber (0.22 cal.) rifle bullets with lead projectiles (photo. 1). Bullet entrance and exit wounds as well as the soft tissues in contact with the path of the lead projectile inside the body cavity are often highly contaminated with lead fragments. It has been shown in a previous study that the lead concentration in the muscles around a bullet wound can be as high as over 600 μg /g w.w.. Traditionally, the breast meat, upper thigh meat, heart, liver and gizzard are consumed as food. More often than not these parts are contaminated with lead fragments from the projectile that passes through the small bird (photo. 2). The objective of the study is to investigate the extent to which lead fragments from bullets contaminate the edible parts of the ptarmigan.

Materials & Methods

To simulate human exposure, the edible parts of each bird (namely the two pieces of breast meat, two pieces of upper thigh meat, the heart, the liver and the gizzard, photo. 3) were thoroughly homogenized with a handheld blender into a paste (photo. 4 & 5). Five samples were taken from each homogenized paste for acid dissolution (16M nitric acid 80°C for 6 hours, photo.6). Lead concentrations in the digested samples were then determined using a graphite furnace atomic absorption spectrometer (GFAAS). Lead concentrations of the homogenized edible parts of a total of 36 birds with body gun-shot wounds were then compared with that from 8 birds without body gun-shot wounds (i.e. birds shot in the heads). In total, 220 samples were analyzed: 36 x 5 = 180 samples from the 36 ptarmigans with body gun-shot wounds; plus 8 x 5 = 40 samples from the 8 ptarmigans without body gun-shot wounds.

Lead determination by graphite furnace atomic absorption spectrometry: A Perkin Elmer PinAAcle 900z Zeeman atomic absorption spectrometer (photo 7), equipped with a transversely-heated graphite atomiser (THGA) was used. A matrix modifier consists of 55μg phosphate (as ammonium dihydrogen phosphate) and 4μg magnesium nitrate was used to tackle chemical interference. Background absorption was corrected using the longitudinal inverse a.c. Zeeman-effect background corrector of the spectrometer. Optimized atomisation temperatures of 1800ºC and prylosis temperature of 850ºC were used.

With the use of a matrix modifier and the thermal advantage gained from the transversely heated graphite tube with integrated platform, no chemical interference was evident. The lack of a significant difference between slopes of normal calibration plots and those of standard addition plots confirmed the absence of chemical interference. Average characteristic mass was 22 pg / 0.0044 absorbance-sec. Lead concentration was determined in duplicate for each digested sample and the mean value is reported.

Quality assurance: (1) For each batch of samples studied, two certified reference materials (dogfish liver DOLT-5 from the National Research Council of Canada and Mussel 2976 from National Institute of Standards and Technology (NIST) were digested and analysed. A recovery of the analyte to within 10% of its certified value was used as a criterion for validation of the batch. (2) Digestion blanks in duplicate are included in each batch of samples digested to monitor contamination during acid dissolution and subsequent preparation of digested samples for analysis. (3) Spike Recovery of tested matrix was carried out by adding known quantities of the analyte into an acid digested sample. Recovery of the spiked analyte to within 10% was used as a criterion for validation of the batch. (4) The mean value of the two GFAAS measurements performed for each digested sample was accepted only when the difference between the two measurements is less than 10%.

Results

See table 1, figure 1 and the Appendix.

Discussion

- The edible parts of 91% of samples from birds with body gun-shot wound exceed European Union Maximum Level of 0.1 µg /g w.w. for livestock and poultry meat destined for human consumption; whereas 72% of samples exceed the Canada's national residue guideline level of 0.5 µg /g w.w. for fish (no Canada guideline for birds has been established). 75% of samples exceed the Danish residue safety guideline value of 0.3 µg /g w.w. for birds used for human consumption.

- World Health Organization has established a "Provisional Tolerable Weekly Intake (PTWI) for lead of 25 µg per kg body weight per week for both adults and children. Despite the great variations in lead concentration between samples (range: 0.01 to 129.4 µg/g w.w) , based on the geometric mean of 1.90µg/g w.w. and the average weight of 220 grams of the edible parts per bird, an adult averaging 60 kg body weight can consume no more than three ptarmigans per week without exceeding the PTWI assuming that there is no other significant dietary sources of lead exposure. Children are more susceptible to the adverse effects of lead exposure due to their still developing nervous systems. It might take no more than two birds per week for children to exceed the PTWI because of their smaller size.
- The high and variable relative standard deviation (%RSD) between the five samples taken from the homogenized edible parts of each bird were due to the random and uneven distribution of lead fragments in the homogenates despite thorough homogenization of the tissues from each bird with a handheld blender (figure 1). A sample taken from a homogenized paste that happen to contain a large lead fragment might have over hundreds of parts-per-million concentration of lead.
- Ptarmigan hunting is a very significant dietary source of lead in Nunavik for three reasons: (1) Hunting ptarmigans for country food is very important to all Nunavik communities; (2) traditionally ptarmigans are hunted almost exclusively using small caliber rifles with lead bullets. Shotguns (hence non-lead pellets cartridges) are very seldom if ever used in hunting ptarmigan; (3) the only non-lead 0.22 caliber rifle bullets are the CCI's COPPER-22™ which have copper-polymer projectiles. They are significantly more expensive than lead bullets and are not readily available in Canada. Also, copper bullets are more likely to wound instead of killing the animal because of the significantly lighter weight of the copper-polymer projectiles (21

grains as oppose to the 36 – 40 grains lead projectiles) which also deform far less than lead projectiles upon impact on soft tissues. More importantly, because of its light weight hence extremely fast speed, the shooting trajectory of the copper-polymer projectile is very different from that of the lead projectile. The Inuit hunters have to re-learn how to hunt with these copper bullets. Hence bullets with lead projectiles are likely to continue to be used in the future in Nunavik.

- Ways that might reduce lead consumption when eating ptarmigans: (1) cut away and discard meat around bullet wounds; (2) do not consume the heart, the liver and the gizzard if these are damaged by bullets: (3) avoid eating birds that are shot up extensively or with multiple bullet wounds; (4) thoroughly wash the edible parts in running water prior to consumption.

Acknowledgements

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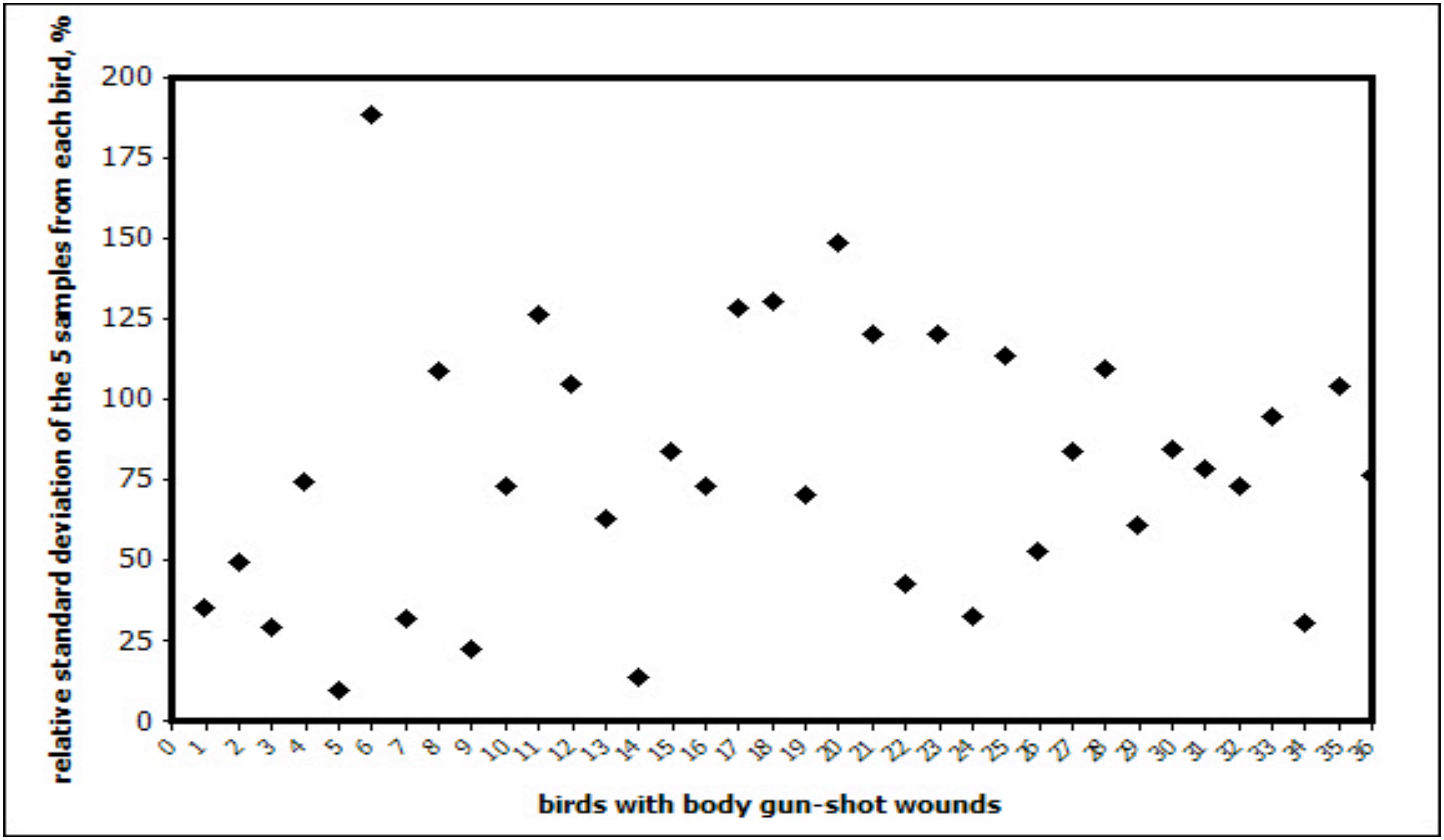
Table 1. Number of samples have lead concentrations [Pb] fall within the following concentration ranges (µg/g w.w.). The number in the parenthesis indicates the percentage of samples in the range. (see Appendix for original data set)

	[Pb] ≤ 0.1	0.1 < [Pb] ≤ 0.5	0.5 < [Pb] ≤ 1.0	1.0 < [Pb] ≤ 10.0	10.0 < [Pb] ≤ 50.0	50.0 < [Pb] ≤ 100.0	[Pb] > 100.0
n_1	16 (8.9%)	35 (19.4%)	17 (9.4%)	70 (38.9%)	35 (19.4%)	4 (2.2%)	3 (1.7%)
n_2	40 (100%)						

n_1 , samples (36 x 5 = 180 in total) from the 36 birds with body gun-shot wounds; range: 0.01 – 129.4 µg/g w.w.; geometric mean = 1.90µg/g w.w.

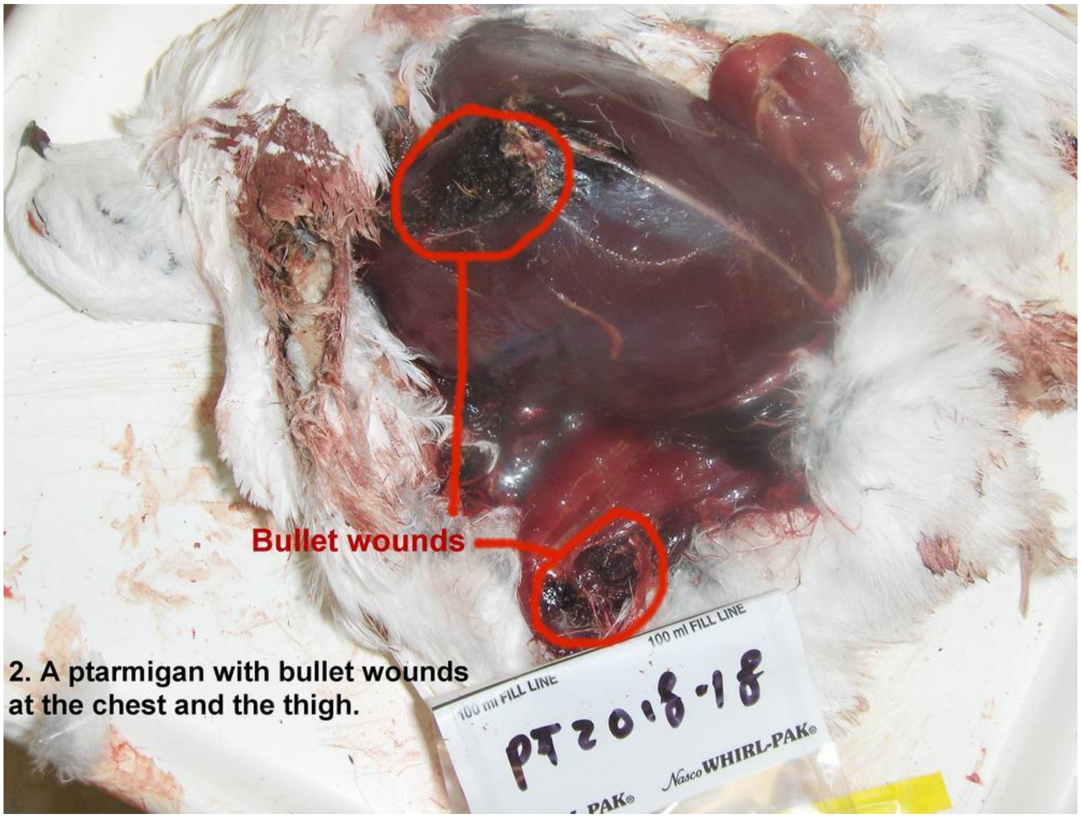
n_2 , samples (8 x 5 = 40 in total) from the 8 birds without body gun-shot wounds, i.e. shot in the heads. All 40 n_2 samples are below the analytical detection limit of 0.01 µg/g w.w.

Figure 1. Relative standard deviation (% R.S.D.) of the five samples from the homogenized edible parts of each of the 36 ptarmigans with body gun-shot wounds.

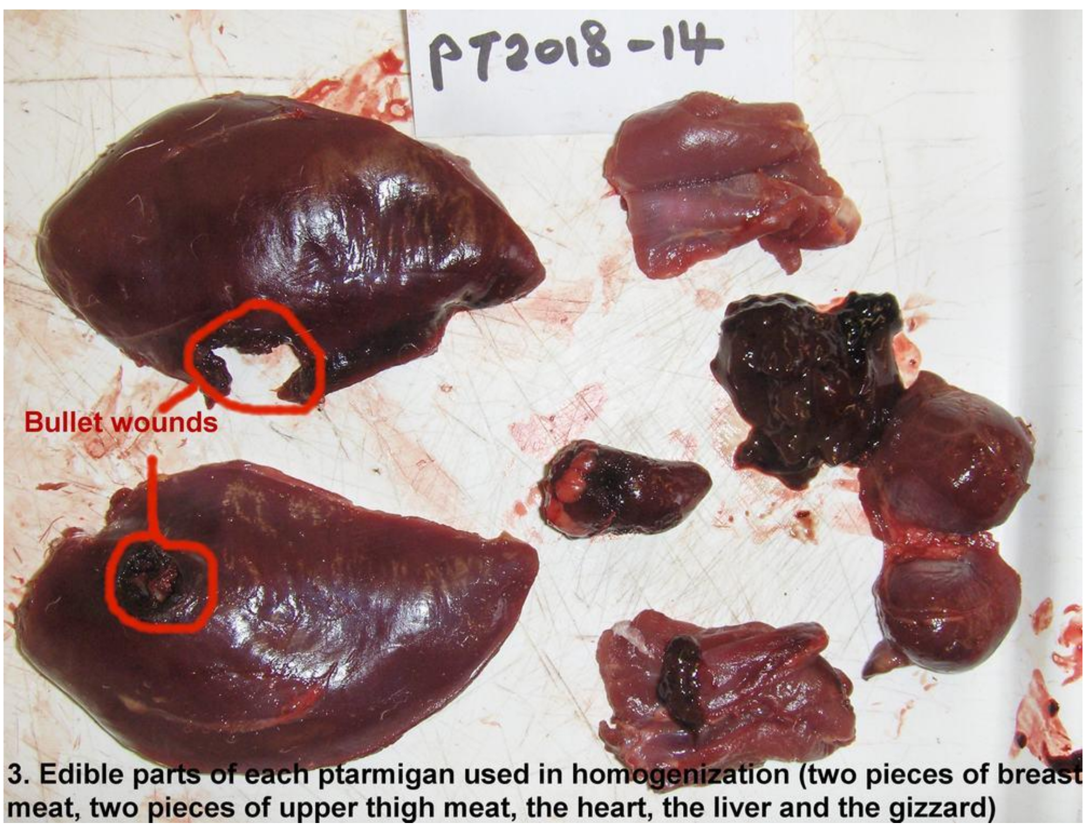


Ptarmigans shot with a 0.22 caliber rifle

1. Small caliber (0.22) bullets with lead projectiles.

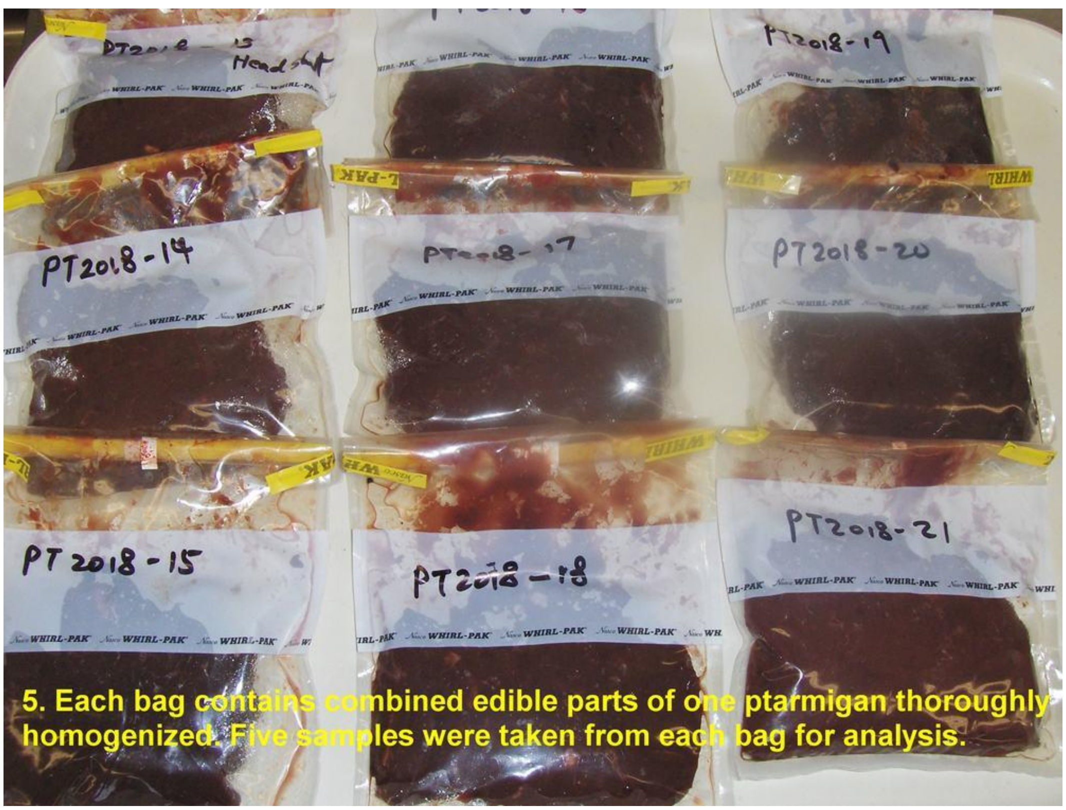


2. A ptarmigan with bullet wounds at the chest and the thigh.

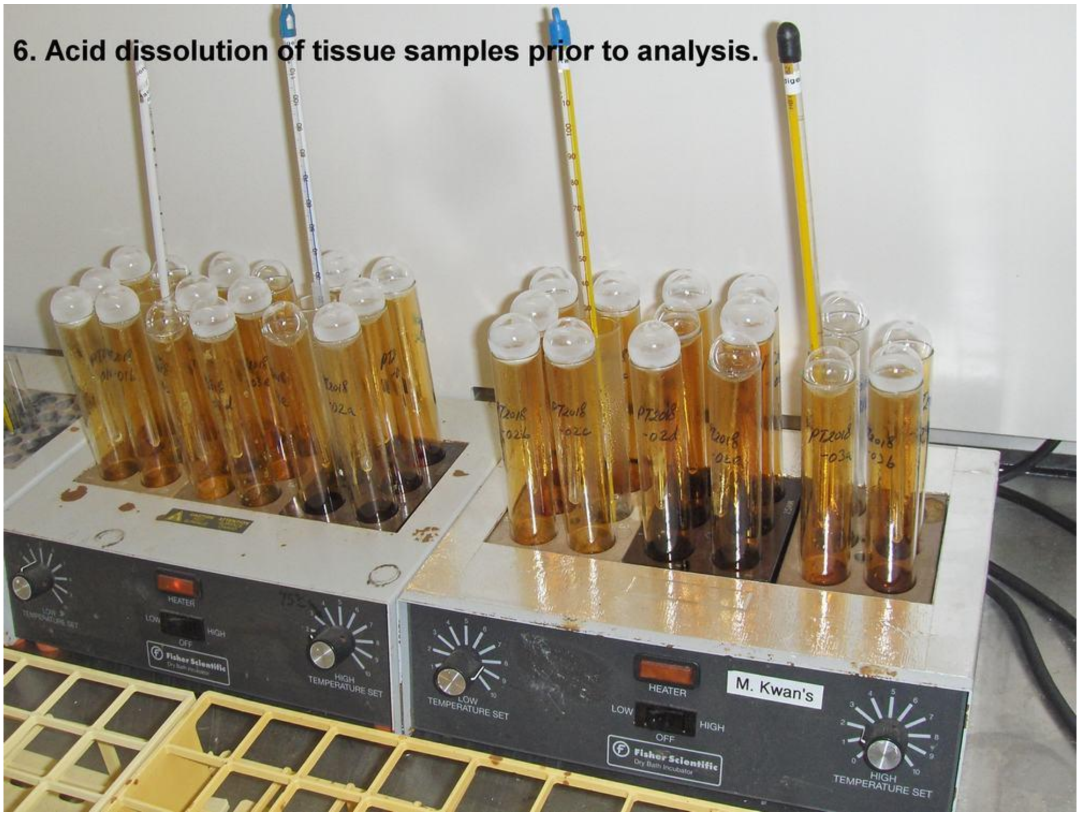


3. Edible parts of each ptarmigan used in homogenization (two pieces of breast meat, two pieces of upper thigh meat, the heart, the liver and the gizzard)

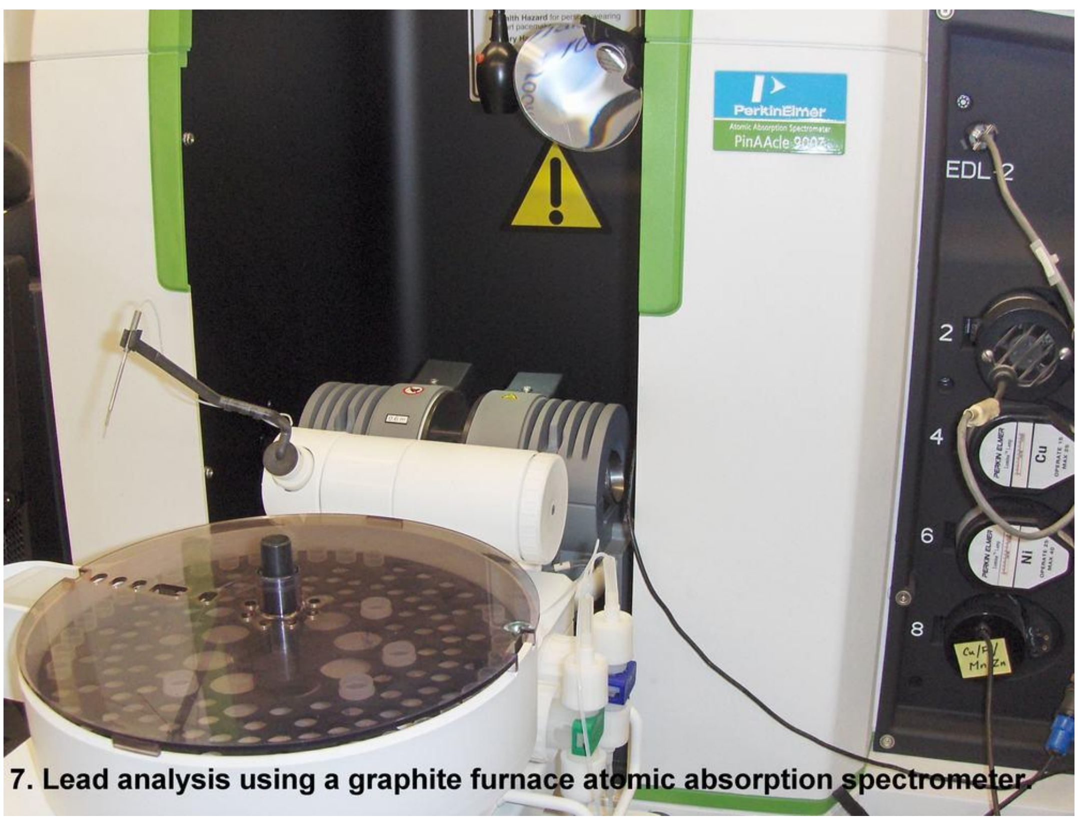

4. Edible parts of each ptarmigan was thoroughly homogenized using a handheld blender.



5. Each bag contains combined edible parts of one ptarmigan thoroughly homogenized. Five samples were taken from each bag for analysis.



6. Acid dissolution of tissue samples prior to analysis.



7. Lead analysis using a graphite furnace atomic absorption spectrometer.

Appendix

Lead concentration (μg/g w.w.) of the 180 samples of homogenized edible parts from 36 ptarmigans with body gun-shot wounds.

Sample ID#	[Pb] ug/g w.w.
1a	0.195
1b	0.216
1c	0.399
1d	0.419
1e	0.268
2a	7.629
2b	6.689
2c	5.117
2d	13.050
2e	3.680
3a	6.791
3b	8.370
3c	5.711
3d	7.907
3e	3.654
4a	1.626
4b	2.806
4c	0.612
4d	0.689
4e	0.668
5a	0.089
5b	0.111
5c	0.090
5d	0.095
5e	0.096
6a	0.529
6b	5.820
6c	0.578
6d	0.182
6e	48.100
7a	0.580
7b	0.405
7c	0.333
7d	0.675
7e	0.360
8a	9.129
8b	129.400

8c	112.000
8d	10.430
8e	15.780
9a	0.121
9b	0.183
9c	0.115
9d	0.162
9e	0.116
10a	6.713
10b	2.740
10c	25.610
10d	20.510
10e	9.994
11a	1.632
11b	8.386
11c	3.158
11d	2.102
11e	26.910
12a	1.121
12b	0.214
12c	0.193
12d	0.183
12e	0.246
13a	0.753
13b	1.519
13c	3.011
13d	1.132
13e	0.880
14a	0.115
14b	0.084
14c	0.084
14d	0.100
14e	0.093
15a	26.840
15b	31.470
15c	6.721
15d	8.048
15e	3.479
16a	0.118
16b	0.468
16c	0.256
16d	0.107

16e	0.117
17a	0.048
17b	0.156
17c	1.206
17d	0.393
17e	0.081
18a	2.224
18b	1.434
18c	3.253
18d	15.580
18e	39.300
19a	0.478
19b	0.126
19c	0.091
19d	0.197
19e	0.194
20a	9.261
20b	5.722
20c	11.230
20d	18.350
20e	119.800
21a	12.690
21b	96.390
21c	2.404
21d	99.680
21e	1.140
22a	5.706
22b	15.680
22c	8.668
22d	15.040
22e	7.734
23a	0.011
23b	0.013
23c	0.009
23d	0.012
23e	0.078
24a	22.080
24b	19.160
24c	28.070
24d	15.330
24e	34.770
25a	0.242
25b	7.298

25c	3.583
25d	0.699
25e	1.107
26a	5.033
26b	1.372
26c	5.287
26d	2.230
26e	2.640
27a	18.170
27b	66.980
27c	6.360
27d	71.050
27e	18.660
28a	5.876
28b	12.363
28c	26.715
28d	2.122
28e	0.986
29a	25.380
29b	9.127
29c	6.263
29d	28.140
29e	12.147
30a	1.316
30b	1.265
30c	4.850
30d	6.124
30e	0.856
31a	5.713
31b	11.366
31c	4.188
31d	2.076
31e	1.610
32a	3.487
32b	0.933
32c	5.142
32d	0.820
32e	2.127
33a	6.173
33b	11.236
33c	14.106
33d	0.482
33e	0.526

34a	10.623
34b	12.630
34c	7.561
34d	7.103
34e	14.360
35a	0.168
35b	0.379
35c	1.287
35d	0.162
35e	0.280
36a	12.485
36b	9.672
36c	1.438
36d	9.023
36e	1.125