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Heavy Metals in Livers and Kidneys of Goats in Alabama

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The popularity of goat farming is increasing in the southeastern region of the United States (Khan et al. 1994). Baseline values of Hg, Pb, and Cd are not available in goat tissues in the United States. These values are needed when monitoring food for heavy metal contamination which may be associated with urbanization and industrialization. Due to human activities or anthropogenic sources of metals in the environment, high concentrations of these metals have been observed in herbage and animal tissues (Ronneau and Cara 1984 and Baars et al. 1988). It has also been reported that toxic heavy metals (Hg, Cd, and Pb) are concentrated mostly in kidneys and livers of animals (Carlton and Henderson 1977). The risk of exposure of humans to heavy metals contained in edible organs of animals has received widespread concern (Falandysz 1993). The objectives of this study were to (i) measure the levels of Hg, Pb, and Cd in livers and kidneys of goats; and (ii) determine whether accumulation of these metals is related to age and/or sex.

MATERIALS AND METHODS

Liver and kidney samples were collected from 20 goats slaughtered on a goat farm in Notasulga, Alabama, USA. The samples were then stored at -20°C until analyzed. The sexes of the goats were recorded at the time of sampling. Age data were obtained and used to assign goats to separate age groups. Goats whose age was between 0.003 and 1.5 years, inclusive, were placed in the younger group and goats between 2.0 and 7.0 years, inclusive, were placed in the older group. Goats over 1.5 but less than 2.0 years of age did not occur on the farm. Liver and kidney samples were digested separately in 10 ml of a 7:3 mixture of ultrapure concentrated $HNO_3 : HClO_4$ in 250

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-ml flask. The solutions were allowed to stand overnight for complete digestion, then heated until evaporated at 95°C. The residues were redissolved in 10 ml of 1N HNO_3. The resulting solutions were filtered through Whatman no. 41 filter paper and analyzed for the presence of Pb and Cd by Inductively Coupled Plasma Atomic Emission Spectroscopy. Dogfish liver samples (certified reference materials for trace metals) were analyzed for Pb and Cd along with goat liver and kidney samples. Recoveries ranged from 90% to 96%. Total Hg in goat liver and kidney tissue samples was analyzed by the Hatch and Ott (1968) cold vapor atomic absorption method in a Bacharach Coleman Model 50B Mercury analyzer. This procedure used a 4:1 mixture of concentrated H_2SO_4:HNO_3 at 58°C for wet-ashing. Dogfish liver samples were analyzed for Hg content along with goat liver and kidney samples. Recoveries ranged from 91% to 97%. Mercury concentrations in the blank samples were undetectable. Data are presented as mean $\pm$ standard error of the mean on a wet weight basis (ppm). Using the t-test, comparisons were made between Pb and Cd levels in all liver vs. all kidney samples, livers and kidneys of males vs. females, and livers and kidneys of young vs. old goats (Zar 1984). Differences were considered significant if $p \leq 0.05$.

RESULTS AND DISCUSSION

Hg was undetectable in liver and kidney tissues. Ayyadurai and Krishnasamy (1986) reported Hg concentrations in Indian slaughtered goat kidneys and livers of 0.094 and 0.014 ppm, respectively. The mean concentrations of Pb in livers and kidneys in the present study were 1.11 and 1.09 ppm, respectively; while the mean concentrations of Cd in livers and kidneys were 0.32 and 0.51 ppm, respectively (Table 1). Pb and Cd levels in livers and kidneys did not show any significant differences. Pb and Cd levels in livers and kidneys of these goats were slightly above the values reported in sheep and lambs in other countries. Salisbury et al. (1991) reported Cd, Hg, and Pb levels of 0.06, 0.02, and 0.08 ppm, respectively in livers and 0.17, 0.03, and 0.10 ppm, respectively, in kidneys of Canadian slaughtered sheep and lambs. Falandysz (1991) found that the concentrations of Cd, Hg, and Pb in Polish slaughtered sheep livers to be 0.56, 0.002, and 0.011 ppm, respectively; and in kidneys to be 0.250, 0.12, and 0.13 ppm, respectively.

The mean concentrations of Pb in the livers and kidneys of male

Table 1. Mean concentrations (ppm, wet weight) and standard errors of Pb and Cd in the livers and kidneys of goats.

Metals	N	Livers	Kidneys
Hg	20	Undetectable	Undetectable
Pb[a]	20	1.11± 0.21	1.09 ± 0.19
Cd[a]	20	0.32 ± 0.08	0.51 ± 0.15

a. no significant difference between livers and kidneys of goats.

Table 2. Mean concentrations (ppm, wet weight) and standard errors of Pb and Cd in the livers and kidneys of male and female goats.

Metals	Organs	N	Males	N	Females
Pb[a]	liver	13	1.37 ± 0.24	7	0.63 ± 0.32
Pb[a]	kidney	13	1.11 ± 0.23	7	1.06 ± 0.35
Cd[a]	liver	13	0.23 ± 0.14	7	0.10 ± 0.10
Cd[a]	kidney	13	0.33 ± 0.15	7	0.80 ± 0.30

a. no significant difference between male and female goats.

Table 3. Mean concentrations (ppm, wet weight) and standard errors of Pb and Cd in the livers and kidneys of young and old goats.

Metals	Organs	N	Young	N	Old
Pb[a]	liver	11	1.41 ± 0.30	9	0.74 ± 0.25
Pb[a]	kidney	11	1.18 ± 0.27	9	0.98 ± 0.27
Cd[a]	liver	11	0.14 ± 0.15	9	0.23 ± 0.13
Cd[a]	kidney	11	0.19 ± 0.14	9	0.88 ± 0.24

a. no significant difference between young and old goats.

goats were 1.37 and 1.11 ppm, respectively; while the mean concentrations of Cd in the livers and kidneys of male goats were 0.23 and 0.33 ppm, respectively (Table 2). In females, the mean concentrations of Pb in livers and kidneys were 0.63 and 1.06 ppm, respectively; while the mean concentrations of Cd in livers and

kidneys were 0.10 and 0.80 ppm, respectively (Table 2). The concentrations of Pb and Cd in livers and kidneys did not show any significant differences between males and females. Similar results were also reported in deer (Crete et al. 1987, Reid et al. 1980, and Khan et al. 1994). However, several authors found sex-related differences in deer (Stansley et al. 1991 and Cowie 1976). Based on the present study, it appears that sex is not a determining factor in the accumulation of Pb and Cd in goats. The mean concentrations of Pb in the livers and kidneys of young goats were 1.41 and 1.18 ppm, respectively; while the mean concentrations of Cd in the livers and kidneys of young goats were were 0.14 and 0.19 ppm, respectively (Table 3). In old goats, the mean concentrations of Pb in the livers and kidneys were 0.74 and 0.98 ppm, respectively; while the mean concentrations of Cd in the livers and kidneys were 0.23 and 0.88 ppm, respectively (Table 3). The concentrations of Pb and Cd in the livers and kidneys did not show any significant differences between young and old goats. Further, several authors recorded no age differences in Cd concentrations in deer and moose (Woolf et al. 1982, Scanlon et al. 1986, Glooschenko et al. 1980, Stansley et al. 1991, and Khan et al. 1994), as well as no age differences in Cu concentrations in deer, and domestic and laboratory animals (Reid et al. 1980, Underwood 1977, and Munshower and Neuman 1979). In conclusion, the concentrations of Pb and Cd in liver and kidney tissues of goat in this study were not influenced by sex or age of the goats.

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