AN INVESTIGATION OF THE LEAD AND CADMIUM LEVELS OF BLOOD SERUM AND WOOL OF WHITE KARAMAN SHEEP IN THE VAN REGION (TURKEY)

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Abstract. This study was conducted to determine heavy metal (lead – Pb and cadmium – Cd) contamination of White Karaman sheep raised in Centrum (industrial area) and Özalp (rural area) districts of Van province in Turkey. Pb and Cd concentrations of blood serum and wool samples were measured with an ICP-OES device at Scientific Research and Implementation Center of Van Yuzuncu Yil University. It was observed that the sheep raised in the Central district of Van had higher levels of Pb and Cd in the blood serum and wool than those of the sheep Özalp district (p < 0.001). However, Pb and Cd levels of the sheep were still below the acceptable limits in both districts of Van province. Present findings revealed that pastures of both districts of Van province were safe with regard to food safety and environmental pollution with heavy metals.

Keywords: heavy metal, blood, wool, sheep

Introduction

Rapid urbanization and industrialization have made heavy metal emissions a global concern even at quite low concentrations for ecosystems (Rouniosi et al., 2018). Especially the heavy metals of lead (Pb) and cadmium (Cd) pose significant health risks for living organisms. Such heavy metals result in disorders in the central nervous system and in the red blood cell synthesis cause weak bone development, pains in muscles, anaemia and deaths ultimately. Therefore, heavy metal pollution levels should be determined and the risks posed on human and animal health should be put forth (Kaptanoğlu et al., 2014).

Pb and Cd are abundant metals in environment and they are the most toxic metals (Domingo, 1998; Boğa, 2007). Annually 7600 tons Cd and 332000 tons Pb is released to atmosphere through natural phenomena (earthquakes, volcanic eruptions and etc.). On the other hand, 8 times greater Cd and 6 times greater Pb is released to atmosphere through anthropogenic activities (urbanization, industrialization and etc.) (Kahvecioğlu et al., 2004). Such a heavy metal pollution has the greatest impacts on plants. Metal pollution not only influence vegetative organs of the plants, but also have significant effects on generative organs of the plants (Zheljazkov and Nielsen, 1996; Okçu et al., 2009).

Pb exists in nature in organic and inorganic forms. While inorganic form exists in atmosphere in particulate forms, organic Pb generally contaminates nutrients and drinking water (De Jonghe and Adams, 1982; Karademir and Toker, 1995; Okçu et al., 2009). Therefore, organic forms of Pb have greater impacts on living organisms. Meat products and plants grown around the industrial zones or city centers may have Pb levels greater than the normal levels. High-concentration heavy metal intakes of the sheep through pasture plants may pose a high risk of toxicity on animals (Smith et al.,
2010). Lead is not an essential nutrient for soils, generally exist in soils at 15-40 ppm doses and does not pose any health risks on human and plant health under 150 ppm concentration. However, lead concentrations over 300 ppm have potential risks for human health (Dürüst et al., 2004; Öktüren Asri and Sönmez, 2007). Smith et al. (2010) defined 250 μg/l Pb level as the safe upper limit for blood Pb levels.

Cd is relatively rare element and does not exist in pure forms in the nature. It is a significant pollutant since it is toxic at quite low concentrations (Lyons et al., 1996; Okçu et al., 2009). Cd is known with greater toxic impacts on plants (Çatak et al., 2000; Okçu et al., 2009). Accumulation of atmospheric Cd dusts, use of Cd-containing fertilizers and irrigations with wastewater effluents contaminate products consumed by the humans and animals, thus may increase Cd intakes (Jarup and Akesson, 2009; Örün and Yalçın, 2011). Cd levels greater than 3 mg/kg may have toxic impacts on soils and Cd levels over 1 mg/kg in plant dry matter may have toxic impacts on plants (Özbek et al., 1995; Öktüren Asri and Sönmez, 2007). Majority of Cd reaching to soils and plants comes from precipitation of Cd-containing atmospheric dust particles. Dust precipitation around the roads with a high traffic intensity may add about 0.2-1.0 mg/m² Cd to soils annually (Öktüren Asri and Sönmez, 2007). Of the Cd quantities reaching to soils through anthropogenic activities, 54-58% comes from phosphorus fertilizers, 39-41% comes from atmospheric storage and 2-5% comes from sludge and manure treatments (Yost and Miles, 1979).

Turkey with a sheep inventory of 31,507,934 head (TUİK, 2016; Tuncer et al., 2017) is the 7th greatest sheep raiser country of the world (FAO, 2016). The present research site, Van province in Eastern Anatolia Region of Turkey, has the greatest sheep inventory of the country (2,456,493 head) (TUIK, 2016; Tuncer et al., 2017). White Karaman sheep is a race that is widely raised because of very well adapted to the cold and long winter conditions of Eastern Anatolia Region. Therefore, in this study, heavy metal contamination in wool and blood seraums of the sheep raised in Van Centrum (industrial area) and Özalp (rural area) districts were investigated and heavy metal contamination was tried to be used as an indicator of food safety and environmental pollution.

**Materials and methods**

**Research site and sampling**

Van province is among the 5 province of Turkey with the greatest altitude (Eymirli and Kaya, 2016). Of the present research sites (Fig. 1), Central district is located between 38°30'4" N and 43°22'22" E coordinates and Özalp district is located between 38°39'29" N and 43°59'21" E coordinates and the districts have altitudes of 1727 m and 2075 m, respectively. There is one organized industrial zone in Van Central District. It has 1943 workplaces and 7 small industrial sites. Özalp is one of the smallest districts of Van. In addition, the town of Özalp is industrially backward (Bakır, 2016).

As the animal material of the study, 1-2 years old 15 sheep grazed over the pastures of Central and Özalp districts of Van province in August 2018 were used (a total of 30 sheep). Attention was paid as to have the sheep grazed over the same pastures and as to take blood and wool samples in the same day. Blood samples taken from vena jugularis were placed into anticoagulant 10 ml tubes. About 5 g wool samples were taken from neck section of the sheep with steel scissors. Wool samples were placed into clean polyethylene bags and preserved till the analyses. Wool samples were taken close to
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skin to eliminate potential differences in heavy metal concentrations in roots and tips (Kurt et al., 2001).

Figure 1. Location of the study areas: A: Van Center, B: Ozalp

Analyses on wool and blood samples

Blood samples taken from the sheep were placed into anticoagulant tubes with disposable needles. For laboratory analysis, the devices in Van Yuzuncu Yil University Van Health Vocational School and Veterinary Faculty Laboratories were used. Blood samples were centrifuged at 3500 rpm for 15 min to separate blood serum. Separated serums were transferred to 1.5 ml Eppendorf tubes and preserved at -20 °C until the analyses (Karademir, 2007). Wool samples taken from the sheep were washed through 1% Triton-X 100 solution and rinsed through distilled water. Washed samples were then dried in a sterilizator at 100 °C for 2 h. Dried samples (100 mg of them) were placed into tubes, supplemented with 1 ml 1/5 nitroperchloric acid mixture and waited for 4 h for dissolution of wool. Dissolved mixture was completed to 10 ml with distilled water. From this mixture, 1 ml was taken for analysis and supplemented with 2 ml distilled water (Kozat, 2006).

Pb and Cd concentrations of blood serum and wool samples were measured with an ICP-OES device at Scientific Research and Implementation Center of Van Yuzuncu Yil University (Alacabey et al., 2017).

Statistical analysis

GLM sub-procedure of SAS 9.4 (2018) statistical software was used for statistical analyses. One-way ANOVA was applied to mean Pb and Cd values of blood serum and wool samples taken from two different regions. Significant means were compared with Duncan’s multiple range test. Pearson correlations were calculated between Pb and Cd values of serum and wool samples of each region.

Results and discussion

Pb and Cd levels of blood serum and wool samples collected from Akkaraman sheep at pasture season of Van Central and Özalp districts are respectively provided in
Tables 1 and 2. The greatest Pb and Cd values were observed in blood serum and wool samples of the sheep raised in Central district and the differences from the values of the sheep raised in Özalp district were found to be significant ($p < 0.01$), a finding compatible with the literature (Kahvecioğlu et al., 2004; Rouniosi et al., 2018).

**Table 1.** Pb and Cd values in blood serum of Akkaraman sheep (mean ± standard error of the mean)

<table>
<thead>
<tr>
<th>Area</th>
<th>n</th>
<th>Pb (µg/l)</th>
<th>Cd (µg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central</td>
<td>15</td>
<td>49.050±0.004**</td>
<td>0.375±0.002**</td>
</tr>
<tr>
<td>Özalp</td>
<td>15</td>
<td>47.025±0.105**</td>
<td>0.150±0.002**</td>
</tr>
</tbody>
</table>

*a, b* Different lower cases in the same column represent statistically significant differences

**$p < 0.01$**

**Table 2.** Pb and Cd values of Akkaraman sheep's wool (mean ± standard error of the mean)

<table>
<thead>
<tr>
<th>Area</th>
<th>n</th>
<th>Pb (µg/kg)</th>
<th>Cd (µg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central</td>
<td>15</td>
<td>49.375±0.018**</td>
<td>0.533±0.068**</td>
</tr>
<tr>
<td>Özalp</td>
<td>15</td>
<td>47.725±0.130**</td>
<td>0.218±0.013**</td>
</tr>
</tbody>
</table>

*a, b* Different lower cases in the same column represent statistically significant differences

**$p < 0.01$**

Blood serum Pb values of the sheep raised in Central and Özalp districts (49.050 µg/l and 47.025 µg/l) (*Table 1*) were quite below the safe limits (250 µg/l). Present values were also quite below the values reported by Villegas et al. (1993) (chronic, 360 µg/l) and Braun et al. (1997) (acute, 940 µg/l). As compared to the values of the studies carried out at Pb-contaminated sites, present values were again quite lower than the values reported by Smith et al. (2010) (147 µg/l) and Swarup et al. (2006) (316 µg/l). But, the present values were greater than the values of the same researchers reported for Pb-clean sites (respectively as 26 µg/l and 15 µg/l). Similar with the present findings, Liu (2003) reported serum Pb value of the control group as 50 µg/l and Vicil et al. (2012) reported the same values as between 50 µg/l - 60 µg/l. Carrera et al. (2014) reported serum Pb value of the sheep grazed around the mine sites as 67 µg/l and reported the Pb value of the rams as 109 µg/l and such values were greater than the present ones. Pb values of wool samples taken from the sheep raised in Van Central and Özalp districts were found as 49.375 µg/kg and 47.725 µg/kg, respectively (*Table 2*). Present values were quite below the values of Liu (2003) reported for the wool samples of healthy sheep (1010 µg/kg) and the sheep grazed over the Pb-contaminated sites (3640 µg/kg); the values of Vicil et al. (2012) reported for the sheep grazed around the mine sites (2070 µg/kg) and the sheep grazed far away from the mine sites (1130 µg/kg–1670 µg/kg). Present findings revealed that Van Central and Özalp districts could be indicated as clean sites with regard to Pb-contamination.

Present Cd values of blood seraums of the sheep raised in Van Central and Özalp districts (0.375 µg/l and 0.150 µg/l, respectively) (*Table 1*) were quite below the values of Barkouch et al. (2008) reported for the sheep grazed around the mine site (3900 µg/l) and rural (2900 µg/l) sections, the value of Liu (2003) reported for healthy sheep (20 µg/l). However, present values were greater than the values reported by Vicil et al.
Cd values of wool samples taken from the sheep raised in Van Central and Özalp districts are provided in Table 2 (0.533 µg/kg and 0.218 µg/kg, respectively). As compared to the results of the studies carried out over the clean and contaminated sites, present values were lower than the values reported by Liu (2003) (2030 µg/kg and 370 µg/kg, respectively), Barkouch et al. (2008) (110 µg/kg and 90 µg/kg, respectively) and Vıcıl et al. (2012) (1340 µg/kg and 450 µg/kg–3340 µg/kg). Present findings revealed that blood serum and wool Cd levels of the sheep grazed over the pastures of Van Central and Özalp districts were at low levels, thus it can be stated that there were no-risk of toxicity.

Conclusions

Pb and Cd levels of blood serum and wool samples were higher in sheep raised in Van Central in industrial area than in the sheep raised in Özalp in rural area (p < 0.001). However, Pb and Cd values of the sheep in both districts of Van province were below the safe limit values. In brief, toxic levels of heavy metal accumulation (Pb and Cd) were not encountered in blood serum and wool samples of the sheep. Present findings also revealed that pastures in both districts of Van province were safe with regard to food safety and environmental pollution with heavy metals.

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(2012) (<0.015 µg/l).


