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Short Paper

The status of cobalt in soil, plants and sheep in Shahrekord district, Iran

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Summary

Cobalt (Co) deficiency occurs in many parts of world especially in tropical and subtropical countries. Primary Co deficiency occurs only in places where the soil is deficient in Co. The type of soil and the presence of other substances like manganese and lime influence the absorption of Co (secondary Co deficiency). To determine the Co status in Shahrekord district, Iran, several important farms were selected and the Co concentration of 80 different soils (before cultivation) under cultivation of alfalfa, clover, barley and wheat and their cultivated plants (after full vegetative growing) were measured by atomic absorption spectroscopy. Moreover, blood samples were taken from 100 sheep fed the grown plants on those areas. The mean ± SD Co concentration in the soil of alfalfa, clover, barley and wheat farms were 0.14 ± 0.04, 0.16 ± 0.06, 0.10 ± 0.03 and 0.11 ± 0.05 mg/kg, respectively and the corresponding concentrations in plants were 1.32 ± 1.01, 2.2 ± 0.08, 1.2 ± 0.76 and 1.37 ± 0.88 mg/kg dry matter (DM), respectively. The mean ± SD Co concentration in sheep serum was 1.45 ± 0.41 µg/dl at various physiological conditions. Results indicated that in all studied areas, Co concentration in soil was lower than the normal range and primary Co deficiency was noticeable. On the other hand, Co concentration in different plants and ration was higher than animal demands, but serum Co was at marginal level and probably interfered with animal health. This study showed that the soils of lands under cultivation of clover and alfalfa and its related plants contained more Co than that of determined for barley ($P<0.05$). Furthermore, clover soil had higher amount of Co than wheat soil ($P<0.05$). There was a negative correlation between the amount of lead in soil of lands under cultivation of alfalfa and the concentration of Co in plants. Such a negative correlation was also detected between the amount of molybdenum and lead in soil and the concentration of Co in plants ($P<0.05$). Presence of some interfering factors in ration such as nitrogen (1.24 ± 0.3%), phosphorus (0.47 ± 0.18%), lead (2.87 ± 1.58 mg/kg DM) and molybdenum (0.1 ± 0.14 mg/kg DM) were negatively affected the uptake of Co and decreased serum Co concentration via secondary Co deficiency.

Key words: Cobalt, Deficiency, Minerals, Sheep, Soil

Introduction

Cobalt (Co) deficiency is important in many parts of the world. Sheep and cattle that graze on Co-deficient pasture may show coast disease and wasting disease, respectively.

Heavy liming is known to reduce the availability of Co in the soil (Radostits *et al.*, 2000). If herbage contains less than 0.11 mg Co/kg dry matter (DM), then grazing lambs and calves show clinical signs of Co deficiency. Under such condition, sheep are more susceptible than cattle and young stock more than adults (Howard, 1986; Radostits *et al.*, 2000). It seems that mature sheep and cattle could tolerate lower levels (0.03–0.05 mg/kg DM) of pasture Co (Quirk and Norton, 1987, 1988).

Co is an essential co-enzyme for formation of vitamin B_{12} by rumen microflora and insufficient Co can cause vitamin B_{12} deficiency (Marston, 1970; Hedrich *et al.*, 1973; Grace *et al.*, 1986; Kennedy *et al.*, 1991; Farningham and Whyte, 1993; Kennedy *et al.*, 1996). The production of vitamin B_{12} from dietary Co was estimated to be about 15% in Co-deficient sheep and almost 3% in Co-sufficient sheep (Smith and Marston, 1970; Babior, 1975; Poston and

Stadman, 1975; Young, 1979). Severe Co deficiency causes inappetence, growth retardation, weight loss, pale mucus membranes, lassitude, profuse lacrimation, dyspnoea, reduce fertility, increase neonatal mortality, depressed milk yields and pica (Howard, 1986). Since Co deficiency has previously been reported by some veterinarians in Shahrekord, northwestern Iran, the current study was conducted to determine the concentration of Co in soil, plants and sheep serum as well as determining of some related factors that could alter the Co status in ration and animal.

Materials and Methods

Eighty composite soils and its related plants were taken from several industrial farms (approximately in 80 ha.) in Shahrekord district, Iran.

Using an auger 35 mm in diameter, soil samples, before application of any fertilizer, were collected from the depth of 30 cm in a 2 m radius of each grid node and then bulked to give a composite sample. These samples were air-dried, sieved through a 2 mm aperture sieve (removing stones > 2 mm, surface debris and coarse root material) and then chemically analysed.

Plant samples were taken from alfalfa, clover, barley and wheat farms after full vegetative growth. The samples were then air-dried and chemically analysed. Moreover, 10 samples from total ration (without additive) of each industrial farm and 100 blood samples of sheep fed on the plants grown on those farms were collected.

For measurement of Co concentration, samples were extracted and then exposed to 240.7 nm wavelength with the aid of background correction of atomic absorption spectroscopy (UNICAM 939, Germany). To determine the factors that may interfere with Co absorption by plant and also utilization by sheep, soil pH, lime value, nitrogen, phosphorus, calcium, sulphate, iron, molybdenum, lead and manganese concentration in both soil and plants were noticed.

The mean and standard deviation of Co concentration in various soils and their plants have been determined. Correlation coefficient between soil Co concentration and its related plants and also between some soil and plant factors and plant Co concentration were estimated by SigmaStat program. P values less than 0.05 were considered statistically significant. One-way analysis of variance (ANOVA) and Tukey's HSD test were used for determining differences between soil and plant Co concentration.

Results

The mean ± SD soil Co level in alfalfa, clover, barley and wheat farms were 0.14 ± 0.04, 0.16 ± 0.06, 0.10 ± 0.03 and 0.11 ± 0.05 mg/kg, respectively. The corresponding concentrations in plants were 1.32 ± 1.01, 2.2 ± 0.08, 1.2 ± 0.76 and 1.37 ± 0.88 mg/kg DM, respectively.

The mean ± SD concentration of Co in composite soil, ration and also sheep serum was measured as 0.127 ± 0.025 mg/kg, 0.87 ± 0.77 mg/kg DM and 1.45 ± 0.41 µg/dl, respectively (Table 1).

Clover and alfalfa soils and its related plants contained more Co than barley

Table 1: The mean ± SD cobalt concentration of different soil types, plants, ration and sheep serum in Shahrekord district, Iran

	Soil				Plant				Sheep
	Clover mg/kg	Alfalfa mg/kg	Barley mg/kg	Wheat mg/kg	Clover mg/kg	Alfalfa mg/kg	Barley mg/kg	Wheat mg/kg	µg/dl
Cobalt	0.16 ± 0.06	0.14 ± 0.04	0.10 ± 0.03	0.11 ± 0.05	2.2 ± 0.08	1.32 ± 1.01	1.2 ± 0.76	1.37 ± 0.88	1.45 ± 0.41
Average	0.127 ± 0.025				1.52 ± 0.45				
Ration	0.87 ± 0.77								

($P<0.05$). Clover soil had higher amount of Co than wheat soil ($P<0.05$).

The mean ± SD concentration of lime, nitrogen, phosphorus, calcium and pH of composite soil were 31.67 ± 1.79%, 0.08 ± 0.02%, 12.73 ± 3.88 mg/kg, 3.87 ± 0.78 mg/kg and 7.6 ± 0.02, respectively.

The mean ± SD concentration of manganese in soil of lands under cultivation of alfalfa, clover, barley and wheat were 18.15 ± 6.7, 17.82 ± 4.75, 13.3 ± 6.61 and 16.4 ± 4.7 mg/kg. The corresponding mean ± SD concentration in plants was 117.71 ± 15.29, 163 ± 24.34, 97.35 ± 9.45 and 113.7 ± 13.78 mg/kg DM, respectively.

There was a negative relationship between the concentration of lead in soil of lands under cultivation of alfalfa and the absorption of Co by alfalfa plant ($r = -0.59$, $P<0.05$). Moreover, the molybdenum ($r = -0.82$) and lead of soil ($r = -0.81$) had an opposite effect on Co absorption by barley plant ($P<0.05$). Pearson correlation was confirmed the positive and significant correlation ($P<0.05$) between lead concentration in alfalfa and barley soils and their plants ($r = +0.554$ and $r = +0.919$, respectively).

Discussion

The results indicated that the mean concentration of Co in composite soil of Shahrekord farms (1.27 ± 0.025 mg/kg) was less than normal. This could in turn predispose animals to develop primary Co deficiency. As indicated by Russel *et al.*, (1975) 50% of lambs that grazed for a period of eight weeks on Co-deficient pastures, with less than 0.25 mg/kg Co in soil, showed signs of Co deficiency (Minson, 1990; Radostits *et al*., 2000).

The concentration of Co in plants (alfalfa, clover, barley and wheat) and animal rations of Shahrekord farms indicated that the Co concentration in clover and alfalfa was higher than barley, so that the mean ± SD concentration of Co was 1.52 ± 0.45 and 0.87 ± 0.77 mg/kg in plants and rations, respectively. While, signs of Co deficiency may appear in animals that receive less than 0.07 mg/kg Co in DM of their rations (Mitchell, 1945; Winter *et al*., 1977; Howard, 1986; Radostits *et al*., 2000), it seemed that Co content in diets of animals (in the current study) was enough to meet the animal requirements. Nevertheless, the serum concentration of Co in sheep (1.45 ± 0.41 µg/dl) was closed to the minimum concentration (1 to 3 µg/dl) of normal range (Radostits *et al*., 2000). On the other hand, in this study, the animals suffered from secondary Co deficiency, due to interference of some elements which could negatively affect the Co uptake that consequently led to decrease in serum Co concentration.

As previously reported, the factors such as liming and high content of manganese in soil were proposed as causes of secondary Co deficiency (Radostits *et al*., 2000). In the current study, the effect of nitrogen, phosphorus, calcium, sulfate, iron, molybdenum, manganese, lead, lime and pH on Co concentration in soil, plants and animals were investigated. The significant and negative relationship was observed between the concentration of lead in soil and the concentration of Co in alfalfa. Such a relationship was also observed between the concentration of Co in barley and the contents of molybdenum and lead of the soil. As was showed, the absorption of Co was negatively influenced by the presence of lead and molybdenum in soil. It was also revealed that nitrogen, phosphorus, lead and molybdenum of diet were interfered with Co uptake by sheep, which consequently led to decrease in serum Co concentration.

In conclusion, Co absorption by plants which was related to Co content of soil was negatively influenced by the presence of some other elements such as lead and molybdenum. Moreover, it was revealed that the presence of the aforementioned interfering factors in Shahrekord farms could predispose the animals to show the sign of secondary Co deficiency. Therefore, using dietary Co supplements in order to provide the animal requirements is highly recommended.

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