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ORIGINAL PAPER

EVALUATION OF THE CONCENTRATIONS OF SOME TRACE ELEMENTS (Fe, Cu, Se, Zn AND Co) IN CALVES NATURALLY INFECTED WITH COCCIDIOSIS

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Abstract

The aim of this study was to determine whether Fe, Cu, Zn, Se and Co levels changed in calves naturally infected with coccidiosis. The study was conducted on a total of 30 calves, 20 with coccidiosis and 10 healthy (control) calves of different races, sexes, and ages ranging from 26 to 78 days, with complaints of bloody diarrhea, weight loss and tenesmus. Serum Fe, Cu, Zn, Se, and Co concentrations of calves with coccidiosis were determined to be significantly lower than in the control group and this decrease was statistically significant ($P<0.001$). As for correlations between parameters of calves with coccidiosis and healthy ones determined as Pearson correlations for both groups, positive correlations were detected at the levels of 0.941, 0.951, 0.947 and 0.969 between Fe, Cu, Zn, Se and Co, respectively. Since significant decreases were detected in the serum Fe, Cu, Zn, Se, and Co concentrations of calves with coccidiosis, it is concluded that use of preparations containing trace elements may be beneficial in addition to the routine treatments in cases of coccidiosis or other diarrhea.

Keywords: calf, coccidiosis, Fe, Cu, Zn, Se, Co.

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INTRODUCTION

Coccidiosis is an important disease caused by *Eimeria* species, especially in poultry, cattle, sheep, goats, pigs and rabbits (Wunderlich et al. 2014). It is a parasitic disease that causes death, poor performance, increased susceptibility to other diseases and economic losses, especially in breeding animal farms and calf rearing. This disease, which causes anemia, weakness, growth retardation and decreased productivity in animals, is seen in all seasons of the year, but mostly occurs in winter months and early spring, and causes severe disease, especially in young calves up to 6 months old (Radostits et al. 2007, Tufan, Çam 2009, Baydar, Özübek 2012, Eğlenti et al. 2020). In calves infected with coccidiosis, either decrease in live weight gain or death of animals due to infection lead to significant economic losses. Worldwide, costs for control measures for coccidiosis in cattle and poultry alone are estimated to exceed approximately $2 billion annually (Wunderlich et al. 2014). Occasionally, coccidiosis can also be diagnosed in humans. In some studies, it has been reported that the isospora genus belonging to the *Eimeriidae* family has been detected in humans (Sloper et al. 1982). They are intracellular parasites of the intestinal epithelium in domestic animals (Ahmed, Hassan 2007, Ocal et al. 2007, Ocal 2016), and the transmission of infection begins with the oral intake of sporulated emeria oocysts. Intestinal oocytes usually produce four sporocysts and two sporozoites from each sporocyst, respectively, and these sporozoites invade intestinal epithelial cells (Seemann et al. 2012).

The disease is seen as subclinical, acute and peracute. Clinical findings such as diarrhea, weight loss, dehydration, and tenesmus are more common in calves with acute coccidiosis, while the disease occurs in older cattle as subclinical infections (Çitil et al. 2004, Arslan et al. 2015, Eğlenti et al. 2020). Disease-causing Eimeria agents multiply in intestinal epithelial cells and cause destruction of intestinal epithelial cells, which results in diarrhea (Levine 1985). Definitive diagnosis of the disease includes clinical findings, such as bloody diarrhea, and examination of stool with native and/or flotation method, demonstrating abundant *Eimeria spp*. It is done by seeing the oocysts (Daugschies, Najdrowski 2005, Tufan, Çam 2009). As in most parasitic diseases, many biochemical and hematological parameters change in coccidiosis (Arslan et al. 2015, Eğlenti et al. 2020). As in many diseases, oxidative stress in coccidiosis causes reactive oxygen forms to be produced faster than their safe neutralization by antioxidant mechanisms. It has a negative impact on animal health and production, and is seen as an important initiator of tissue damage (Ahmed, Hassan 2007). Coccidiosis in animals is characterized by oxidative stress, inflammation, malabsorption of nutrients, diarrhea, dehydration, dehydration and increased susceptibility to bacterial pathogens such as necrotic enteritis, especially in chickens (Alnassan et al. 2014). Zinc, copper and selenium are essential trace elements that have important roles in maintaining the health status of farm animals (Kozat 2006, Denizhan et al. 2017, Tuncer 2018.). In young and fast-growing animals, low serum/blood copper and zinc concentrations result in general weakness, growth retardation, anemia, delayed puberty, and infertility (Damir et al. 1988, Kozat 2006). In particular, elements such as selenium and zinc, vitamins A and E are reported to play a protective role against oxidative stress that occurs not only in the intestines of Eimeria--infected animals, but also in non-parasite-infected tissues, especially in the first-pass organ liver (Wunderlich et al. 2014). Selenium (Se) is known to easily cross the placental and mammary gland barriers (Shamberger 1983, Enjalbert et al. 1999). In a study conducted in the poultry industry, it was reported that supplementation of Se to the ration of chickens increased immunity against *Eimeria*, and *E. tenella* infections in chickens were associated with low Se levels (Gabrashanska et al. 2009). It has been reported that vitamin D supplementation in the diets of chickens infected with *Eimeria acervulina* increases the antioxidant capacity and body performance of chickens (Georgieva et al. 2011). Similarly, injection of Selenite (10 and 20 μg Se/egg) into eggs has been reported to increase the immune response following oral infection of the hatched hen with sporulated *E. maxima* oocysts and also to contribute to better weight gain (Lee et al. 2014). Iron is an essential component of several enzymes, such as hemoglobin, myoglobin, catalase, peroxidase, cytochrome and oxidase. Iron supply for pets is essential for age and growth rate. Newborn calves are more likely to have iron deficiency because cows' milk is low in iron (approximately 10 ppm) (Kozat 2006, Heidarpour et al. 2008). Zinc is an important trace element for a balanced redox state, immune system, growth and development in the organism (Kozat 2006). It has been reported that when Zn – Cu – salt is added to the rations of chickens infected with *E. acervulina* in the poultry industry has a curative antioxidative effect (Georgieva et al. 2011).

The aim of this study was to determine changes in the serum Fe, Cu, Se, Zn and Co levels in calves infected with coccidiosis.

MATERIAL AND METHOD

Animal material

This study material consisted of 20 calves with coccidiosis and 10 healthy (control) calves of different races, sexes and ages ranging from 26 to 78 days, with bloody diarrhea, weight loss and tenesmus, which were brought to Yüzüncü Yıl University Veterinary Faculty Clinic or bred in various enterprises in the Van region.

Laboratory Analysis

Parasitic analysis

Rapid diagnostic commercial test kits (BoviD-5 Ag Test Kit- BIONOTE) including *Rotavirus, Coronavirus, Cryptosporidium, E. coli K99* and *Giardia lamblia* agents were applied to calves with hemorrhagic diarrhea. Calves with negative results according to these rapid tests were included to the study and parasitological examinations of these calves were performed. For the parasitological examination of stool in calves with diarrhea, fresh stool samples were taken from the rectal region of the animal. Each stool sample taken was examined by using the flotation method with Fülleborn's saturated salt water and a large number of coccidia oocysts were detected. The number of oocysts (OPG) in gram stool was determined by the McMaster method. Then, the stool sample with coccidia oocyst was crushed and mixed in some tap water, filtered and transferred to a Petri dish. For the detection of *Eimeria* oocysts, 2.5% potassium dichromate ($K_2Cr_2O_7$) was added to the Petri dish and left to sporulate at room temperature. Samples containing sporulated oocysts were centrifuged and examined using the flotation technique at 10X100 (immersion) magnification under a microscope (Soulsby 1986, Çakmak, Vatansever 2001, Sayin 2001). In addition, it was determined by anamnesis whether the calves with coccidiosis had had any disease in the past, whether any treatment had been applied, and the calves that had been treated for any disease in the past were not included in the study.

Biochemical analysis

Blood samples from calves diagnosed with coccidiosis and control (healthy) calves were taken from the vena jugularis into gel biochemical tubes without anticoagulant in accordance with the blood sampling protocol, and their serums were removed by centrifugation at 3000 rpm 10 min^{-1}. The obtained serum samples were stored in serum storage tubes in a refrigerator at -20°C until the Fe, Cu, Zn, Se, and Co analysis. For the analysis of serum trace elements, 1 ml of serum was taken from the serum samples, which were stored at -20°C after thawing. It was measured with a Coupled Plasma Mass Spectrometer (Thermo Scientific, designed in the UK and made in China).

Statistical analysis

Descriptive statistics for the results were expressed as mean and standard deviation. A *t*-test for independent samples was used to compare two groups (with coccidiosis and healthy calves). The Pearson correlation method was applied to some variables in calves with diarrhea. SPPS 21 package program was used for necessary statistical analyses.

RESULTS AND DISCUSSION

Trace element concentrations of the calves with Coccidiosis and control are given in Table 1. Pearson correlations for both groups are given in Table 2. Rotavirus, coronavirus, *E. coli K99* and *Giardia lamblia* were not detected in the stool samples of the calves included in the study. However, *Eimeria* spp. species were detected in the stool examination.

Table 1

Trace element concentrations in calves with coccidiosis and control

Parameter	Control X±SD	Coccidiosis X±SD	*P*<
Fe (μg dL^{-1})	158.7±32.5	60.4±24.6	0.001
Cu (μg dL^{-1})	113.8±10.9	63.9±25.0	0.001
Zn (μg dL^{-1})	80.6±8.7	50.5±13.6	0.001
Se (μg dL^{-1})	2.8±0.2	1.1±0.2	0.001
Co (μg dL^{-1})	4.0±0.5	2.8±0.4	0.001

As for the Pearson correlations for both groups, positive correlations were found at the levels of 0.941, 0.951, 0.947 and 0.969 concerning Fe, Cu, Zn, Se, and Co, respectively (Table 2).

Table 2

Pearson correlation for both groups

Parameter	Fe	Cu	Zn	Se	Co
Fe	1	0.941**	0.951**	0.947**	0.969**
Cu	0.941**	1	0.968**	0.859**	0.952**
Zn	0.951**	0.968**	1	0.861**	0.942**
Se	0.947**	0.859**	0.861**	1	0.898**
Co	0.969**	0.952**	0.942**	0.898**	1

** Correlation is significant at the 0.01 level.

Clinical findings

As a result of the clinical examination of the calves included in the study, clinical findings such as being sluggish, stagnant, with mixed hair, slanting body, dehydrated abdomen, perineum region and hind legs contaminated with feces, tenesmus and increased heart rate were detected.

Biochemical findings

The changes in the biochemical parameters of the coccidiosis and control groups are given in Table 1. As a result of the statistical analysis, it was demonstrated that the Fe, Cu, Zn, Se, and Co concentrations of calves with coccidiosis were significantly lower than in the control group ($P<0.001$).

Coccidiosis causes great economic losses among livestock as a result of reduced feed efficiency in young offspring, slowed weight gain, and increased susceptibility to other diseases (Wunderlich et al. 2014). In severe coccidiosis, acute bloody diarrhea occurs as a result of extensive damage to the intestinal epithelium (Wright, Coop 2007). Damage induced by *Eimeria* spp. comprising villous atrophy, crypt hyperplasia, and cellular infiltration, and loss of the absorbent surface area of the intestine leads to severe diarrhea and dehydration as a result of impaired absorption of liquids and nutrients (Davoodi, Kojouri 2015). Mineral deficiencies can cause many problems in animals, such as decreased productivity, slow growth, and low weight gain, as well as animals being more susceptible to diseases. Approximately 5% of the animal body weight consists of minerals, and the concentrations of mineral substances may vary according to age, species, breed and individual characteristics (Kozat 2006, Cazarotto et al. 2018). Since there are not enough data on trace elements in calves with coccidiosis in the current literature, this study was designed to shed light on coccidiosis disease and concentrations of trace elements in calves.

In another study, it has been reported that in calves with coccidiosis, the disease is characterized by diarrhea with an acute course, as the disease causes the destruction of the intestinal mucosa. (Baydar, Özübek 2012). Studies have reported that clinical coccidiosis is more common in animals younger than one year of age, and there is a negative correlation between the infection rate of cattle and age (Reddy et al. 2015). While there are many studies on serum or plasma trace element concentrations in calves with diarrhea, there are limited studies on the changes in serum or plasma trace element concentrations in calves with coccidiosis. Iron, Cu, Zn, Co and Se are essential trace elements for the growth, development and healthy maintenance of young and fast-growing animals. The diagnosis of deficiencies of these trace elements is revealed by measuring their concentrations in serum or plasma (Gooneratne et al. 1989, Yatoo et al. 2013).

Iron is a necessary microelement for the growth of microorganisms in the host after the host is exposed to the infectious condition, and it has been reported that the concentration of host serum Fe decreases in infectious states. (Davoodi, Kojouri 2015). In our study, Fe concentrations of calves with coccidiosis were found to be significantly lower than in the control group ($P<0.001$). The decrease in Fe concentrations of calves with coccidiosis is known to be due to the reasons suggested by researchers (Ahmed, Hassan 2007, Davoodi, Kojouri 2015).

Copper in living organisms, cytochrome oxidase, lysyl oxidase, ceruloplasmin, tyrosinase, super oxide dismutase, catalase, mono amino oxidase, ascorbic acid oxidase, urokinase, beta-hydroxylase and uricase, diamine oxidase, and as a cofactor for several enzymes such as 2,3 tryptophan dioxygenase activator plays a role (Elmasoğlu 2008). Copper is involved in the structure of different protein compounds such as erythrocuprein, hepatocuprein, cerebrocuprein, which have a specific metabolic function. These cupreins, which have an enzyme function, are defined as superoxide dismutase and play a role in the inactivation of peroxide radicals. The relationship between the immune system and Cu is via superoxide dismutase, an enzyme containing Zn, Cu and Mn, and its role in the microbial systems of phagocytes (Evans, Halliwell 2001). Copper-dependent metabolic events include melanin synthesis, collagen and elastin production, Fe metabolism and Hb synthesis (Radostitis et al 2000, Laiblin, Stöber 2002).

Serum Zn concentration in healthy cattle is between 70-130 μg dL^{-1}. If the Zn values are less than 40 μg dL^{-1}, it is defined as a deficiency (NRC 2001). Copper has an important role in the metabolism and transport of iron in the body. Microcytic hypochromic anemia is one of the consequences of copper deficiency. Since copper absorption decreases with rumen activity, therefore, copper deficiency and impaired iron utilization are seen together in the first month of life (Bami et al. 2008). Serum Fe, Cu and Zn concentrations in healthy calves have been reported as 57-162 μg dL^{-1}, 126±31 μg dL^{-1} and 80-120 μg dL^{-1}, respectively (Radostits et al. 2007). In a study on calves with diarrhea, it was reported that serum Cu and Zn concentrations in calves with diarrhea were significantly lower than in healthy calves. In the same study, Fe, Cu and Zn concentrations in healthy calves were 132.7±114.9, 56.8±24.9 and 125.6±56.8 μg dL^{-1}, respectively, and serum Fe, Cu and Zn concentrations in calves with mild dehydration were respectively 91.1±47.2, 41.7±19.9 and 96.5±55.1 μg dL^{-1}, whereas the Fe, Cu and Zn concentrations in calves with moderately dehydrated diarrhea were 89.1±47.7, 47.7±25.4 and 102.3±48.3 μg dL^{-1}, respectively (Elmasoglu 2008). In another study, it was reported that blood Zn ($P<0.05$), Cu ($P<0.001$), Fe ($P<0.001$) and Se ($P<0.001$) were found to be significantly lower in calves infected with Eimeria spp compared to the control group (Ahmed, Hassan 2007). Zinc (Zn) is fundamentally important for a balanced redox state in animals, proper functioning of the immune system, as well as for the growth and development of an organism. It is also required for the activity of Zn-dependent enzymes, including Cu/Zn-dependent superoxide dismutase SOD1 (Nielsen 2012). In this study, the Fe, Cu and Zn concentration levels of calves with coccidiosis were found to be significantly lower than in the control group ($p<0.001$). While the Fe, Cu and Zn concentrations of healthy calves were within the reference values reported by the researchers (Radostits et al. 2007, Elmasoglu 2008), the Fe, Cu and Zn concentrations of the calves with coccidiosis were lower than the reference values.

Selenium (Se) is predominantly found in plant sources as selenomethionine and cemethylselenocysteine, and in meat as selenocysteine. Dietary supplements may include sodium selenite, selenate, and selenomethionine (Rayman 2012). Intestinal epithelial cells use dietary Se compounds for the biosynthesis of selenoprotein P, which can support the intestinal immune system by supplying Se to secreted and antibody-producing plasma cells (Speckmann, Steinbrenner 2014). Se is important for the proper regulation of the immune system in inflammation and infection. Se status influences the activation, differentiation and proliferation of immune cells, including T and B cells and macrophages (Huang et al. 2012, Rayman 2012). It has been reported that the concentrations of essential microelements such as serum Se and Fe in Eimeria-infected sheep are lower than in healthy sheep (Davoodi, Kojouri 2015). In this study, Se concentration levels of calves with coccidiosis were found to be significantly lower than in the control group (P<0.001). A positive correlation was found between Fe, Cu, Zn, Se, and Co at levels of 0.941, 0.951, 0.947 and 0.969, respectively, in the Pearson correlation assays made for both groups. The results on the Se concentrations corresponded with the findings from earlier studies (Davoodi, Kojouri 2015). This can indicate that the decreases in selenium concentrations in calves with coccidiosis may be due to the reasons stated by the researchers (Huang et al. 2012, Rayman 2012, Speckmann, Steinbrenner 2014, Davoodi, Kojourip 2015).

Cobalt is an important trace element and its biological activity is mainly limited by the effect of vitamin B_{12} coenzymes, which play an important role in erythrocyte production and prevention of anemia (Abdel-Maksoud et al. 2012). In another study, it was reported that serum vitamin B_{12} levels in Oman goat pups infected with *E. arloingi* were significantly lower than in healthy pups, and the decrease in vitamin B_{12} levels was due to cobalt deficiency (Al-Habsi et al. 2020). In this study, the Co concentrations in calves with coccidiosis were found to be significantly lower than in the control group (P<0.001). The decreases in Co concentrations in calves with coccidiosis support the data provided by others (Al-Habsi et al. 2020).

CONCLUSIONS

In this study, it was determined that the serum Fe, Cu, Zn, Se and Co concentrations were significantly lower in calves with coccidiosis. Decreases in the serum Fe, Cu, Zn, Se and Co concentrations in calves with coccidiosis are concluded to be a result of diarrhea, intestinal damage, malassimilation and eventual anorexia. It can be thought that the use of preparations containing trace elements may be beneficial in addition to the routine treatments in cases of coccidiosis or other cases of diarrhea.

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