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ORIGINAL ARTICLE

Relationship between liver and blood plasma copper level and abortion in cattle

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Abstract Copper is a component of a number of metalloenzymes. Copper deficiency is endemic in ruminants worldwide and causes diseases of economic importance. Blood plasma samples were collected from 318 cows (198 aborting and 120 recently calved cows) originating from 16 commercial Holstein dairy herds in southeast Iran. Liver samples were taken from 76 cows (64 aborting and 12 recently calved cows) from a total of 318 followed cases. Liver copper concentrations of aborting cows are lower than 20 mg/kg DM (the marginally deficient status) in all of the slaughtered cows except two cases (96.875%) and all of 12 samples of recently calved cows, which were followed, had liver copper concentrations between 15 and 20 mg/kg DM. If we consider 20 mg/kg DM as the threshold level of liver copper, therefore serum copper concentration =9 mmol/L will be a good indicator of copper deficient status. The results of the present study show that plasma copper concentration of aborting cows is significantly lower than recently calved cows ($p<0.05$). Results of the evaluation of plasma copper concentrations show that 87.87% of aborting cows and 11.67% of recently calved cows are copper deficient. Based on the results of present study it seems that copper deficiency has close relationship with abortion in cattle. To prevent the economic loss due to hypocuprosis, early treatment of positive cows is necessary and prevention of the abortion has to be achieved through proper nutritional programs during gestation.

Keywords Copper · Abortion · Cattle

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Introduction

Copper is an essential trace element that is normally present in a wide variety of tissues such as liver, kidney, spleen, heart, lung, muscle, stomach, intestine, nails, and hair. It is a component of a number of metalloenzymes such as catalase, peroxidases, and cytochrome oxidase, and is essential for the utilization of iron (Goyer 1991; Suttle 1986; Stokinger 1981).

Copper deficiency may be primary, when the intake in the diet is inadequate, or secondary (conditioned) when the dietary intake is sufficient but the utilization of the copper by tissues is impeded. Copper deficiency is endemic in ruminants worldwide and causes diseases of economic importance that may be severe enough to render large areas of otherwise fertile land unsuitable for grazing by ruminants of all ages, but primarily young, growing ruminants (Radostits et al. 2007).

The diagnosis of copper deficiency in a herd of animals is based on a combination of collection and interpretation of the history, clinical examination of the affected animals, laboratory tests on serum and liver samples, and examination of the environment including analysis of the feed and water supplies and perhaps soil analysis (Underwood and Suttle 1999). One marker commonly used by clinicians is plasma or serum copper level, however plasma copper concentration often do not reflect the true copper status of cattle (Milne 1998). Liver copper concentration is an excellent marker of copper status of cattle, however liver

Table 1 Number and frequency of cattle with different blood copper levels in a total of 198 aborting cows

Blood plasma copper level	Number of cows
<3 (μmol/L)	2 (1.01%)
>3 (μmol/L), <6 (μmol/L)	16 (8.08%)
>6 (μmol/L), <9 (μmol/L)	156 (78.79%)
>9 (μmol/L), <15 (μmol/L)	19 (9.60%)
>15 (μmol/L)	5 (2.52%)
Total	198 (100%)

Numbers in parenthesis indicate the frequency of each group

Table 3 Number and frequency of cows with different blood copper level in a total of 120 recently calved cows

Blood plasma copper level	Number of cows
<3 (μmol/L)	0 (0%)
>3 (μmol/L), <6 (μmol/L)	0 (0%)
>6 (μmol/L), <9 (μmol/L)	14 (11.67%)
>9 (μmol/L), <15 (μmol/L)	81 (67.5%)
>15 (μmol/L)	25 (20.83%)
Total	120 (100%)

Numbers in parenthesis indicate the frequency of each group

biopsy is time-consuming, invasive and expensive (Suttle 1986).

There is no evidence that copper deficiency causes reproductive failure in dairy cows. Experimentally, the addition of molybdenum to the diet of heifers delayed the onset of puberty, decrease the conception rate, and caused anovulation and anestrous in cattle without accompanying changes in copper status or in live weight gain (Radostits et al. 2007). Present study conducted to evaluate relationship between liver and blood plasma copper level and abortion in cattle.

Materials and methods

Blood plasma samples were collected from 318 cows (198 aborting and 120 recently calved cows) originating from 16 commercial Holstein dairy herds in southeast Iran from February 2007 to November 2008. The herds were selected randomly and samples were collected aseptically using sterile 10-ml vacutainers with anticoagulant from tail vein and transported on ice to the laboratory. Plasma samples were separated by centrifugation of blood at 3,000×*g* for 10 min at room temperature and were kept at −20°C until the day of analysis. Liver samples were taken from 76 dairy cows (64 aborting and 12 recently calved cows) from total 318 followed cases that were slaughtered because of other disorders after their abortion. Samples of at least 100 g were taken from caudal lobe of each liver. The samples were transferred to the laboratory in a thermos flask containing ice and stored at −20°C until processed. All samples were submitted to Department of Chemistry, University of Tehran, Iran, and analyzed using atomic absorption spectrophotometer (BRIAC FX-130, Beijing, China). All data were analyzed by the Statistical Package for Social Sciences software version 16.0 (SPSS Inc, Chicago, IL, USA). The concentrations of blood plasma copper between aborting and recently calved cows were compared using the independent samples *t* test. The differences were considered significant at values of $p<0.05$.

Table 2 Number and frequency of aborting cows with different liver copper concentrations in a total of 64 slaughtered cows

Copper status of the liver	Number of cows
<5 (mg/kg DM)	1 (1.56%)[a]
>5 (mg/kg DM), <10 (mg/kg DM)	7 (10.94%)
>10 (mg/kg DM), <15 (mg/kg DM)	36 (56.25)
>15 (mg/kg DM), <20 (mg/kg DM)	18 (28.125%)
>20 (mg/kg DM)	2 (3.125%)
Total	64 (100%)

Numbers in parenthesis indicate the frequency of each group

Results

Three hundred and eighteen cows from 16 commercial dairy herds in southeast Iran were tested for copper deficiency. The calving seasons and management programs were almost similar in all herds. The frequency of distribution of blood plasma copper concentrations of aborting and recently calved cows have been shown in Tables 1 and 3, respectively.

As Table 2 shows, liver copper concentrations of aborting cows are lower than 20 mg/kg DM (the marginally deficient status) in all of the slaughtered cows except two

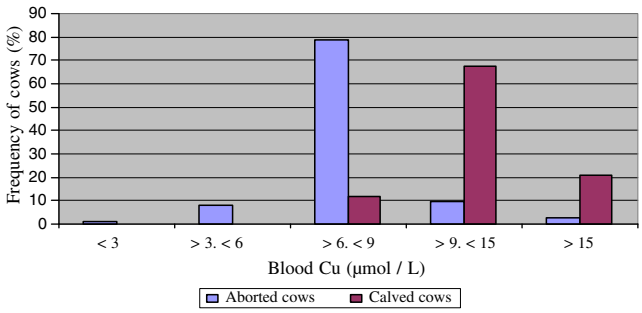

Fig. 1 Comparison of frequency of distribution of blood plasma copper concentrations between recently calved and aborting Holstein cows

cases (96.875%). All of 12 samples of recently calved cows, which were followed, had liver copper concentrations between 15 and 20 mg/kg DM.

Evaluation of plasma copper level of recently calved cows shows that only 14 cows out of 120 cases are copper deficient and 88.33% of this group has normal blood copper level (Table 3).

Discussion

Various minerals (copper, cobalt, selenium, manganese, iodine, zinc, and iron) can influence reproductive performance of ruminants. A variety of clinical symptoms have been associated with copper deficiency. Hypocuprosis in cattle is associated with female reproductive disorders. Where such disorders have been attributed to copper deficiency, the most common symptoms have been delayed puberty, anoestrus, sub-estrus, poor pregnancy rates and prenatal mortality, particularly early embryonic loss. Most of the relevant studies have been with sheep or goats (Hidiroglou 1979). McChowell, showed that 50% of pregnant ewes and goats aborted about one month after experimental copper deficiency (McChowell 1968; McChowell and Hall 1970). In New Zealand, in herds in which blood copper was marginally subnormal, a single administration of 400 mg of copper glycinate improved fertility (Hunter 1977). Although many infectious agents have been associated with bovine abortion, little is known about the multi-causality of abortion, particularly with respect to trace elements (Thomas et al. 1994).

The interpretation of serum copper can change depending on what liver copper concentration is considered low. With a liver copper <20 μg/g DM as indicative of copper deficiency, serum copper concentrations =9 mmol/L will be a good indicator of copper-deficient status but concentrations >9 mmol/L will be a poor indicator of copper sufficient status. If 10 μg/g DM is used as liver copper cut-off, then serum concentrations >9 mmol/L are reliable as indicative of copper sufficient status but not on concentrations =9 mmol/L as indicative of copper deficiency (Minatel and Carfagnini 2002).

In the present study, as Table 2 shows, liver copper concentrations of more than 96% of aborting cows, is lower than 20 mg/kg DM. If we consider 20 mg/kg DM as the threshold level of liver copper, therefore serum copper concentration =9 mmol/L will be a good indicator of copper deficient status. According to the Fig. 1, results of the evaluation of plasma copper concentrations show that 87.87% of aborting cows and 11.67% of recently calved cows are copper deficient.

The results of the present study show that plasma copper concentration of aborting cows is significantly lower than recently calved cows ($p<0.05$).

To establish a specific nutrient deficiency as causally related to abortion, other elements should be equal to or higher than their stage of gestation adjusted value, and the suspected causal element should be lower than its expected value. Consequently, multiple elements should be evaluated to establish specificity of cause.

In conclusion, based on the results of the present study, it seems that, copper deficiency has close relationship with abortion in cattle. To prevent the economic loss due to hypocuprosis, early treatment of positive cows is necessary and prevention of the abortion has to be achieved through proper nutritional programs during gestation.

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References

Goyer RA (1991) Toxic effects of metals. In: Amdur MO, Doull J, Klaasen CD (eds) Casarett and Doull's Toxicology, 4th edn. Pergamon Press, New York, pp 653–655

Hidiroglou M (1979) Trace element deficiencies and fertility in ruminants: a review. J Dairy Sci 62:1195–1206

Hunter AP (1977) Some nutritional factors affecting the fertility of dairy cattle. NZ Vet J 25:305

McChowell J (1968) The effect of experimental copper deficiency on growth, reproduction and haemopoiesis in the sheep. Vet Rec 83:226

McChowell J, Hall GA (1970) Infertility associated with experimental copper deficiency in sheep, guinea pigs and rats. In: Mills CF (ed) Trace element metabolism in animals. E.S. Livingstone, Edinburgh, p 106

Milne DB (1998) Copper intake and assessment of copper status. Am J Clin Nutr 67:1041–1047

Minatel L, Carfagnini JC (2002) Evaluation of the diagnostic value of plasma copper level in cattle. Preven Vet Med 53:1

Radostits OM, Gay CC, Hinchcliff KW, Constable PD (2007). Diseases associated with deficiencies of mineral nutrients. In: Veterinary Medicine, 10th edn. Saunders, Edinburgh, p 1707

Stokinger HE (1981) Copper. In: Clayton GD, Clayton E (eds) Patty's industrial hygiene and toxicology. Wiley, New York, pp 1620–1630

Suttle NF (1986) Copper deficiency in ruminants: recent developments. Vet Rec 119:519–522

Thomas W, Graham MC, Thurmond F, Charles M, Charles A, Holmberg ML, Anderson CL (1994) Relationships between maternal and fetal liver copper, iron, manganese, and zinc concentrations and fetal development in California Holstein dairy cows. J Vet Diagn Invest 6:77–87

Underwood EJ, Suttle NF (1999) Copper. In: The mineral nutrition of livestock, 3rd edn. Wallingford, Oxon: CAB International, pp 283–342