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Variation of Copper, Zinc, Manganese and Magnesium in Blood Serum and Tissues of Two Breeds of Dromedary Camels in Saudi Arabia

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ABSTRACT

A study was conducted to evaluate the blood serum, liver, kidney and meat tissues Zn, Cu, Mn and Mg concentrations by collecting samples from two dominant camel (Camels dromedaries) breeds, Majaheem (n = 15 males) and Maghateer (n = 15 males): 1.5±0.5 years old raised under traditional semi intensive system in Saudi Arabia. Blood and tissues samples were prepared and analyzed for the Zn, Cu, Mn and Mg concentrations by Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES). Results showed that a significantly (p<0.05) higher Cu and Zn and lower Mn and Mg concentrations in blood serum of the Majaheem compared with the Maghateer breed. Copper and Mg concentration in Majaheem liver were significantly (p<0.01) higher, but lower Zn when compared with the Maghateer breed. For kidney samples, a significantly higher concentrations of Cu (p<0.0001) and lower Mn (p<0.05) and Zn (p<0.05) were found for Majaheem than for Maghateer. Furthermore, a significantly (p<0.05) higher Mg concentration and lower Cu (p<0.05) in meat samples from Majaheem breed when compared with the Maghateer. The inorganic matter percentages of liver, meat and kidney were significantly higher (p<0.05) for the Majaheem breed than for Maghateer (1.91, 1.2 and 1.371 vs. 1.46, 0.76 and 1.07%, respectively). Furthermore, Zn concentration in serum of Majaheem and Maghateer were positively correlated to Zn concentration in meat (R² = 0.552 and 0.603, respectively; p<0.05). In conclusion, results indicate a breed differences may exist in Cu, Zn, Mn and Mg metabolism as a heritable characteristic. So, further studies are recommended.

Key words: Breed, Camels dromedaries, minerals, serum, tissues

INTRODUCTION

Minerals are very crucial for animal health and productivity by playing an important role in many physiological activities and their deficiency causes a variety of pathological problems and metabolic defects (Deen et al., 2004). The level of nutrition and mineral intakes are known to affect the production and reproductive ability of male and female camels (Ali et al., 2010; El-Bahrawy and El Hassanein, 2011). Zinc has a catalytic, coactive, or structural role in a wide variety of enzymes that regulate many biological processes and consequently animal health and productivity (Vallee and Falchuk, 1993). A zinc finger protein is a main domain in DNA binding protein which regulates transcription and hence gene expression, consequently impacting a wide variety of
functions including cell division, growth and hormone production (Predieri et al., 2005). Copper (Cu) and manganese (Mn) play an important role in animal health and productivity through their function as a main component of many essential metalloenzymes. These enzymes regulate the metabolism of carbohydrates and lipids and also function as an antioxidant (Andrieu, 2008; NRC, 2001; Tomlinson et al., 2004). One of the most popular Cu metalloenzyme is ceruloplasmin (bind 95% of circulating Cu) that affect immune system by regulating Iron availability and the oxidation reduction reactions (Healy and Tipton, 2007). Magnesium plays an important role in energy metabolism, muscle contraction, bone mineralization and nerve impulses as a cofactor and activator of many enzymes such as myokinase, creatine kinase and pyruvic acid oxidase (Murray et al., 2000; Soetan et al., 2010).

A few scientific studies have shown that some evidence of sensitivity of camels to trace minerals disorders as a result of deficiency or toxicity in the same way as other ruminants (Faye and Bengoumi, 1994). Fay et al. (1992), Faye and Bengoumi (1994) and Zong-Ping et al. (1994) reported several incidences of clinical mineral deficiencies in camels which may be underestimated because the signs of subclinical deficiencies signs may unclear for long time. In recent studies by Seboussi et al. (2008, 2009a, b, 2010), sensitivity of camels to Se supplementation with an increase in their level in serum and milk with possibility of toxicity was reported. Wiener (1979) reviewed the genetic variation in the incidences of many minerals metabolic disorders regarding the deficiencies and imbalances. The study concluded that animal breeds and strains differ in their mineral requirements with various concentrations in blood and tissues. Few studies have been conducted to evaluate the effect of camel breeds on the minerals metabolism with no studies found in Saudi Arabia.

Therefore, this study was conducted to evaluate the blood serum, liver, kidney and meat tissues Zn, Cu, Mn and Mg concentrations of two camel breeds (Majaheem and Maghateer) raised under traditional semi intensive system in Saudi Arabia.

MATERIALS AND METHODS
Animal management and sampling: Fifteen healthy male camels (Camels dromedaries) from each breed, Majaheem and Maghateer, with mean age of 1.5±0.5 years old were used in this study. Majaheem and Maghateer breed are reported to be the most numerous and widely distributed in Al Riyadh region, Saudi Arabia (Ministry of Economic and Planning, 2010). Camels are raised under the semi intensive system in which they fed barely and alfalfa hay with very limited grazing and without any mineral supplements. Before slaughtering, blood samples were collected from the jugular vein using vacutainer tubes without heparin. Serum were collected by centrifugation for 3000 rpm/15 min and prepared for mineral analysis according to AOAC (1990). After slaughtering at Al-Riyadh abattoir, liver, kidney and meat samples were collected using stainless steel surgical blades and prepared by wet digestion using sulphuric acid, nitric acid and hydrogen peroxide and diluted with 0.1 M HCl in 25 mL volumetric flask. All prepared samples were analyzed for Cu, Zn, Mn and Mg by using Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES).

Statistical analysis: Data were analyzed using SAS Institute (2003) as a complete randomized design to compare the means of mineral concentrations in blood serum and tissues between the two different camel breeds. Pearson correlation analysis was conducted for the serum and tissues copper, zinc, manganese and magnesium concentrations. The significant levels were declared at p<0.05.
RESULTS AND DISCUSSION

The nutritional status of camels has received significant attention for some time, particularly in developing countries which depend on their products (meat, milk and liver) as a main source of nutrients for human consumption. The issue of mineral status of camels and other farm animals has received very little attention to date in Saudi Arabia (SA). There is no any reported data that study the differences between camels’ breeds in Saudi Arabia in term of their mineral metabolism and ability to accumulate minerals in their tissues. Most of the studies regarding camels focus on the levels of mineral in blood serum and possibility of different mineral metabolism in camels as unique ruminant animal.

Mineral concentrations in blood serum and tissues: The results of this study showed that a significantly (p<0.05) higher Cu and Zn and lower Mn and Mg concentrations in the serum of the Majaheem breed than that of the Maghateer. Copper deficiency (hypocupremia) in camels has been reported in western Sudan by Tartour (1975) and also documented by Abu Damir et al. (1983) and Faye and Bengourni (1997). Abu Damir et al. (2008) reported high incidences of hypocupremia in breeding camels’ in UAE as a result of low dietary copper.

Tartour (1975) and Faye and Grillet (1984) and Faye et al. (1990) reported slightly higher plasma Cu concentrations in camels compared with other ruminants (ranging from 70 to 140 μg dL⁻¹). In general, serum copper levels below 50 μg dL⁻¹ can be considered deficient according to values reported by Mohamed (2004); (57.2 to 72.4 μg dL⁻¹ normal) and Faye et al. (2008), (70 to 120 μg dL⁻¹ normal). Eltahir et al. (2010) reported Cu levels in Omani camels which were considered to be marginally adequate (75.51 μg dL⁻¹). In this study, Cu concentration in blood serum falls within the normal range as shown in Table 1.

Zinc deficiency was reported in camels raised in UAE (Abdalla et al., 1988) with serum levels below what is considered to be adequate. The normal level of Zn in camel serum was 30-50 μg dL⁻¹, which is lower than that in other ruminant animals (70-120 μg dL⁻¹) according to Faye et al. (2008). In this study, the Zn level in the blood serum for both breeds is above the normal level which found to be 78.0 and 82.3 μg dL⁻¹ for the Majaheem and Maghateer breed, respectively.

Few studies reported in the literature have discussed levels of Mn in camels in either SA or other countries. The Mn concentration in plasma of camels (up to 174 μg dL⁻¹) is reported to be higher than that in other ruminant animals (10 μg dL⁻¹; Lamand, 1987). El-Tohamy et al. (1985) reported lower plasma Mn in non-pregnant camels (33.8 μg dL⁻¹) but this is still higher than other ruminant animals. Significantly lower values for Mn concentration were reported in this study when compared with the normal range as shown in Table 1.

The Mg concentrations in the blood serum of the Majaheem camels (2.74 mg dL⁻¹) and Maghateer camels (3.773 mg dL⁻¹) were almost fallen with the same range compare with camels from United Arab Emirate (1.8-2.4 mg dL⁻¹; Wernery et al., 1999), Kuwait (1.8-4.2 mg dL⁻¹; Mohamed and Hussein, 1999) and Oman (2-4 meq L⁻¹; Eltahir et al. (2010). Furthermore, the Mg level in the blood serum found to be lower than those of cattle and sheep (Osman and Al-Busadah, 2003).

The reference values for the concentration of minerals in the tissues of camels are not well documented and may vary according to many factors such as environmental, dietary, breeds, seasons and physiological status. The importance of trace and macro minerals and their potential toxicities were well defined in most of animal species including ruminant animals. In camels,
Table 1: Mineral concentration in blood serum and tissues on wet weight basis

<table>
<thead>
<tr>
<th>Breed</th>
<th>Cu (µg dL⁻¹)</th>
<th>Zn (µg dL⁻¹)</th>
<th>Mn (µg dL⁻¹)</th>
<th>Mg (mg dL⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serum</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Majaheem</td>
<td>71.2</td>
<td>62.3</td>
<td>10.00</td>
<td>2.674</td>
</tr>
<tr>
<td>Maghateer</td>
<td>57.5</td>
<td>76.0</td>
<td>50.00</td>
<td>3.773</td>
</tr>
<tr>
<td>SEM</td>
<td>6.0</td>
<td>5.0</td>
<td>1.50</td>
<td>0.172</td>
</tr>
<tr>
<td>Significance</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>***</td>
</tr>
<tr>
<td>Liver</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Majaheem</td>
<td>23.80</td>
<td>43.67</td>
<td>2.43</td>
<td>807.81</td>
</tr>
<tr>
<td>Maghateer</td>
<td>16.12</td>
<td>89.89</td>
<td>2.28</td>
<td>702.58</td>
</tr>
<tr>
<td>SEM</td>
<td>1.3</td>
<td>7.7</td>
<td>0.08</td>
<td>47.40</td>
</tr>
<tr>
<td>Significance</td>
<td>***</td>
<td>**</td>
<td>ns</td>
<td>**</td>
</tr>
<tr>
<td>Meat</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Majaheem</td>
<td>1.21</td>
<td>46.91</td>
<td>0.237</td>
<td>624.63</td>
</tr>
<tr>
<td>Maghateer</td>
<td>1.67</td>
<td>45.68</td>
<td>0.279</td>
<td>456.37</td>
</tr>
<tr>
<td>SEM</td>
<td>0.33</td>
<td>2.26</td>
<td>0.05</td>
<td>30.6</td>
</tr>
<tr>
<td>Significance</td>
<td>*</td>
<td>ns</td>
<td>ns</td>
<td>**</td>
</tr>
<tr>
<td>Kidney</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Majaheem</td>
<td>9.03</td>
<td>16.04</td>
<td>0.90</td>
<td>478.65</td>
</tr>
<tr>
<td>Maghateer</td>
<td>4.28</td>
<td>20.56</td>
<td>1.07</td>
<td>652.44</td>
</tr>
<tr>
<td>SEM</td>
<td>2.10</td>
<td>1.40</td>
<td>0.03</td>
<td>36.70</td>
</tr>
<tr>
<td>Significance</td>
<td>***</td>
<td>*</td>
<td>*</td>
<td>ns</td>
</tr>
</tbody>
</table>

SEM: Standard error of means. Values are significant at *p<0.05, **p<0.01 and ***p<0.001, ns: Nonsignificant

especially in Saudi Arabia, the trace mineral status and reference values are scarce and even not available in the literature. The result of this study revealed that Cu and Mg concentrations in Majaheem liver were significantly (p<0.01) higher than lower Zn when compared with the Maghateer breed and no significant differences for Mn concentrations. For kidney samples, a significantly higher concentrations of Cu (p<0.0001) and lower Mn (p<0.05) and Zn (p<0.05) were found for Majaheem than for Maghateer. Furthermore, a significantly (p<0.05) higher Mg concentration and lower Cu (p<0.05) in meat samples from Majaheem breed when compared with the Maghateer breed meat samples. Although, the hepatic Cu, Zn, Mn and Mg concentration were significantly higher (p<0.05) when compared with the concentrations in meat and kidney (Table 1).

Liver Cu and Zn concentration varied from one country to another depending on the mineral content of forage and soils, in addition to being influenced by the production system. The ranges of hepatic Cu in different countries were reported to be as follows: 6.5 to 543 ppm in Sudan (Abu Damir et al., 1983); 10 ppm in Morocco; 20 to 286 ppm in Egypt (Khalifa et al., 1973); 51.5 to 72.6 ppm in Pakistan (Badie et al., 2006); 19 to 88 ppm in Djibouti (Fay et al., 1992) and 230 to 538.2 ppm in China (Zongping, 2003). In Sudan, Bakhiet et al. (2007) reported higher hepatic Cu in camels compared with cattle (103±12.3 ppm), sheep (65.5±8.1 ppm) and goats (54.6±4.1 ppm), but lower Zn levels (34.7±1.02 ppm). Our result regarding hepatic Cu and Zn were disagreed with Bakhiet et al. (2007) in which Cu concentration was lower and Zn was higher, shown in Table 1, when compared with cattle (85±3.1 ppm), sheep (139.4±7.9 ppm) and goats (141.0±3.3 ppm).

Moreover, the normal level of Mn in liver ranged from 2.6 to 10.3 ppm (Abu Damir et al., 1983; Wensvoort, 1992; Al-Busadah, 2003) which considered being lower when compared with
ruminants. In the present study, Mn concentration in liver of both breeds fall within the general range reported above. Furthermore, no studies reported the normal levels of Mg in liver to compare with. Although, hepatic Mg and Mn found to be significantly higher when compared with the meat and kidney (Table 1).

The reference values for the concentrations of Mg, Zn, Cu and Mn in camels’ meat were reported by Rashed (2002) and supported by Badiei et al. (2006) for Cu. The values were as follow: Mg range from 0.27 to 0.38 mg g⁻¹; Zn from 0.06 to 0.10 mg g⁻¹; Mn from 2.0 to 2.5 μg g⁻¹ and Cu from 1.0 to 2.3 μg g⁻¹. In recent study by Mahmud et al. (2011) reported Mg in camels’ meat around 567 μg g⁻¹. Moreover, Kadim et al. (2009) reported Mg level to be 510±35.2 μg g⁻¹ which similar to beef meat (661±49.5 μg g⁻¹). The results of this study regarding meat Zn and Mn were not in line with the finding of Rashed (2002), but for Cu and Mg was agreed with the above previous studies.

Regarding mineral concentration in camels’ kidney, few experimental works were done. Badiei et al. (2006) conducted an experiment in Iran to provide some data to establish the normal values of some trace minerals in serum and different tissues of male and female dromedary camels. The Cu level reported in their study was 5.09±0.58 ppm which higher than reported in cattle (Radostits et al., 1994; Benemariya et al., 1993). The Cu level reported above was partially agreed with our finding in which we reported a breed effect on Cu concentration (Table 1). For other minerals, no studies reported in the literature cover this issue.

Table 2 shows the inorganic percentages in liver, meat and kidney tissues of the two camel breeds. The results revealed a significantly (p<0.05) higher inorganic percentages in liver, meat and kidney from Majahem breed (1.91, 1.20 and 1.37%, respectively) than for the Maghateer breed (1.46, 0.76 and 1.07%, respectively). These findings indicated differences between breeds in term of mineral accumulation in tissues and mineral metabolism.

**Correlations of mineral between blood serum and tissues:** A correlation analysis between blood serum and tissues copper, zinc, manganese and magnesium concentration was carried out for Majahem and Maghateer breeds separately. For the Majahem breed, the results showed a significant positive correlation between serum Zn and meat Zn (R² = 0.552; p<0.05); serum Zn and kidney Zn (R² = 0.543; p<0.05); kidney Zn and meat Zn (R² = 0.837; p<0.01); kidney Mg and meat Mg (R² = 0.658; p<0.01), while negative correlation detected between serum Zn with kidney Cu (R² = -0.538; p<0.05, Table 3). On the other hand, correlation data for Maghateer breed, the results revealed positive correlation between serum Zn and meat Zn (R² = 0.603; p<0.05); Mg in serum and kidney Mg (R² = 0.724; p<0.01); meat Mn and meat Mg (R² = 0.791; p<0.01), while significant negative correlation reported for liver Zn and liver Cu (R² = -0.721; p<0.01, Table 4). There was no significant correlation between all minerals in the blood serum of this breed.

<table>
<thead>
<tr>
<th>Breeds</th>
<th>Liver</th>
<th>Meat</th>
<th>Kidney</th>
</tr>
</thead>
<tbody>
<tr>
<td>Majahem</td>
<td>1.91</td>
<td>1.20</td>
<td>1.37</td>
</tr>
<tr>
<td>Maghateer</td>
<td>1.46</td>
<td>0.76</td>
<td>1.07</td>
</tr>
<tr>
<td>SEM</td>
<td>0.3</td>
<td>0.02</td>
<td>0.05</td>
</tr>
<tr>
<td>Significance</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
</tbody>
</table>

SEM: Standard error of means. *: p<0.05
Unfortunately, there are no many previous studies reported regarding this aspect. Eltahir et al. (2010) reported a significant correlation between blood serum Cu and Zn ($R^2 = 0.3839$; $p<0.05$) in racing camels which disagreed with our findings.

In conclusion, results indicate a breed differences may exist in Cu, Zn, Mn and Mg metabolism as a heritable characteristic. Further studies are recommended in the area of genetic selection for tolerance of minerals disorders.

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