Relation between Mastitis Test Score, Mineral Composition of Milk, and Blood Electrolyte Profiles in Holstein Cows

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ABSTRACT

The relationship between mastitis, mineral composition of milk, and blood electrolyte profiles was investigated in 54 Holstein cows. Sodium potassium, calcium, magnesium, and chloride in blood and milk were compared under two indices of mastitis, a milk quality test and a milk somatic cell count. Milk from cows with evidence of udder infection had higher sodium and chloride and lower potassium than cows free of mastitis. Although there was a correlation between blood calcium and milk calcium and between milk calcium and milk somatic cell count, as well as differences in mean potassium and calcium in blood between mastitic and nonmastitic cows, there was no direct relationship between the indices of mastitis and electrolyte profiles of blood.

INTRODUCTION

Changes in the composition of milk have been associated with a number of factors including stage of lactation (21), environmental conditions (9, 10), genetic make-up of the cow (9), fever and disease (6), and amount and composition of the feed (8). Some of the most dramatic changes in milk composition have been attributed to bacterial infections of the udder. Mastitis has depressed milk yield (16, 22), altered the amount and composition of milk proteins (2), decreased lactose (22), raised pH (1), and altered the mineral composition of milk (7).

We have studied the mineral composition of bovine mastitic milk as well as electrolyte profiles of blood from the same cows. Data on sodium, potassium, calcium, magnesium, and chloride content of milk and blood as a function of milk somatic cell count (MSCC) and milk quality (MQT) are presented in this paper.

MATERIALS AND METHODS

Cows

Samples of blood and quarter milk were taken from 54 cows over 4 days. The animals ranged from their first to fourth lactations and were in various stages of lactation at sampling. They were selected from the University dairy herd with an effort to include approximately equal numbers with low and high mastitis test scores based on the previous month's Dairy Herd Improvement records. On the basis of these tests, 30 cows had evidence of udder infection and 24 were free of mastitis.

Milk Samples

Asceptically drawn foremilk samples were taken from each quarter immediately prior to routine daily milking. The udder of each cow was washed with a dilute solution of Bovadine (West Agro-Chemical, Inc.) in warm water, dried with paper towels, and teats were swabbed with 70% ethyl alcohol and allowed to air dry for 1 min. Foremilk samples (ca. 50 ml) were drawn aseptically from each quarter directly into labeled Whirl-pak bags (28 g, Van Waters and Rogers Scientific) and placed in iced styrofoam chests.

The MQT (Bow-Matic Milker, Inc., Ontario, Canada) was according to published methods (20), usually within 5 h of collection. The MSCC was determined by direct microscopic count with Newman-Lampert stain (20).

The major minerals of milk were determined on the casein-free filtrates of whole milk (3) by atomic absorption spectrophotometry (Model...
TABLE 1. Mean blood electrolytes for low and high MQT cows.

<table>
<thead>
<tr>
<th>Blood electrolytes</th>
<th>Low MQT c cows (n = 20)</th>
<th>SD</th>
<th>High MQT cows (n = 34)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium</td>
<td>135 ± 6a</td>
<td></td>
<td>137 ± 7a</td>
<td></td>
</tr>
<tr>
<td>Potassium</td>
<td>5.8 ± .6a</td>
<td></td>
<td>5.2 ± .4b</td>
<td></td>
</tr>
<tr>
<td>Calcium</td>
<td>3.5 ± .7a</td>
<td></td>
<td>4.6 ± .3b</td>
<td></td>
</tr>
<tr>
<td>Magnesium</td>
<td>1.9 ± .2a</td>
<td></td>
<td>1.9 ± .2a</td>
<td></td>
</tr>
<tr>
<td>Chloride</td>
<td>106 ± 3a</td>
<td></td>
<td>108 ± 2a</td>
<td></td>
</tr>
</tbody>
</table>

a,b Values in same row with different superscripts are different (P<.05).
cMilk quality test.

RESULTS AND DISCUSSION

Means for blood electrolytes and milk minerals are in Tables 1 and 2. Cows were grouped into low MQT cows, cows judged to be mastitis free with an MQT < 1 in all four quarters, and high MQT cows, MQT > 2 in one or more quarters. Mineral content of milk of high MQT cows was further divided into mastitic and nonmastitic quarters based on the same criteria. Values in Tables 1 and 2 compare reasonably well with recorded figures, although milk calcium was some 20 to 25% less than literature values for both high and low MQT cows (Table 2) (5, 17). We have no explanation

TABLE 2. Mean milk minerals and milk production for low and high MQT cows.

<table>
<thead>
<tr>
<th>Milk minerals</th>
<th>Low MQT c cows</th>
<th>Nonmastic quarters</th>
<th>Mastitic quarters</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>x</td>
<td>SD</td>
<td>x</td>
</tr>
<tr>
<td>Sodium</td>
<td>40 ± 8a</td>
<td>34 ± 8a</td>
<td>73 ± 30b</td>
</tr>
<tr>
<td>Potassium</td>
<td>162 ± 17a</td>
<td>168 ± 18a</td>
<td>139 ± 29b</td>
</tr>
<tr>
<td>Calcium</td>
<td>85 ± 12a</td>
<td>108 ± 13b</td>
<td>94 ± 20c</td>
</tr>
<tr>
<td>Magnesium</td>
<td>11.2 ± 4.5a</td>
<td>11.5 ± 1.6a</td>
<td>11.0 ± 1.8a</td>
</tr>
<tr>
<td>Chloride</td>
<td>117 ± 8a</td>
<td>98 ± 17a</td>
<td>154 ± 38b</td>
</tr>
<tr>
<td>Milk production (kg/head per day)</td>
<td>18.3 ± 6.4a</td>
<td>12.0 ± 6.4b</td>
<td></td>
</tr>
</tbody>
</table>

a,b Values in same row with different superscripts are different (P<.05).
cMilk quality test.
for this discrepancy, but it may have been a procedural error. We do not believe it was any fault in handling the samples, because strict attention to thorough mixing was practiced during the transfers. Furthermore, our magnesium values are similar to those in the literature (5, 17).

Comparison of mean values indicated significant differences between high and low MQT cows for blood potassium and calcium (Table 1) and milk sodium potassium, calcium, and chloride (Table 2). Mineral content of milk of low MQT cows and nonmastitic quarters of high MQT cows was similar with the exception of calcium. Milk calcium in nonmastitic quarters of high MQT cows was higher (P<.01) than either mastitic quarters of high MQT cows or low MQT cows. This could be a reflection of the higher blood calcium in high MQT cows (Table 1).

Correlation coefficients between milk minerals and mastitis indicate highly significant positive relationships between milk sodium and chloride and the two indices of mastitis and negative correlations for milk potassium and calcium (Table 3). These data agree with several other reports of high sodium chloride in milk from mastitic quarters (7, 8, 9, 22). High sodium and chloride in mastitic milk results from blood transudation that is complemented osmotically by reduced lactose and potassium (13). Both sodium and chloride increased about 50 mg/100 ml milk as MQT increased through its subjective index (Table 4). However, the molar ratio of sodium to chloride was 1.6, indicating that these two ions did not pass in equivalent amounts into mastitic milk.

Potassium declined 20% with increasing infection, and calcium dropped 11%. Only the magnesium content of mastitic milk remained relatively constant. Either magnesium did not enter into the osmotic adjustment which accompanied udder inflammation, or its association with casein altered the milk-blood permeability of this mineral.

The relationship between blood electrolytes, mastitis, and the mineral content of the milk is difficult to assess. Since maintenance of blood sodium normally is well orchestrated (19), we did not expect to find changes in this blood component as a result of the ion flux attendant to mastitis. However, the concentration of other blood electrolytes may well play a role in the patterns of mineral distribution between blood and milk. Comparison of means for high and low MQT cows (Tables 1 and 2) indicated that cows with evidence of udder infection had lower blood potassium, high blood calcium, and produced less milk than mastitis-free cows.

Correlation coefficients between blood calcium and milk calcium were highly significant and positive. Those between blood potassium and milk calcium were significant and negative (Table 5). These data are consistent with the relative concentrations of these minerals in blood and milk listed in Tables 1 and 2, and suggest that milk calcium varies directly with the concentration of blood calcium and inversely with blood potassium.

Blood electrolytes were not correlated with milk production. This tends to negate the suggestion that reduced blood calcium in low

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**TABLE 3.** Correlation coefficients (r) between two indices of mastitis and milk minerals.

<table>
<thead>
<tr>
<th>Mastitis test</th>
<th>Sodium</th>
<th>Potassium</th>
<th>Calcium</th>
<th>Magnesium</th>
<th>Chloride</th>
</tr>
</thead>
<tbody>
<tr>
<td>MQT&lt;sup&gt;a&lt;/sup&gt;</td>
<td>.71**</td>
<td>-.43**</td>
<td>-.09</td>
<td>.05</td>
<td>.66**</td>
</tr>
<tr>
<td>MSCC&lt;sup&gt;b&lt;/sup&gt;</td>
<td>.67**</td>
<td>-.39**</td>
<td>-.18</td>
<td>-.04</td>
<td>.59**</td>
</tr>
</tbody>
</table>

<sup>a</sup>Milk quality test.

<sup>b</sup>Milk somatic cell count.

<sup>c</sup>Average of all four quarters.

*Correlation coefficients are significant (P<.05).

**Correlation coefficients are significant (P<.01).
MQT cows (Table 1) resulted from their higher milk yield.

There were no differences in blood sodium, magnesium, and chloride between high and low MQT cows (Table 1) although, mastitis was associated with the greatest influx of sodium and chloride into the milk (Table 3).

In addition, there was no consistent relationship between blood electrolytes and either MSCC or MQT. Either homeostatic mechanisms are sufficiently dynamic to cope with any mass mineral losses from blood into a mastitic gland or the magnitude of the mineral passing into the diseased udder section is so small as to be negligible as compared to the total electrolyte pool of blood. Since milk yield is reduced greatly in the mastitic gland (16), the latter explanation seems most plausible.

**REFERENCES**


6 King, J. L. O. 1955. Variation in the quantity and composition of milk yielded by diseased cows while their body temperatures were elevated. Vet. Rev. 67:432.