EXCRETION OF CREATININE AND CREATINE BY BEEF STEERS*

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In the classical theory of protein metabolism proposed by Folin (1) two types of protein metabolism are recognized, one a constant or endogenous metabolism, and the other a variable or exogenous metabolism. According to this theory the endogenous metabolism is represented by the excretion of creatinine at a relatively constant rate which is independent of protein intake. More recently, as pointed out by Friedemann and associates (2), there has been increased emphasis on the variation rather than on the uniformity of creatinine excretion, and the independence of creatinine excretion of protein intake has been questioned. Most of the research relating to this problem has been conducted with human subjects and laboratory animals.

The creatinine and creatine excretion of dairy cattle on standard dairy rations was studied by Ashworth and Brody (3); however, no data were presented to show the effect of protein intake on the excretion of these two urinary constituents. Carpenter (4) determined the creatinine and creatine excretion of beef steers on pasture and on maintenance rations. The protein intake of the animals was not calculated. Although similar values for creatinine excretion were obtained in these two investigations, slightly higher creatine values were reported for the dairy cows than for the steers. In a comparison of the results, Ashworth and Brody (3) suggest that creatine excretion in cattle is influenced by the level of protein intake.

The present study was undertaken to determine the creatinine and creatine excretion of beef steers on rations containing different amounts of protein and different amounts of dietary urea added as a protein substitute (5).

EXPERIMENTAL

Hereford steers, 2 years old, in metabolism stalls were fed rations of constant composition during 20 day periods. During the last 10 days of each period urine was quantitatively collected by means of rubber funnels

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### TABLE I

**Daily Values for Total N, Creatinine N, and Creatine N in Urine of Beef Steers Receiving Supplements of Cottonseed Meal and Urea-Containing Pellets**

<table>
<thead>
<tr>
<th>Steer No.</th>
<th>Supplement fed*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Urea-containing pellets†</td>
</tr>
<tr>
<td>Average body weight, kg.</td>
<td>348.8</td>
</tr>
<tr>
<td>N intake, gm.</td>
<td>124.0</td>
</tr>
<tr>
<td>Day of determination</td>
<td>(a)</td>
</tr>
<tr>
<td>1</td>
<td>53.9</td>
</tr>
<tr>
<td>2</td>
<td>60.0</td>
</tr>
<tr>
<td>3</td>
<td>58.1</td>
</tr>
<tr>
<td>4</td>
<td>67.8</td>
</tr>
<tr>
<td>5</td>
<td>62.0</td>
</tr>
<tr>
<td>6</td>
<td>54.8</td>
</tr>
<tr>
<td>7</td>
<td>50.3</td>
</tr>
<tr>
<td>8</td>
<td>60.9</td>
</tr>
<tr>
<td>9</td>
<td>62.4</td>
</tr>
<tr>
<td>10</td>
<td>63.6</td>
</tr>
</tbody>
</table>

Average: 60.0 3.92 1.15 55.3 4.33 0.61 60.2 2.78 0.89 51.9 3.62 1.07 67.3 3.84 0.98 54.4 2.27 0.77 58.4 2.93 0.65

(a), (b), and (c) represent total urinary N, creatinine N, and creatine N, respectively, in gm.

* All steers received 10 pounds of prairie hay and 3 pounds of supplement daily.

† The urea pellets contained 75 per cent cottonseed meal, 1 per cent urea, 10 per cent molasses, and 11 per cent hominy feed. Urea supplied 18.8 per cent (23.3 gm.) of the total nitrogen intake of steers 1, 3, 5, and 6.
which led to glass collection jars beneath the floor of the stalls. Toluene was used as a preservative and sufficient sulfuric acid was added to the collection jars to maintain the urine below pH 6. Preliminary work showed that at values below pH 6 both creatinine and creatine are stable. Urine was collected and measured daily. Creatinine and creatine were determined by Folin's method as outlined by Hawk et al. (6).

In the first series of experiments the nitrogen intake of all of the steers was approximately the same, the rations being composed of prairie hay supplemented with either cottonseed meal or a pelleted feed containing 75 per cent cottonseed meal, 4 per cent urea, 10 per cent molasses, and 11 per cent hominy feed. Creatinine and creatine were determined on daily samples of urine. The results are presented in Table I.

**Table II**

*Average Creatinine and Creatine Nitrogen Excretion by Beef Steers on Rations Containing Different Amounts of Protein and Urea Nitrogen*

<table>
<thead>
<tr>
<th>Daily N intake*</th>
<th>No. of</th>
<th>Average</th>
<th>Daily</th>
<th>Daily</th>
<th>Average</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>As urea</td>
<td>body weight</td>
<td>creatinine N excreted</td>
<td>creatinine N excreted</td>
<td>creatinine coefficient</td>
<td>creatinine coefficient</td>
</tr>
<tr>
<td>gm.</td>
<td>gm.</td>
<td>kg.</td>
<td>gm.</td>
<td>gm.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>53.8</td>
<td>0.0</td>
<td>4</td>
<td>332.8</td>
<td>3.39</td>
<td>0.32</td>
<td>10.19</td>
</tr>
<tr>
<td>61.6</td>
<td>7.8</td>
<td>4</td>
<td>326.0</td>
<td>3.16</td>
<td>1.11</td>
<td>9.69</td>
</tr>
<tr>
<td>95.7</td>
<td>0.0</td>
<td>4</td>
<td>330.2</td>
<td>3.68</td>
<td>0.54</td>
<td>10.85</td>
</tr>
<tr>
<td>96.0</td>
<td>24.0</td>
<td>24</td>
<td>318.5</td>
<td>3.72</td>
<td>0.97</td>
<td>11.68</td>
</tr>
<tr>
<td>100.0</td>
<td>0.0</td>
<td>8</td>
<td>317.5</td>
<td>3.67</td>
<td>0.89</td>
<td>11.56</td>
</tr>
<tr>
<td>117.7</td>
<td>0.0</td>
<td>3</td>
<td>340.7</td>
<td>3.63</td>
<td>0.84</td>
<td>10.65</td>
</tr>
<tr>
<td>119.2</td>
<td>23.5</td>
<td>4</td>
<td>336.3</td>
<td>3.94</td>
<td>0.45</td>
<td>11.72</td>
</tr>
<tr>
<td>124.0</td>
<td>23.3</td>
<td>4</td>
<td>320.0</td>
<td>3.20</td>
<td>0.94</td>
<td>10.00</td>
</tr>
</tbody>
</table>

* All steers received 10 pounds of prairie hay supplemented with varying amounts of cottonseed meal, urea, molasses, and hominy feed daily.

In the second series of experiments, the nitrogen intake of the steers was progressively increased from about 54 gm. daily to 124 gm. daily. The rations were composed of prairie hay supplemented with different amounts of the pelleted feed constituents used in the first experiments. Creatinine and creatine were determined on 10 day pooled samples of urine which had been preserved as described above and stored at 0° during the collection period. The combined results representing data secured from 55 animals are presented in Table II.

**RESULTS AND DISCUSSION**

The results in Table I show that the excretion of total nitrogen and creatinine nitrogen of individual steers on a uniform nitrogen intake is...
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relatively constant from day to day as compared to the differences between individuals. There are, however, some apparent exceptions. The greatest variations were observed with Steers 3 and 6 on the 9th and 10th days of collection. Such variations as were observed in the daily creatinine excretion of individual animals were for the most part unrelated to the daily total nitrogen excretion. Creatine excretion varied markedly from day to day.

Differences between animals in excretion of total nitrogen over the 10 day periods were related to small differences in the amount, and particularly in the form, of nitrogen ingested. As might be expected total nitrogen excretion of steers that received urea was generally high. There were also marked differences between animals in creatinine excretion. The differences were unrelated to the amount and form of nitrogen ingested. Although creatinine excretion is generally related to body weight, in these experiments the steers with low creatinine excretion values had correspondingly low creatinine coefficients.

Average creatinine and creatine coefficients for steers ingesting from 53.8 to 124.0 gm. of nitrogen daily are given in Table II. The nitrogen balance status of these animals varied from nitrogen equilibrium to a positive nitrogen balance of 22.3 gm. daily. It is obvious from the results that changes in nitrogen intake over the range studied and the addition of urea to the rations were without effect on the creatinine coefficients. The weighted mean creatinine coefficient was 11.18. This value is higher than the value of 9.5 reported by Ashworth and Brody (3) for dairy cows. Differences in breed, age, and sex of the animals might contribute to this difference. Carpenter (4) reported creatinine coefficients between 8 and 9 for steers; however, destruction of creatinine during storage and shipping of the urines as described in his paper might easily account for these lower values.

The creatine coefficients shown in Table II varied from 0.96 to 3.40 and could not be correlated with total nitrogen intake. The weighted mean creatine coefficient was 2.62, a value similar to that reported by Carpenter (4) but considerably lower than the value of 7.6 reported by Ashworth and Brody (3) for dairy cows.

SUMMARY

The daily excretion of creatinine nitrogen by beef steers is relatively constant and is unaffected by changes in the protein content of the ration or by the addition of urea to the ration as a protein substitute.

1 In Tables I and II and in the text, creatinine and creatine coefficients refer to the mg. of creatinine N and creatine N, respectively, excreted per kilo of body weight per day.
There appears to be an individual variation in the amount of creatinine excreted by steers of similar breed, age, and body weight. The average creatinine coefficient of 2 year-old Hereford steers ingesting from 54 to 124 gm. of nitrogen daily is 11.18.

Creatine excretion by steers is variable.

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