Postprandial Blood Glucose and Insulin in Cows Fed High Grain

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Abstract

The effects of ration on postprandial serum glucose and insulin were determined in 12 lactating Holstein cows. Six were fed a high grain ration of 15% hay and 85% concentrate (dry basis) and the other six a control ration of 55% corn silage, 10% hay, and 35% concentrate. High grain feeding increased glucose and insulin at all hours postfeeding as compared to control cows. In the cows fed high grain, glucose increased from 63.3 to 72.2 mg/100 ml and insulin from 19.2 to 25.6 \( \mu \)units/ml serum just before feeding to 3 h postfeeding. Values for 2, 3, and 4 h samples were greater than for other sampling times. Serum glucose was 55.5 mg/100 ml at 1 h in control cows which was above other samples. Serum insulin followed a pattern similar to glucose in controls but was not significantly different with time. The blood changes due to high grain feeding are probably related to low milk fat production.

Introduction

A possible involvement of insulin in the low-fat milk syndrome was first proposed by McClymont and Vallance (7). Although only limited data specifically relate insulin and milk fat depression (3, 14) much has been learned about factors regulating insulin release in ruminants (1, 2, 5, 6, 10, 12). Cows previously adapted to high grain rations in another experiment (3) were used to study the effects of high grain feeding on postprandial serum glucose and insulin.

Materials and Methods

Of 12 Holstein cows at least 90 days postpartum and beyond peak lactation, one-half had been adapted to a ration of hay and 14% crude protein pelleted concentrate in a ratio of 15:85 dry matter. As a control group, the remaining six cows were fed corn silage, mixed red clover-orchard grass hay, and a pelleted concentrate (28% crude protein) in a 55:10:35 dry matter ratio. Silage, hay, and concentrates were offered twice daily in individual stalls. Concentrates and hay normally were consumed within an hour, and silage was available free choice to the control cows. Total protein intake was similar for cows on the two rations. However, crude fiber averaged 10.5% for the high grain and 17.9% for the control ration on a dry basis. All cows fed high grain were depressed 25 to 50% in milk fat test as compared to their pretreatment test (3) whereas controls did not change significantly.

Jugular catheters were placed in all cows 1 day prior to sampling. On the morning of the test day a blood sample was obtained from each cow and labeled as time zero. Immediately following the initial blood sample, all cows were given their morning ration. Blood samples were taken at .5, 1, 2, 3, 4, 6, 8, and 10 h postfeeding. All blood samples were centrifuged, and blood serum was frozen for analysis.

Serum insulin was determined with a commercially prepared radioimmunoassay kit by a modified procedure for cow serum. Blood serum was analyzed for glucose with a Harleco Glucose Reagent Kit and 6% orthotoluidine in glacial acetic acid as the color developing reagent. All data were analyzed by analysis of variance for a split plot design, and differences between time means within treatments were tested by Duncan's multiple range test (9).

Results and Discussion

Analysis of variance for serum concentrations of insulin and glucose is in Table 1. Treatment, time, and treatment \( \times \) time interaction were significant \( (P < .01) \) for both serum insulin and glucose. The interaction is manifested by the greater response of both glu-
Table 1. Analysis of variance for serum insulin and glucose of cows fed control and high grain rations.

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>df</th>
<th>Mean serum insulin (units/ml)</th>
<th>Mean serum glucose (mg/dl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>1</td>
<td>705.487*</td>
<td>4935.882*</td>
</tr>
<tr>
<td>Error A</td>
<td>10</td>
<td>34.746</td>
<td>86.532</td>
</tr>
<tr>
<td>Time</td>
<td>8</td>
<td>25.997*</td>
<td>97.563*</td>
</tr>
<tr>
<td>Treatment × time</td>
<td>8</td>
<td>23.712*</td>
<td>34.915*</td>
</tr>
<tr>
<td>Error B</td>
<td>60</td>
<td>2.913</td>
<td>8.150</td>
</tr>
<tr>
<td>Total</td>
<td>107</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*P < .01.

glucose and insulin for cows fed high grain with only modest changes in controls.

Fig. 1 and 2 show the effect of type of ration and time on serum glucose and insulin. Mean serum glucose concentration (Fig. 1) was greater in cows fed high grain than in controls for all times sampled. Serum glucose peaked between 2 and 4 h postfeeding, and the 2, 3, and 4 h means were greater (P < .05) than other hourly means for cows fed high grain. Mean serum glucose of control cows peaked at 1 h postfeeding.

Using sheep fed ad libitum, Thye et al. (11) observed peak glucose values at 3 h postfeeding while in the same sheep with restricted intake, glucose peaked at 1.5 h postfeeding. All sheep were fed a ground and pelleted feed with minimal long hay available. Since lactating dairy cows respond to fasting by increasing free fatty acid in less time than animals with lower requirements (8), they can be considered to be under greater nutritional stress. Even with possible increased nutritional stress, cows fed high grain were most likely in positive energy balance and would be comparable to the sheep fed ad libitum in the study by Thye et al. (11). Control cows with lower energy intake and under greater nutritional stress (8) might be comparable to restricted fed sheep (11). The 3 h peak of serum glucose in cows fed high grain could be caused by combined effects of increased energy intake due to greater concentrate consumption and a state of positive energy balance which could allow accumulation of glucose in circulating blood.

Serum insulin (Fig. 2) responded similarly to serum glucose. Mean serum insulin at each hour postfeeding was greater for cows fed high grain as compared to controls. Serum insulin of cows fed high grain peaked at 2 to 4 h postfeeding following the same pattern as glucose.
These values were greater \( (P < .05) \) than other hourly means. Serum insulin of control cows (Fig. 2) peaked at 1 h postfeeding but was not different \( (P > .05) \) from other hourly means with exception of 6 h. The increase in serum insulin after feeding the high grain ration was most likely the result of increased secretion rate since, in sheep, feeding or fasting did not affect insulin turnover rate (13).

The general increase in serum glucose and/or insulin of cows fed high grain rations is consistent with previous reports (3, 4, 14). However, it does not appear that insulin secretion can be attributed to any one factor. Published reports have shown low correlations between blood glucose and plasma insulin concentrations in cattle (6) and sheep (2). More recently Jenny et al. (3) observed a significant correlation \( (r = .71) \) between serum glucose and insulin of cows fed high grain past peak lactation which was not observed in cows earlier in lactation. Since intravenous infusions of glucose have increased serum insulin in cattle (6) and sheep (12), it appears that blood glucose concentration is important in determining serum insulin.

Cows that respond to high-grain low-roughage rations by producing low-fat milk also respond with increased serum glucose and insulin (3). The extent of insulin's involvement in the production of low-fat milk has not been elucidated.

References