Introduction

Several amino acids are known to affect the secretion of metabolic hormones such as insulin, glucagon and growth hormone (GH). As these hormones are central to the regulation of amino acid metabolism, it is worthwhile to quantify the extent to which each amino acid could stimulate the secretion of these hormones. In ruminants, however, the effects of very few amino acids on the secretion of insulin and GH has been studied (Davis, 1972). In the present experiment, using sheep, we investigated the secretory response of insulin, glucagon and GH to intravenous infusion of 17 amino acids.

Materials and Methods

Six cross-bred castrated male sheep were used. They were housed in metabolic cages and offered alfalfa pellets once daily and water ad libitum. Sheep were intravenously infused with solution of individual amino acids through a jugular venous catheter at a rate of 3 mmol/kg of body weight over a period of 30 min. Infusion solutions were adjusted to pH 7.4, except for the solution of Leu to pH 2.5. The amino acids used for infusion are shown in table 1. Blood samples were obtained from a carotid artery surgically placed in a loop of skin, from 20 min before to 90 min after starting the infusion, and were transferred into heparinized test tubes containing benzamidine, and centrifuged. Plasma sample were stored at –20°C until radioimmunoassay. Plasma glucagon and GH were assayed using antiserum G-42 E and NIADDK-anti-oGH-2, respectively. The incremental hormone areas enclosed by hormone concentration curves above basal levels were calculated between 0 and 90 min, and significant differences in hormone areas between amino acids were analyzed by Duncan’s multiple range test using General Linear Model of the SAS program package.

<table>
<thead>
<tr>
<th>Amino Acids</th>
<th>Insulin Area (µg·min·ml⁻¹)</th>
<th>Glucagon Area (pg·min·ml⁻¹)</th>
<th>GH Area (ng·min·ml⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ala</td>
<td>64.8 ± 7.4ab</td>
<td>307.5 ± 62.7a</td>
<td>1.130 ± 0.3bcd</td>
</tr>
<tr>
<td>Arg</td>
<td>25.5 ± 4.5bcde</td>
<td>139.2 ± 20.0b</td>
<td>1.0 ± 0.4bcd</td>
</tr>
<tr>
<td>Asp</td>
<td>25.5 ± 13.8bcd</td>
<td>135.8 ± 20.8b</td>
<td>1.920 ± 0.5bcd</td>
</tr>
<tr>
<td>Gin</td>
<td>−3.6 ± 1.2cde</td>
<td>−3.5 ± 14.4ef</td>
<td>9.820 ± 0a</td>
</tr>
<tr>
<td>Glu</td>
<td>15.0 ± 3.4d</td>
<td>99.6 ± 19.4bc</td>
<td>2.5 ± 1.2bcd</td>
</tr>
<tr>
<td>Gly</td>
<td>−7.8 ± 3.7d</td>
<td>4.3 ± 11.0gdef</td>
<td>3.250 ± 0.8bc</td>
</tr>
<tr>
<td>His</td>
<td>101.6 ± 19.2a</td>
<td>295.5 ± 57.1a</td>
<td>1.150 ± 0.6bc</td>
</tr>
<tr>
<td>His</td>
<td>−1.9 ± 1.2cde</td>
<td>3.7 ± 5.8def</td>
<td>0.430 ± 0.2d</td>
</tr>
<tr>
<td>Ile</td>
<td>6.1 ± 0.7cde</td>
<td>−10.8 ± 5.6f</td>
<td>0.250 ± 0.4d</td>
</tr>
<tr>
<td>Leu</td>
<td>99.8 ± 38.5a</td>
<td>−8.8 ± 5.0f</td>
<td>1.250 ± 0.5bc</td>
</tr>
<tr>
<td>Lys</td>
<td>17.2 ± 1.9cde</td>
<td>45.8 ± 14.5cdef</td>
<td>0.230 ± 0.2d</td>
</tr>
<tr>
<td>Met</td>
<td>36.1 ± 11.9bcde</td>
<td>62.7 ± 8.1bcdef</td>
<td>0.830 ± 0.5cd</td>
</tr>
<tr>
<td>Phe</td>
<td>37.6 ± 8.3bcde</td>
<td>77.3 ± 15.1bcd</td>
<td>3.340 ± 0.8b</td>
</tr>
<tr>
<td>Pro</td>
<td>21.4 ± 2.9cde</td>
<td>83.8 ± 9.5bcd</td>
<td>0.650 ± 0.5d</td>
</tr>
<tr>
<td>Ser</td>
<td>88.9 ± 18.9a</td>
<td>242.5 ± 44.6a</td>
<td>1.250 ± 0.3bcd</td>
</tr>
<tr>
<td>Thr</td>
<td>26.8 ± 5.2bcd</td>
<td>90.7 ± 11.1bc</td>
<td>0.750 ± 0.2d</td>
</tr>
<tr>
<td>Val</td>
<td>3.7 ± 0.5cde</td>
<td>23.5 ± 3.2cdef</td>
<td>0.440 ± 0.5d</td>
</tr>
</tbody>
</table>

Values represent Mean ± SE.
ab,c,d,e,f Mean values in the same vertical column not
sharing common letters differed significantly (p < 0.05).

Results

Large differences were observed in the responses of plasma insulin, glucagon and GH concentrations to individual amino acids. Insulin secretion induced by Gly, Ser or Leu infusion was significantly (p < 0.05) greater than that induced by other amino acids. Most amino acids increased the plasma insulin concentration above the basal level, while His, Asp and Glu produced slight decreases in plasma insulin. Glucagon secretion was significantly (p < 0.05) augmented by infusion of Ala, Gly or Ser, which were much more potent than other amino acids, plasma glucagon remaining
elevated even after cessation of infusion. The intra-
venous infusion of Asp caused the greatest enhance-
ment of GH secretion among the amino acids
tested.

Discussion

The results of the present experiment show that
Gly, Ser and Leu were the most potent amino
acids for stimulating insulin secretion, while Ala,
Gly and Ser were most effective for glucagon and
Asp for GH in sheep. Unlike Leu or Asp, which
stimulate only insulin or GH secretion respecti-
vely, no amino acid was found that only induce
glucagon secretion in this study. It has been well
documented that Arg has a remarkable effect in
enhancing insulin (Floyd et al., 1966) and GH
(Knopf et al., 1966) secretion, so that Arg has
been commonly used as a standard secretagogue.
We suggest, however, that it would be reasonable
to use Leu for specifically inducing insulin secre-
tion and to use Asp rather than Arg as the secreta-
gogue to induce GH secretion, at least in castrated
male sheep.

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(Key Words: Amino Acids, Metabolic Hormones)

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