EFFECT OF AMINO ACID ADDITIONS IN A FORTIFIED CASEIN-LACTOSE DIET FOR EARLY-WEENED PIGS


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The importance of proper protein level and amino acid balance in swine rations is well established. Terrill et al. (1952) demonstrated that excessive protein in the diet of finishing swine could result in depressed gains, diarrhea, and hypertrophy of the kidneys. The latter effect was attributed to the extra work required of the kidneys in eliminating excess urea resulting from the high-protein ration. The roles of arginine and glycine in the urea cycle suggest that additions of these amino acids to the diet could aid in the removal of excess amino nitrogen from the body. Studies with rats (Brown and Allison, 1948; Van Pilsum and Berg, 1950; Greenstein et al., 1956; Gullino et al., 1956; du Ruisseau et al., 1956; Winitz et al., 1956; Greenstein et al., 1957; Gullino et al., 1958; and with chicks (O'Dell et al., 1960) provide support for the suggestion that arginine can function in this way. Studies by Snetsinger (1959) demonstrated that, in the chick, glycine provides a greater protective effect against excess amino nitrogen than does arginine.

It was the purpose of this study to investigate the effect, upon gains of early-weaned pigs, of the addition of arginine to diets unbalanced with excess protein, and of additions of arginine and of arginine plus glycine to diets unbalanced with excess methionine.

Materials and Methods

Experiment I. Forty-eight pigs were maintained for a 28-day experimental period in groups of four pigs each in small pens with expanded-steel mesh floors. Feed was supplied in self-feeders and water was available in automatic fountains. Supplemental heat was provided by lamps suspended over small, wooden overlays, one in each pen, which the pigs used as sleeping areas.

The pigs were weaned at approximately 21 days of age and divided into eight outcome groups of six pigs each on the basis of litters. Pigs from four outcome groups were randomly allotted to six treatments in one block of six pens, the remaining four outcome groups being allotted similarly in a second block of six pens.

The basal diet (table 1) contained 75% protein, and adequate vitamin, mineral, and antibiotic fortification. It was fed also at 50% or 25% protein (replacing crude casein by lactose), and to each of these three rations 1% arginine hydrochloride was added to replace casein on an isonitrogenous basis, making a total of six ration treatments.

The pigs were weighed individually, and 28-day gain was the criterion for evaluation of treatment effects. To minimize differences in fill, feed was removed from all lots 12 hours prior to final weighing.

Experiment II. Fifty-four pigs, in three replicates of 18 pigs each, were maintained for the 28-day experimental period in groups of three pigs each in small pens with expanded-steel mesh floors. Feed, water, and supplemental heat were supplied as described previously. The pigs were weaned at 16 to 18 days of age, divided into three outcome groups of six pigs each on the basis of litters, and each outcome group was randomly divided among treatments.

The basal diet (table 1), containing 0.2% DL-methionine and adequate vitamin, mineral, and antibiotic fortification, was one which has been routinely used in early-weaning studies at this station. Excess amino acid additions were made on an equimolar basis and replaced an equal weight of lactose, the amount of casein being constant for all treatments.

The pigs were weighed individually, and 21-day gain was the criterion for evaluation of treatment effects. To minimize differences in fill, feed was removed from all lots 12 hours prior to final weighing.
TABLE 1. PERCENT COMPOSITION OF BASAL DIETS

<table>
<thead>
<tr>
<th>Experiment no</th>
<th>I</th>
<th>II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein level, %</td>
<td>75.0</td>
<td>20.0</td>
</tr>
</tbody>
</table>

**Ingredients:**
- Crude casein: 88.5
- Lactose: 23.5
- Woodlock: 4.0
- Corn oil: 4.0
- Mineral mixture #2: 3.0
- Vitamin A & D oil: 1.3
- Vitamin mixture #26: 4.0
- Arginine: 2.6
- DL-methionine: 0.2

**Notes:**
- Composition was as follows, in percent: CaHPO4, 65.00; NaCl (iodized), 16.00; K2CO3, 14.00; MgCO3, 3.27; FeSO4·7H2O, 1.09; MnSO4·H2O, 0.30; CoCl2·6H2O, 0.10; CuSO4, 0.10; NaF, 0.02; ZnCO3, 0.20; and KI, 0.01.
- Vitamin additions per 100 lb. of diet: thiamine HCl, 222.70 mg.; riboflavin, 443.20 mg.; pyridoxine HCl, 177.70 mg.; calcium pantothenate, 2.66 gm.; inositol, 8.86 gm.; biotin, 3.40 mg.; niacin, 2.66 gm.; folic acid, 1.80 gm.; vitamin B6, 1.36 mg.; choline chloride, 68.17 gm.; ascorbic acid, 1.36 gm.; choline bitartrate, 340.90 mg.; and 2-methyl-4-naphthoquinone, 88.60.
- Chlorotetracycline added at 2.5 gm. per 100 lb. of diet.

**Experiment I** (tables 2 and 3). Gains were significantly (P<0.01, table 3) depressed linearly as protein percent increased. This depression was associated with reduced feed intake at the highest protein levels, and feed efficiency was also reduced slightly at the highest level. Arginine had no significant effect. It appears from this trial that, if the variation between replicates appeared most noticeable in the gains of basal-fed pigs. This variation was associated with wide differences in feed intake, for which we can offer no explanation.

**Results and Discussion**

**Experiment I** has been conducted to determine the effectiveness of adding arginine to the diet of early-weaned pigs. The results and discussion are as follows:

**TABLE 2. AVERAGE PERFORMANCE OF EARLY-WEANED PIGS FED THREE LEVELS OF PROTEIN WITH AND WITHOUT ADDED ARGinine**

<table>
<thead>
<tr>
<th>Lot no.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein level, %</td>
<td>25</td>
<td>50</td>
<td>75</td>
<td>25</td>
<td>50</td>
<td>75</td>
</tr>
<tr>
<td>Arginine-HCl a</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Av. gain, lb.</td>
<td>12.4</td>
<td>12.0</td>
<td>7.2</td>
<td>12.2</td>
<td>10.1</td>
<td>8.2</td>
</tr>
<tr>
<td>Av. gain/lb feed, lb.</td>
<td>0.58</td>
<td>0.64</td>
<td>0.54</td>
<td>0.58</td>
<td>0.60</td>
<td>0.68</td>
</tr>
</tbody>
</table>

**Notes:**
- Analysis of variance of gains in experiment I.
- Source of variation: Replicates, 1; Outcome groups/replicate, 6; Treatments, 5; Arginine (A), 1; Protein (P), 2; A x P, 2.
- Mean square: Replicates, 1.14; Outcome groups/replicate, 15.05; Treatments, 70.69; Arginine (A), 5.74; Protein (P), 166.33; A x P, 7.52.
- **P<0.01.**

**TABLE 3. ANALYSIS OF VARIANCE OF GAINS IN EXPERIMENT I**

<table>
<thead>
<tr>
<th>Lot no.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Additions, % a</td>
<td>DL-methionine</td>
<td>...</td>
<td>...</td>
<td>3.6</td>
<td>3.6</td>
<td>3.6</td>
</tr>
<tr>
<td>L-arginine HCl</td>
<td>...</td>
<td>1.3</td>
<td>1.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glycine</td>
<td>...</td>
<td>1.3</td>
<td>1.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Av. gain, lb.</td>
<td>6.1</td>
<td>6.3</td>
<td>9.6</td>
<td>2.2</td>
<td>10.1</td>
<td>1.8</td>
</tr>
<tr>
<td>Av. gain/lb feed, lb.</td>
<td>0.50</td>
<td>0.52</td>
<td>0.82</td>
<td>0.35</td>
<td>0.69</td>
<td>0.29</td>
</tr>
</tbody>
</table>

**Notes:**
- Amino acid additions replaced an equal weight of lactose.
- Three pigs per lot, average initial wt.=11.4 lb.
- Three pigs per lot, average initial wt.=12.4 lb.
TABLE 5. ANALYSIS OF VARIANCE OF GAINS
(Experiment II)

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>d.f.</th>
<th>Mean square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replicates (R)</td>
<td>2</td>
<td>17.42</td>
</tr>
<tr>
<td>Outcome groups/replicates (OG)</td>
<td>6</td>
<td>13.07</td>
</tr>
<tr>
<td>Treatment (T)</td>
<td>5</td>
<td>91.14</td>
</tr>
<tr>
<td>Methionine (M)</td>
<td>1</td>
<td>379.74</td>
</tr>
<tr>
<td>Arginine (A)</td>
<td>1</td>
<td>35.94</td>
</tr>
<tr>
<td>Glycine (G)*</td>
<td>1</td>
<td>1.32</td>
</tr>
<tr>
<td>M x A</td>
<td>1</td>
<td>36.17**</td>
</tr>
<tr>
<td>M x G*</td>
<td>1</td>
<td>2.51</td>
</tr>
<tr>
<td>R x T</td>
<td>10</td>
<td>5.15</td>
</tr>
<tr>
<td>OG x T</td>
<td>30</td>
<td>4.00</td>
</tr>
</tbody>
</table>

** P<.01.  * In the presence of arginine.

Summary

Two experiments, involving a total of 102 early-weaned pigs, were conducted to measure the effect upon pig gains of additions of arginine to diets unbalanced with excess protein, and of additions of arginine and of arginine plus glycine to diets unbalanced with excess methionine.

A significant (P<.01) growth depression resulted from feeding excessive protein levels in a casein-lactose diet. This depression appeared to result largely from reduced feed intake and was not affected by the addition of 1% L-arginine hydrochloride to the diet.

Pig gains were significantly (P<.01) depressed by the addition of 2.6% DL-methionine to a fortified, casein-lactose basal diet, and to diets supplemented with arginine or both arginine and glycine. Glycine, added at 1.3% of the diet, had no significant effect, but was tested only in the presence of arginine.

Arginine, added to a diet containing excess methionine, did not exert a protective effect; rather, a significantly (P<.01) greater growth depression resulted.

**Literature Cited**


Terrill, S. W., W. K. Warden, D. E. Becker and P. B. Brown and Allison (1948) and by Van Pilsum and Berg (1950) but agrees with those for chicks reported by Fisher et al., (1955), and lends credence to the suggestion by the last group of workers and by Russell et al. (1952) that the toxic effect of excess methionine is due not merely to amino acid imbalance. Failure of arginine to protect against excess methionine was demonstrated also by amino acid injection studies by du Ruisseau et al. (1956).

The failure of added arginine to overcome the depression in gain caused by excess methionine may have resulted from one or both of two possible causes: (1) the depression from excess methionine may have resulted from toxic effects other than amino acid imbalance; or (2) the supplemental arginine, at the relatively high level used, may have exerted a toxic effect outweighing any protective effect it might have had at a lower level. In the light of the evidence cited above (Russell et al., 1952; Fisher et al., 1955), the former possibility appears more likely.
