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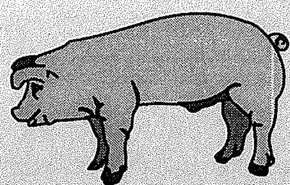

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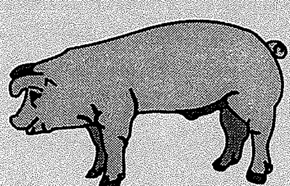

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# Effects of body weight on total losses and amino acid composition of endogenous protein in growing pigs

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**Abstract**

An experiment was conducted to investigate the effect of BW on the losses of endogenous protein and the amino acid composition of endogenous protein in growing pigs. A significant ($P < .05$) decrease in endogenous losses calculated as g/kg DMI between 36-kg pigs and 61-kg pigs was observed for protein and amino acids, whereas the estimated endogenous losses of protein and most amino acids in 95-kg pigs were similar to those estimated for 61-kg pigs ($P > .05$). The amino acid composition of endogenous protein changed significantly ($P < .05$) with changing BW of the pigs. The data from this experiment support the hypothesis that the endogenous flow of protein and amino acids at the distal ileum of growing pigs given free access to feed is influenced by the BW of the animals. Hence, a standard value for endogenous losses of amino acids can not be applied to all group of pigs.

**Introduction**

Estimates for endogenous losses of protein and amino acids have been used to calculate standardized or true digestibility coefficients of amino acids for feed ingredients (Jondreville et al., 1995). In these calculations, only one value for endogenous losses have been used, and it was assumed that this value was representative for all groups of pigs regardless of their BW.

Novel methods for estimating the endogenous flow of protein and amino acids in pigs include the $^{15}N$-dilution technique (Souffrant et al., 1981) and the homoarginine technique (Hagemeister and Ebersdobler, 1985). With either of these two methods, only the flow of one or a few amino acids is measured, and the endogenous flow of all other amino acids is estimated assuming a constant amino acid composition of endogenous protein. Recently, standardized amino acid compositions of endogenous protein have been proposed (Wünsche et al., 1987; Boisen and Moughan, 1996).

In no experiments has the assumption that the total loss of and the amino acid composition of endogenous protein is constant during the growing period of pigs been investigated. It was the objective of the present experiment to test this hypothesis.

**Materials and methods**

Five growing barrows arising from the matings of Camborough 15 sows to PIC line 326 boars (PIC, Franklin, KY) with an initial BW of approximately 26 kg were prepared with simple T-cannulas inserted into the distal ileum.

The endogenous losses were quantified using a cornstarch-casein diet (Table 1). Casein was the only protein source in the diet, and it was assumed that all dietary proteins were completely hydrolyzed and that all amino acids of dietary origin were absorbed prior to the distal ileum (Kies et al. 1986; Souffrant et al., 1993).

Ileal digesta were collected when pigs reached an average BW of 36, 61 and 95 kg, respectively. During the collection periods, pigs were given ad libitum access to the experimental diet, but feed intake was recorded on a daily basis. Water was available from nipple drinkers 24 h a day. The initial 5 d of each collection period was considered an adaptation period, and ileal digesta were collected for 12 consecutive hours on d 6 and d 7. Before collections were initiated on d 6, the BW of each pig was recorded.

Feed intake data were summarized at the end of each collection period, and average daily feed DM intake was calculated for each pig and period on a total basis as well as in relation to the metabolic body weight ($kg^{0.75}$) of the pigs.

The endogenous flow of each amino acid was calculated for each pig and period as g lost/kg DMI. The amino acid composition of endogenous protein was calculated by relating the ileal flow of each amino acid to the total endogenous protein flow on a percentage basis.

Results were subjected to repeated measures analysis using the Proc Mixed procedure of SAS (Littell et al., 1996). Treatment means were separated using an LSD test.

**Results**

Pig weights, calculated metabolic BW, and data for average daily feed intake during each experimental period are given in Table 2. As expected, average daily feed intake increased from period 1 to period 2 ($P < .05$); however, no further increase in feed intake was observed, and average daily feed intake in period 3 was the same as in period 2 ($P > .05$). Because the pigs were heavier in period 3 than in period 2, average feed intake per $kg^{0.75}$ was lower in period 3 ($P < .05$).

Endogenous flow of protein and amino acids per kg DMI are presented in Table 3. The calculated protein loss per kg DMI was higher ($P < .05$) in period 1 as compared to period 2 and period 3, while no difference ($P > .05$) between period 2 and period 3 was detected. Likewise, a higher loss of amino acids was observed in the first period than in the second period with the difference being significant ($P < .05$) for all amino acids except lysine ($P = .054$).

Significant differences ($P < .05$) in the amino acid composition of endogenous protein between period 1 and period 3 were observed for all amino acids except for threonine, histidine, arginine, and cysteine (Table 4). The difference in the composition of endogenous protein between period 1 and period 2 was significant ($P < .05$) only for lysine, leucine, phenylalanine, histidine, arginine, and alanine, whereas significant ($P < .05$) differences between period 2 and period 3 were observed for tryptophan, methionine, isoleucine, phenylalanine, proline, aspartate, serine, and alanine.

**Discussion**

*The effect of body weight on endogenous losses*

Pigs had a significantly ($P < .05$) higher endogenous flow of protein and amino acids, expressed as g/kg DMI, at 36 kg than they had at heavier weights (Table 3). Based on this comparison, it would appear that BW *per se* has a significant influence on endogenous protein losses. However, no further decrease in endogenous secretions after 61 kg was observed, and endogenous losses of amino acids and protein were the same in period 2 and period 3. There are two possible explanations for this observation. First, it could be a true physiological mechanism that enables heavier pigs either to secrete less endogenous protein per kg DMI than younger pigs or that enables them to reabsorb larger amounts of endogenous secretions before it reaches the distal ileum because of a more efficient digestive system. Secondly, an alternative explanation for the lack of a decrease in endogenous losses between the 61-kg pigs and the 95-kg pigs could be that feed intake as a function of $kg^{0.75}$ was lower in the heavier pigs. A decreased feed intake would be expected to increase the amount of endogenous losses per kg DMI (Butts et al., 1993; Stein and Easter, 1997), thus circumventing a possible decrease in endogenous losses due to increased BW of the animals.

Leibholz and Mollah (1988) reported lower losses of endogenous protein per kg DMI in growing pigs fed a protein-free diet as compared to values obtained in younger pigs. They suggested that the relatively higher gut surface area in younger pigs increased the sloughing of epithelial cells into the gut lumen, and thus increased the endogenous losses at the distal ileum. Therefore, endogenous losses will not increase linearly with feed intake as the pigs grow (Leibholz and Mollar, 1988). The results from the present experiment tend to support this hypothesis. However, in a previous study, we compared the endogenous losses in 110-kg growing pigs and adult, gestating sows, and we found no difference between these two groups if the animals were given free access to a protein-free diet (Stein and Easter, 1997). In the present experiment, no difference was found between pigs of 61 kg and 95 kg BW; hence, BW does not seem to influence endogenous losses in animals above 60 kg. In younger animals (less than 60 kg BW), endogenous amino acid losses seem to be elevated per kg DMI as compared to older animals.

*The composition of endogenous protein*

Significant differences ($P < .05$) in the amino acid composition of endogenous protein were detected among periods, with the differences being particularly large for tryptophan, phenylalanine, the branched chained amino acids, glutamate, and serine. Threonine and cysteine were the only two amino acids with constant ($P > .05$) values relative to total endogenous protein. The results in Table 4 show that not even when the overall protein flow to the distal ileum is constant, as was the case for period 2 and period 3, is the composition of endogenous protein constant. This observation underscores the difficulties in estimating the losses of all amino acids of endogenous origin using the $^{15}N$-dilution technique and the homoarginine technique because these two techniques rely on the assumption that the amino acid composition of endogenous protein is constant. Our results suggest that the amino acid composition of endogenous protein in growing pigs is not constant over the weight range from 36 to 95 kg live weight.

**Implications**

Results of this experiment indicate that values for the total flow of endogenous protein relative to DMI as well as the amino acid composition of endogenous protein may change during the growing period, and that values obtained in younger pigs are not representative for the losses in pigs heavier than 60 kg. Therefore, if values for endogenous losses are used to calculate true or standardized amino acid digestibilities of feed ingredients, care should be taken to ensure that these values are only applied to pigs of the same BW as they were obtained in. Furthermore, calculating true amino acid digestibilities based on a constant composition of endogenous protein may yield unreliable results.

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Table 1. Composition (as is) of the experimental diet[a]

| Ingredient | % |
|---|---|
| Casein[b] | 11.7 |
| Soybean oil | 4 |
| Cornstarch | 70.9 |
| Sugar | 4 |
| Solka floc[c] | 5 |
| Dicalcium phosphate | 3.2 |
| Limestone | .4 |
| Trace mineral salt[d] | .35 |
| Vitamin premix[e] | .2 |
| Chromium Oxide | .25 |
| Total | 100 |

[a] 10 % CP, .7 % Ca, .6% P.

[b] Erie Casein, Erie, IL.

[c] James River, Berlin, NH.

[d] Trace mineral mix provided the following quantities of nutrients per kg of diet: Se, .30 mg; I, .35 mg; Cu, 8 mg; Mn, 20 mg; Fe, 90 mg; Zn, 100 mg; NaCl, 2.87 g.

[e] Vitamin premix provided the following quantities of vitamins per kg of diet: Vitamin A, 5,250 IU; vitamin $D_3$, 525 IU; vitamin E, 40 IU; menadione K, 2 mg; vitamin $B_{12}$, .016 mg; riboflavin, 4 mg; D-pantothenic acid, 11 mg; niacin, 15 mg; choline chloride, 110 mg.

Table 2. Weight and average daily feed intake (ADFI) of pigs

| Item | Period 1[a] | Period 2[a] | Period 3[a] | SEM[b] |
|---|---|---|---|---|
| Avg wt, kg | 36.5[c] | 61.4[d] | 94.9[e] | 2.6 |
| Avg wt, $kg^{0.75}$ | 14.8[c] | 21.9[d] | 30.4[e] | .68 |
| ADFI, kg DM | 1.78[c] | 2.39[d] | 2.46[d] | .08 |
| ADFI, g DM/ $kg^{0.75}$ | 120[c] | 109[d] | 79[d] | 4.4 |

[a] Means of five observations.

[b] Pooled standard error of the mean.

[c,d,e] Means within a row lacking a common superscript are different ($P < .05$).

Table 3. Endogenous losses of dry matter, protein, and amino acids (g/kg DMI)[a]

| Item | Period 1 | Period 2 | Period 3 | SEM [b] |
|---|---|---|---|---|
| Dry Matter | 129 [c] | 114 [d] | 119 [cd] | 5.4 |
| Protein | 21.55 [c] | 15.22 [d] | 15.06 [d] | 1.23 |
| Indispensable amino acids | | | | |
| Arginine | .52 [c] | .34 [d] | .34 [d] | .04 |
| Histidine | .32 [c] | .19 [d] | .21 [d] | .02 |
| Isoleucine | .80 [c] | .59 [d] | .76 [c] | .06 |
| Leucine | 1.14 [c] | .70 [d] | .68 [d] | .08 |
| Lysine | .51 [c] | .46 [cd] | .41 [d] | .02 |
| Methionine | .22 [c] | .14 [d] | .17 [d] | .02 |
| Phenylalanine | .63 [c] | .39 [d] | .31 [e] | .04 |
| Threonine | 1.16 [c] | .87 [d] | .78 [d] | .08 |
| Tryptophan | .23 [c] | .16 [d] | .11 [e] | .02 |
| Valine | 1.02 [c] | .71 [d] | .76 [d] | .06 |
| Mean | 6.54 [c] | 4.55 [d] | 4.53 [d] | .41 |
| Dispensable amino acids | | | | |
| Alanine | 1.06 [c] | .84 [d] | .65 [e] | .06 |
| Aspartate | 1.44 [c] | .94 [d] | 1.02 [d] | 0.11 |
| Cysteine | .37 [c] | .26 [d] | .26 [d] | .03 |
| Glutamate | 2.44 [c] | 1.92 [d] | 2.28 [cd] | .18 |
| Glycine | 1.45 [c] | .94 [d] | .76 [d] | .09 |
| Proline | .97 [c] | .70 [d] | .78 [d] | .06 |
| Serine | 1.05 [c] | .75 [d] | 1.15 [c] | .09 |
| Tyrosine | .46 [c] | .31 [d] | .27 [d] | .03 |
| Mean | 9.24 [c] | 6.64 [d] | 7.15 [d] | .58 |
| All amino acids | 15.78 [c] | 11.20 [d] | 11.68 [d] | .97 |

[a] The endogenous loss of protein and each amino acid was calculated as the amino acid or protein concentration in digesta DM multiplied by the relationship between chromium in digesta DM and chromium in feed DM. n = 5.

[b] Pooled standard error of the mean.

[c,d,e] Means within a row lacking a common superscript are different ($P < .05$).

Table 4. Relative amino acid composition of endogenous protein (% of endogenous protein loss) [a]

| Item | Period 1 | Period 2 | Period 3 | SEM [b] |
|---|---|---|---|---|
| Protein | 100 | 100 | 100 | |
| Indispensable amino acids | | | | |
| Arginine | 2.40 [c] | 2.23 [d] | 2.26 [cd] | .08 |
| Histidine | 1.46 [c] | 1.25 [d] | 1.41 [cd] | .05 |
| Isoleucine | 3.69 [c] | 3.87 [c] | 5.09 [d] | .12 |
| Leucine | 5.22 [c] | 4.61 [d] | 4.49 [d] | .14 |
| Lysine | 2.38 [c] | 3.02 [d] | 2.75 [d] | .10 |
| Methionine | .99 [c] | .95 [c] | 1.14 [d] | .03 |
| Phenylalanine | 2.93 [c] | 2.56 [d] | 2.04 [e] | .09 |
| Threonine | 5.35 | 5.73 | 5.21 | .18 |
| Tryptophan | 1.08 [c] | 1.02 [c] | .75 [d] | .04 |
| Valine | 4.70 [c] | 4.64 [cd] | 5.06 [d] | .10 |
| Mean | 30.21 | 29.87 | 30.20 | .54 |
| Dispensable amino acids | | | | |
| Alanine | 4.94 [c] | 5.51 [d] | 4.28 [e] | .12 |
| Aspartate | 6.62 [cd] | 6.16 [c] | 6.78 [d] | .20 |
| Cysteine | 1.70 | 1.73 | 1.72 | .05 |
| Glutamate | 11.26 [c] | 12.59 [cd] | 15.25 [d] | .54 |
| Glycine | 6.72 [c] | 6.20 [cd] | 5.08 [d] | .41 |
| Proline | 4.49 [c] | 4.63 [c] | 5.20 [d] | .16 |
| Serine | 4.82 [c] | 4.89 [c] | 7.61 [d] | .24 |
| Tyrosine | 2.14 [c] | 2.00 [cd] | 1.77 [d] | .08 |
| Mean | 42.68 [c] | 43.70 [cd] | 47.70 [d] | 1.09 |
| All amino acids | 72.90 | 73.57 | 77.90 | 1.45 |

[a] Calculated by expressing the concentration of each amino acid in endogenous protein (Table 3) as a percentage of total endogenous protein. n = 5.

[b] Pooled standard error of the mean.

[c, d, e] Means within a row lacking a common superscript are different ($P < .05$).