Slovak J. Anim. Sci., 39, 2006 (1-2): 65 - 68

Effect of body weight and pig individuality on apparent ileal digestibility of amino acids and total nitrogen

S. NITRAYOVÁ, J.HEGER, P. PATRÁŠ, M. BRESTENSKÝ

Slovak Agricultural Research Center, Institute of Animal Nutrition, Nitra, Slovakia

ABSTRACT

Six ileally cannulated pigs were used to estimate apparent ileal digestibilities of amino acids and total N of a rye-based diet (96 % rye) at two body weights (20.6 kg and 61.7 kg). On average, the digestibility coefficients were higher in growing pigs than in piglets, the difference being approximately 7 % ($P<0.01$). The digestibility of all individual amino acids was higher in growing pigs than in piglets except for methionine and phenylalanine. Of essential amino acids, the effect of body weight was significant ($P<0.05$) in arginine, leucine, lysine, threonine and valine. There was a significant effect ($P<0.05$) of pig individuality on the the digestibility of all amino acids except for glycine, phenylalanine, tyrosine and proline. It is concluded that the apparent ileal digestibility of amino acids and total N increases with increased body weight and that the animals who digested protein well in an early age retained their ability during subsequent growth.

Keywords: pigs, body weight, ileal digestibility, nitrogen, amino acids

INTRODUCTION

The digestibility of nutrients in pigs can be influenced by the characteristics of the feed (chemical composition and processing), by animal factors (body weight, sex, physiological stage and genotype), and by the experimental procedures (method of measurement and feeding level). Literature results indicate that total tract digestibility of dietary energy and nutrients in growing pigs increases with body weight (Cunningham et. al, 1962). Significant differences were observed when total tract digestibility in growing pigs and sows was compared (Fernández et al., 1986, Noblet and Shi 1993, Etienne et al., 1997). More experiments of this type was conducted in poultry. The results of Batal and Parsons (2002) indicated that the MEn and amino acids digestibility of corn-soyabean meal diet and corn-canola meal diets increased with age for New Hampshire x Columbian male young chicks. For example, lysine digestibility increased from 78 to 89% between 0 and 14 d of age. The results of experiment with commercial broiler chicks also showed significant ($P < 0.05$) increases in MEn and amino acids digestibility with increasing age.

The results of Huang et al. (2005) suggested that the age of broilers significantly influenced the apparent ileal digestibility of amino acids. The effects, however, varied among amino acids and ingredients. The digestibility of amino acids in canola meal, soyabean meal and meat and bone meal was higher at 28 and 42 day compared to those at 14 day, and similar between 28 and 42 day of age.

Analysis of the combined results for the 8 feed ingredients showed that, in general, the digestibility coefficients of amino acids increased with advancing age of broiler chicks.

Little information is available on the effect of body weight on ileal digestibility of amino acids in pigs. Mariscal-Landin (1992) observed higher standardized ileal digestibility (SID) of amino acids in sows than in growing pigs while Stein et al. (2001) found that, with a few exceptions, there were no differences in the digestibility between growing pigs and lactating sows. Interestingly, gestating sows had higher SID of amino acids, except for tryptophan and aspartate, compared with growing pigs. Likewise, the SID of most amino acids obtained in gestating sows was higher than that in lactating sows.

Owing to the lack of relevant data for growing pigs of various weight classes, the objective of the present experiment was to study the effect of body weight and pig individuality on apparent ileal digestibility of amino acids and total nitrogen in piglets and growing pigs fed on a rye-based diet.

Correspondence: E-mail: nitrayova@scpv.sk

MATERIALS AND METHODS

Animals and experimental design

Six Large White young gilts of the Institute herd weaned at 30 days were used. The piglets were fed on a common weaner diet until the beginning of the experiment. When they reached 10 - 15 kg body weight, they were fitted with a simple T-cannula at terminal ileum. After a recovery period of 12 days, the piglets were weighed and housed individually in metabolism cages in a thermoneutral environment.

The experiment consisted of two parts. The first part was started when the mean initial body weight of piglets was 17 kg. The same pigs were used in the second part of the study when their body weight reached approximately 60 kg. There was a 7-days balance period in each part of the experiment. The pigs were weighed at the beginning and end of each balance period and mean body weight at the time of digesta collection was calculated. All experimental procedures were reviewed and approved by the Ethics Committee of the Research Institute of Animal Production.

Diets and feeding

The composition of the diet and the results of its chemical analysis for proximate nutrients are shown in Table 1. Rye (cv. Fernando, harvest 2003) was used as the main source of energy and protein.

Table 1: Ingredient and chemical composition of the diet (g/kg, air-dry basis)

Rye cv. Fernando[1]	958.0
Sunflower oil	9.0
Monocalcium phosphate	11.0
Limestone	13.0
Salt	3.0
Chromic oxide	3.0
Premix[2]	3.0
Chemical analyses	
Dry matter	900.3
Organic matter	953.7
Crude protein	136.7
Ether extract	26.3
Crude fibre	28.6
Gross energy (MJ/kg)	17.6

[1]Contained g/kg air-dry: DM, 897; CP, 138; crude fibre, 23.3; ether extract, 15.1; ash, 17; Ca, 0.46; P, 1.8; lysine, 4.6

[2]Supplied per kg of diet: vit. A, 7200 IU; vit. D3, 1350 IU; á– tocophe-rol 18 mg; vit. B1, 0.54 mg; vit. B2, 3.6 mg; vit. B6 19.5 mg; Ca-panto-thenate, 10.5 mg; niacin, 15 mg; vit. K3, 0.54 mg; biotin, 0.06 mg; cyano-cobalamin, 0.021 mg; choline, 102 mg; betaine, 51 mg; Fe, 60 mg; Zn, 90 mg; Mn, 42 mg; Cu, 21 mg; I, 0.42 mg; Co, 0.54 mg; Se, 0.21 mg.

The analyzed amino acid composition is presented in Table 2. Chromium oxide was included into the diet as an indigestible marker. The pigs were fed twice daily at 6.00 and 16.00 hours in two equal meals at a daily rate of 80-90 g/kg0.75. Water was available ad libitum. The spilled feed was dried and weighed to check the actual feed intake.

Table 2: Amino acid analysis of the diet (g/kg DM)

Arginine	9.51
Histidine	3.30
Isoleucine	4.18
Leucine	9.55
Lysine	5.35
Methionine	1.68
Phenylalanine	6.53
Threonine	4.86
Valine	6.18
Alanine	5.13
Aspartic acid	9.20
Cystine	2.00
Glutamic acid	33.68
Glycine	6.00
Proline	16.74
Serine	5.39
Tyrosine	3.38

Digestibility study

Both balance period consisted of a 6-day preliminary period followed by a 24-h collection period. During the collection period, samples of ileal digesta were collected into plastic bags attached to the cannula barrel in 60-min intervals. Digesta samples were acidified with 5M sulphuric acid to pH 3.5 to stop microbial activity and stored at -20 oC. Faeces were collected by grab sampling, immediately analyzed for total N and stored at -20 oC. At the end of the experiment, samples of digesta and faeces were pooled, freeze-dried, ground to pass a 1 mm screen and stored for subsequent analysis.

Chemical analysis

Samples of ileal digesta were analysed for dry matter and total N. Dry matter, organic matter, total nitrogen , ether extract , crude fibre and gross energy contents of the diet were analyzed in accordance with AOAC (1984) standard procedures. The amino acid composition of diet and digesta was analysed by ion-exchange chromatography (AAA400 automatic analyzer, Ingos, Prague) using the manufacturer's recommendations. Chromic oxide was analysed by atomic absorption spectrometry as described by Williams et al. (1962).

Calculations and statistical analysis

Coefficients of apparent ileal digestibility of amino acids and N were calculated using the following formula:

Digestibility (%) = 100 x [1-(Ni x Cd)/(Nd x Ci)]

where Nd = dietary concentration of the nutrient under study, Cd = dietary concentration of Cr2O3, Ni = concentration of the nutrient in ileal digesta and Ci = concentration of Cr2O3 in ileal digesta (all values in g.kg-1 dry matter).

Statistical analysis of experimental data was performed using the General Linear Model of Statgraphic Plus package v. 3.1. (1997). Each animal was considered as experimental unit. Analysis of covariance was conducted to evaluate the effect of body weight and pig on the apparent ileal digestibility.

RESULTS AND DISCUSSION

The data on apparent ileal digestibilities of amino acids and of total N are summarized in Table 3. In general, the digestibility coefficients were higher in growing pigs than in piglets, the difference for both total N and total amino acids being approximately 7 % (P<0.01). Irrespective of body weight, the digestibility of essential amino acids was slightly higher than that of nonessential amino acids. However, the effect of body weight was more apparent in the case of nonessential amino acids. The digestibility of all individual amino acids was higher in growing pigs than in piglets except for methionine and phenylalanine. Of essential amino acids, the differences were significant (P<0.05) for arginine, leucine, lysine, threonine and valine.

Table 3: Effect of body weight on apparent ileal digestibility of amino acids and total N (%, ± SEM)

Amino acid	Mean body weight (kg)						Significant effects	
	20.6	±	0.9	61.7	±	0.7	BW	Pig
Alanine	59.1	±	1.6	62.7	±	1.8	NS	**
Arginine	79.0	±	0.6	82.5	±	0.6	***	*
Aspartic acid	68.9	±	1.1	72.0	±	1.1	*	*
Cystine	62.9	±	3.5	68.8	±	1.3	NS	*
Glutamic acid	85.7	±	1.0	88.0	±	0.6	*	*
Glycine	47.3	±	2.3	55.1	±	1.6	*	NS
Histidine	70.4	±	1.6	72.9	±	0.8	NS	**
Isoleucine	68.2	±	1.8	71.0	±	1.3	NS	**
Leucine	74.6	±	1.6	78.7	±	0.9	**	**
Lysine	66.6	±	1.6	71.3	±	1.3	*	**
Methionine	74.7	±	1.2	74.1	±	1.4	NS	**
Phenylalanine	75.2	±	2.0	74.9	±	1.6	NS	NS
Proline	71.0	±	4.8	71.7	±	2.6	NS	NS
Serine	68.1	±	1.5	74.4	±	0.8	**	*
Threonine	62.9	±	2.2	69.1	±	1.2	*	*
Tyrosine	60.2	±	2.3	78.5	±	0.8	***	NS
Valine	68.8	±	2.0	71.9	±	1.3	***	**
Essential AA	70.6	±	0.9	73.9	±	0.7	**	***
Nonessential AA	65.6	±	1.8	71.8	±	1.3	**	NS
Total AA	67.9	±	1.1	72.8	±	0.8	***	*
Total N	62.3	±	1.1	67.0	±	0.8	**	*

* P<0.05 ** P<0.01 *** P<0.001 NS = non-significant

Body weight (age) is one of the factors influencing the ability of pigs to digest protein. It has been repeatedly demonstrated that sows had higher total tract protein digestibility than growing pigs (Fernández et al. 1986, Noblet and Shi 1993, Etienne et al. 1997). This was attributed to the microbial activity of the hindgut which was shown to be significantly higher in sows as compared to growing pigs (Shi and Noblet 1994). However, Stein et al. (1999) reported that lactating sows, and to a lesser extent pregnant sows, had a higher apparent ileal digestibility coefficient for most amino acids than growing pigs. It seems therefore that other factors than microbial fermentation of protein in the hindgut might be involved. There is paucity of experimental data regarding the comparison of ileal amino acid digestibility in piglets and growing pigs. The present results suggest that there may be significant differences between both weight groups which should be taken into consideration. The present values for apparent ileal digestibility of amino acids for different feed ingredients have been summarized based on experiments on pigs weighing 25 - 120 kg (Southern 1991, Jondreville et al. 1995, Pedersen and Boisen 2002). The large body weight range involved might be a reason why a considerable variability in the digestibility coefficients of the same feedstuff estimated in different experiments is often observed.

The reason for higher apparent ileal digestibility in older pigs is not readily apparent. There are several possible explanation: (1) longer transit time of digesta along the small intestine; (2) higher activity or secretion rate of enzymes degrading protein; (3) more efficient absorption of free amino acids or small peptides; (4) lower endogenous losses of amino acids; (5) higher microbial activity in the small intestine. To date, no unambiguous experimental evidence is available to accept or reject any of the above mentioned hypotheses.

The estimation of apparent ileal digestibility on the same pigs at two body weights allowed to analyze the effect of pig individuality. As shown in Table 2, there was a significant effect of pig on the digestibility of all amino acids except for glycine, phenylalanine, tyrosine and proline. The animals who digested protein well in an early age retained their ability during subsequent growth.Thus mean ileal digestibility of lysine for both measurements in pig No. 5 was 73.3 % while the same value for pig No. 2 was 65.4 %, i.e. 11% lower. Similar results were reported by Hess and Seve (1999) who found a significant effect of individual pigs on ileal endogenous losses of amino acids. These results indicate the necessity to estimate ileal amino acid digestibility on a sufficiently large group of pigs to obtain an average value representative for the population. On the other hand, the existence of individual variability presents a challenge for pig breeders to select animals with higher ability to digest protein and therefore with better feed efficiency.

REFERENCES

AOAC. 1984. Official methods of analysis. 14th. ed. Washington, D.C., Association of Official Analytical Chemists.

BATAL, A.B. – PARSONS, C.M. 2002. Effects of age on nutrient digestibility in chicks fed different diets. In: *Poult. Sci.*, Vol. 81(3), 2002, p. 400 - 407.

CUNNINGHAM, H. M. – FRIEND, D. W. – NICHOLSON, J. W. G. 1962. The effect of age, body weight, feed intake and adaptability of pigs on the digestibility and nutritive valye of cellulose. In: *Can. J. Anim. Sci.* Vol. 42, 1962, p. 167-175.

ETIENNE, M. – NOBLET, J. – DOURMAD, J. Y. – CASTAING, J. 1997. Digestive utilization of feeds in lactating sows. Comparison with growing pigs. In: *Digestive Physiology in Pigs*, JP Laplace, C Fevrier, A Barbeau eds, EAAP Publ. No. 88, 1997, pp.583-586, St. Malo, France.

FERNÁNDEZ, J. A. – JORGENSEN, H. – JUST, A. 1986. Comparative digestibility experiments with growing pigs and adult sows. In: *Anim. Prod*., Vol. 43, 1986, p. 127-137.

HESS, V. – SEVE, B. 1999. Effects of body weight and feed intake level on basal ileal endogenous losses in growing pigs. In: *J. Anim. Sci*. Vol. 77, 1999, p. 3281-3288.

HUANG, K. H. – RAVINDRAN, V. – LI, X. – BRYDEN, W. L. 2005. Influence of age on the apparent ileal amino acid digestibility of feed ingredients for broiler chickens. In: *Br. Poult. Sci.*, Vol. 46(2), 2005, p. 236-245.

JONDREVILLE, C. – Van den BROECKE, J. – GATEL, F. – Van CAUWENBERGHE, S. 1995. Ileal amino acid digestibility of feedstuffs for pigs. Eurolysine/ITFC Publ., Paris, France, 1995.

MARISCAL-LANDIN, G. 1992. Facteurs de variation de l´utilisation digestive des acides amines chez le porc. Ph. D. thesis . Rennes University. Rennes, France, 1992.

NOBLET, J. – SHI, X. S. (1993) Comparative digestibility of energy and nutrients in growing pigs fed ad libitum and adult sows fed at maintenance. In: *Livest. Prod. Sci*., 34, 137/152.

PEDERSEN, C. – BOISEN, S. 2002. Establishment of tabulated values for standardized ileal digestibility of crude protein and essential amino acids in common feedstuffs for pigs. In: *Acta Agric. Scand.*, Sect. A, Anim. Sci. Vol. 52, 2002, 121-140.

SHI, X. S. – NOBLET, J. 1994. Effect of body weight and feed composition on the contribution of hindgut to digestion of energy and nutrients in growing pigs. In: *Livest. Prod. Sci.,* Vol. 38, 1994, 225-235.

SOUTHERN, L. L. 1991. Digestible amino acids and digestible amino acid requirements for swine. Biokyowa Tech. Rev. 2, Biokyowa Inc., Chesterfield, MO, USA.

Statgraphic Plus 3.1. 1997. Statistical Graphic Corp., Rockville, MD, USA.

STEIN, H. H. – AREF, S. – EASTER, R. A. 1999. Comparative protein and amino acid digestibilities in growing pigs and sows. In: *J. Anim. Sci.,* Vol. 77, 1999, p. 1169-1179.

WILLIAMS, CH. - DAVID, D. J. - LISMOA, O. 1962. The determination of chromic oxide in fecal samples by atomic absorption spectrophotometry. In: *J. Agric. Sci.*, Vol. 59, 1962, p. 381-390.

Authors' address: MVDr. Soňa Nitrayová, PhD., Slovak Agricultural Research Center, Institute of Animal Nutrition, Hlohovská 2, 949 92 Nitra, Slovakia