An attempt to predict protein digestibility of feedstuffs in pigs by using the values for poultry

A.M. ROOSENSTEIN[1,2], J.W. CONE[1,*] AND A.C. BEYNEN[1,2]

[1] ID TNO Animal Nutrition, P.O. Box 65, NL-8200 AB Lelystad, The Netherlands
[2] Department of Nutrition, Faculty of Veterinary Medicine, Utrecht University, P.O. Box 80.152, NL-3508 TD, Utrecht, The Netherlands
* Corresponding author (fax: +31-320-237320; e-mail: j.w.cone@idtno.nl)

Received 26 July 2000; accepted 31 December 2000

Abstract

The protein value of feedstuffs for pigs depends on the ileal digestibility of amino acids. The measurement of ileal digestibility requires cannulated pigs, which is time consuming and causes discomfort in the animals. We have tested the hypothesis that faecal digestibility of crude protein and amino acids in poultry could predict digestibility in pigs. We used the digestibility values for various feedstuffs in cocks, broilers and pigs as listed in the Dutch Feed Value Table.

There were statistically significant correlations for the faecal digestibility coefficients (%) of crude protein and amino acids in either cocks or broilers on the one hand and the values for ileal amino acid digestibility (%) and faecal crude protein digestibility in pigs on the other hand. However, the explained variance was only up to 70% so that the poultry data cannot serve as accurate predictor for the values in pigs.

Keywords: pigs, poultry, digestibility, amino acids, crude protein

Introduction

In feed evaluation for pigs, ileal digestibility of protein and amino acids rather than faecal digestibility is of interest (Sauer & Ozimek, 1986). Dietary proteins and amino acids reaching the large intestine do not contribute to growth and maintenance (McNab, 1989; Bayley *et al.*, 1974). Amino acids are not absorbed by the caecum and colon of the pig (Just *et al.*, 1981; Darragh *et al.*, 1990). Furthermore, in the hindgut, undigested and endogenous protein can be broken down by bacteria, yielding ammonia which may be absorbed and, after conversion into urea, be excreted with urine (Just *et al.*, 1981; Wünsche *et al.*, 1982), which will raise faecal digestibility of nitrogen. Under certain dietary conditions, urea may even diffuse from the bloodstream into the colon and subsequently serve as a nitrogen source for bacterial growth (Grala *et al.*, 1995), which will lower faecal digestibility of nitrogen. It is clear that faecal digestibility of nitrogen is not an accurate measurement of amino acid availability to the animal. Thus, various surgical techniques have been developed to collect ileal chyme in pigs in order to determine ileal digestibility of protein and amino acids (Van Leeuwen *et al.*, 1988; Mroz *et al.*, 1991).

For ileal chyme collection, operating techniques and cannulas have been improved over the years, but the procedures are expensive, time-consuming and cause discomfort in the animals. The animals have to undergo surgery, are housed individually, while the cannulas entail a considerable risk of infection. Clearly, there is a need for alternatives to the *in vivo* ileal measurements in pigs. One alternative could be the use of a model animal, that is less expensive, can be used expeditiously and is subjected to little discomfort. In poultry, the hindgut appears to have little influence on the total intestinal tract digestion of dietary proteins (Salter & Fulford, 1974). Moughan & Donkoh (1991) compared the ileal and faecal digestibility of protein in both poultry and growing pigs and noted that the difference is smaller in poultry than in pigs. The species difference may imply that in poultry nitrogen absorption in the hindgut contributes less to faecal nitrogen absorption than it does in pigs. We thus hypothesised that the faecal digestibility of protein and amino acids in poultry would be a predictor of the ileal digestibility in pigs. The data in the Dutch Feed Value Table (Anonymous, 1998a) were used in an attempt to demonstrate a correlation between ileal digestibility of protein and amino acids for feedstuffs in pigs and that of the faecal digestibility in poultry.

Materials and methods

The data used were taken from the Dutch Feed Value Table (Anonymous, 1998a). The Dutch table lists chemical composition and nutritive value of feedstuffs for various animal species, including pigs and poultry. The pig data refer to pigs weighing 40 to 100 kg and being fed at 2.4 times maintenance level. Poultry refers to adult cocks or broilers. For data on faecal digestibility of crude protein, 49 feedstuffs for both pigs and broilers, 105 feedstuffs for both pigs and adult cocks and 49 feedstuffs for both broilers and adult cocks were used in our analyses. For 74 feedstuffs there were data on the standardised ileal digestibility of all 18 amino acids in pigs as well as on the faecal digestibility in poultry. For pigs standardised ileal digestibility of amino acids was listed, which is the apparent ileal digestibility corrected for undigested basal endogenous proteins. Based on the amount of the amino acids in the feedstuffs and their digestibility values, total amino acid digestibility (%) of the different feedstuffs was calculated for pigs and poultry. The values for digestibility (%) of the individual amino acids were also used in our analyses. Regression analysis (Anonymous, 1998b) was conducted to assess the correlation of digestibility coefficients (%) between the different animal species. In order to validate the relationship for faecal digestibility for crude protein in adult cocks and pigs literature data on the two values for different feedstuffs were used (Anonymous, 1987; Rundgren *et al.*, 1985). The digestibilities for pigs, as predicted on the basis of values of adult cocks, were compared with the actual digestibilities.

Results

Digestibility of Crude Protein

Figure 1 shows the relationship of crude protein digestibility coefficients in pigs and that in broilers (R^2_{adj}= 0.91, *P*<0.001, n=49, RSD=5.5), both for pigs and broilers faecal digestibility data were used. The lower cluster of points refers to feeds (tapioca and molasses cane) with low protein contents. Omitting these points the correlation coefficient dropped (R^2_{adj}=0.41, *P*<0.001, n=44, RSD=5.7). As would be expected, the data for broilers and adult cocks were strongly related (R^2_{adj} =0.94, *P*<0.001, n=49, RSD=4.7). The values for adult cocks correlated less strongly with those in pigs (y=0.76x+18.5, R^2_{adj} =0.70, *P*<0.001, n=105, RSD=8.7).

Digestibility of Amino Acids

In Figure 2 the relationship between the standardised ileal glutamin digestibility in pigs and the faecal glutamin digestibility in poultry (R^2_{adj}=0.61, *P*<0.005, n=77, RSD=8.2) is presented. For the digestibilities of the other amino acids the relationships were less evident (R^2_{adj} ranged from 0.11 to 0.55). Standardised ileal digestibility of total amino acids in pigs and total tract digestibility of total amino acids in poultry were only weakly correlated (R^2_{adj}=0.53, *P*<0.005, n=74, RSD=7.6), Figure 3.

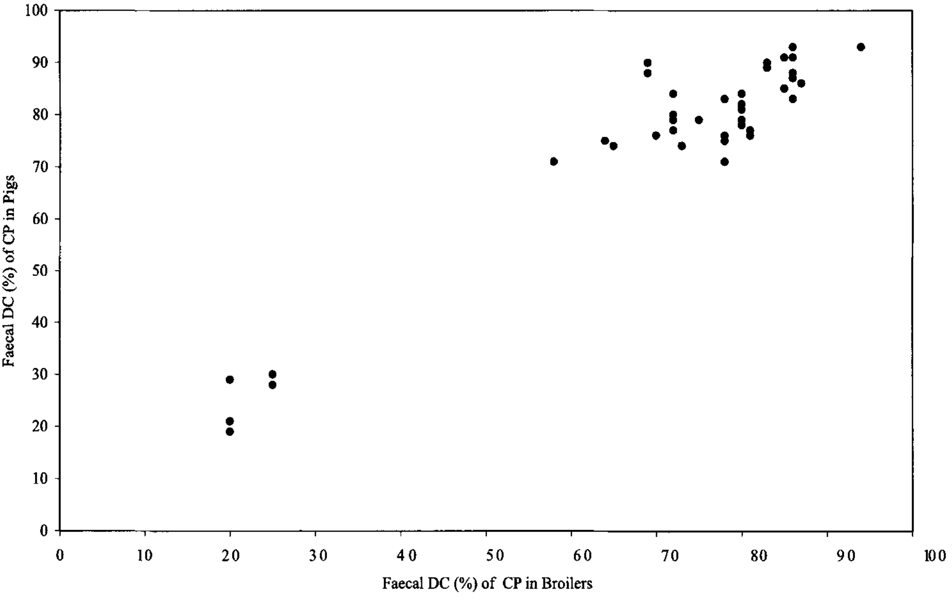

Figure 1. Relationship between the faecal digestibility coefficients (DC, %) of crude protein (CP) for various feedstuffs in pigs and broilers (y = 0.94x + 8.2, R^2_{adj} = 0.91, *P*<0.001, n = 49, RSD = 5.5).

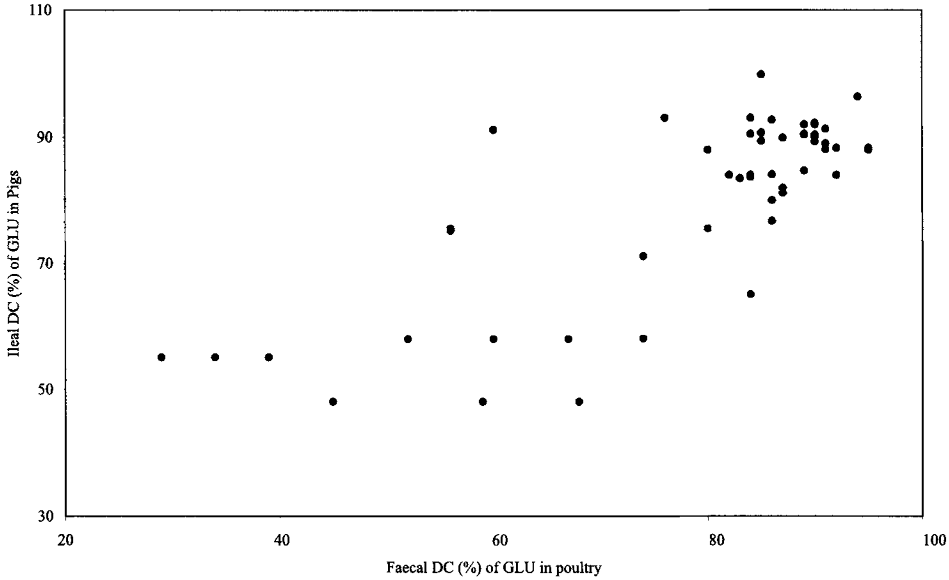

Figure 2. Relationship between the ileal digestibility (DC, %) of glutamin (GLU) for various feedstuffs in pigs and the total tract digestibility (DC,%) of glutamin (GLU) for the same feedstuffs in poultry ($y = 0.71x + 23.7$, $R^2_{adj} = 0.61$, $P<0.005$, n = 77, RSD = 8.2).

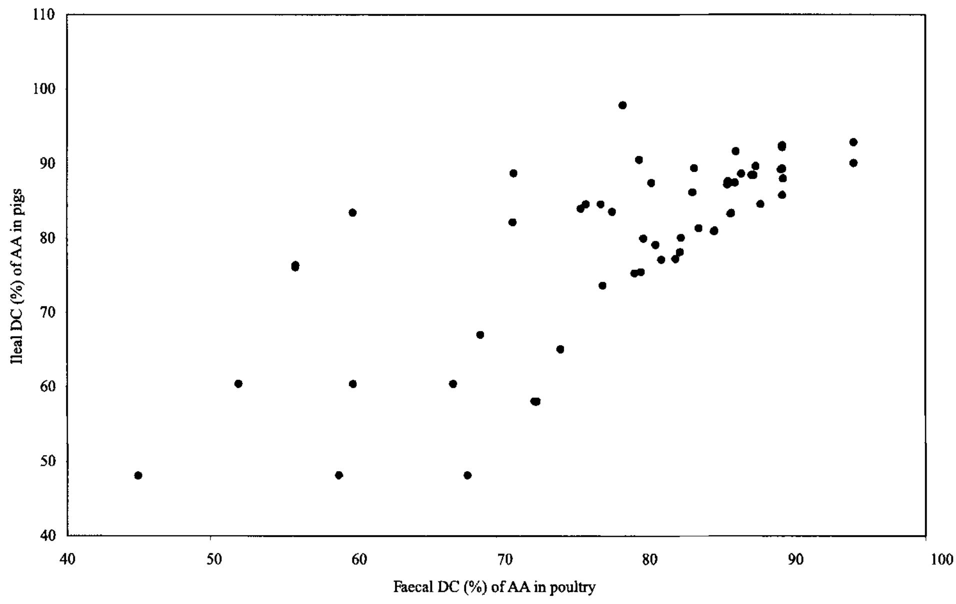

Figure 3. Relationship between the ileal digestibility (DC, %) of total amino acids (AA) for various feedstuffs in pigs and the total tract digestibility (DC, %) of total amino acids (AA) in the same feedstuffs in poultry ($y = 0.80x + 16.5$, $R^2_{adj} = 0.53$, $P<0.005$, n = 74, RSD = 7.6).

Validation

Literature research only yielded values for different feedstuffs of total tract digestibility of crude protein in both pigs and cocks. Table 1 shows that the predicted values in pigs were on average 4.6 units (SD=6.4) lower than the actual values. For individual feedstuffs the differences were not systematic. It may be noted that the predicted digestibility in pigs was extremely low when compared with the actual digestibility.

Discussion

There appeared to be a significant relationship between faecal digestibility in pigs and broilers (Figure 1), but it was mainly due to clustering of points on the extreme ends of the scale. To either confirm or disprove the relationship further data on feedstuffs in between two clusters are needed. For both adult cocks and pigs there were more corresponding data than for pigs and broilers and there was no clustering of points. However, the variance in faecal digestibility of crude protein in pigs was explained for only 70% by that in adult cocks. We feel that the explained variance is not sufficient and that faecal digestibility of crude protein in adult cocks is not an

Table 1. Comparison of predicted and actual faecal digestibility of crude protein in pigs. The predicted value was calculated using the following regression formula: $y - 0.76x + 18.5$ in which y = predicted faecal digestibility of crude protein in pigs and x = measured faecal digestibility in adult cocks. The x values for the various feedstuffs were taken from Anonymous (1987) or Rundgren et al. (1985) and so were the actual values.

Feedstuff	Digestibility of crude protein (%)			
	Adult Cocks	Pigs		
		Predicted	Actual	Difference
Soft wheat	82	81.1	87	–5.9
Maize	86	84.1	81	3.1
Two rowed barley	70	71.9	78	–6.1
Six rowed barley	70	71.9	76	–4.1
Low tanins sorghum	75	75.7	75	0.7
Hard wheat	82	81.1	86	–4.9
Whole seed soya been	80	79.6	85	–5.4
Peanut 50	90	87.2	90	–2.8
Dehulled rapeseed	64	67.3	87	–19.7
Expeller rapeseed	64	67.3	80	–12.7
Rapeseed oilmeal solvent-extracted	64	67.3	79	–11.7
Soyabean meal 44	83	81.9	87	–5.2
Soyabean meal 50	83	81.9	89	–7.2
Sunflower meal 34	83	81.9	88	–6.2
Summer rapeseed of LG-type	84	82.6	82	0.6
Summer rapeseed of HG-type	83	81.9	76	5.9
Winter rapeseed of HG-type	83	81.9	78	3.9

accurate predictor of faecal digestibility in pigs. An attempt to validate the regression formula for the relationships between faecal digestibility of crude protein in pigs and that in adult cocks (Table 1) further showed that prediction of the digestibility in pigs is inaccurate. The present data show that the same holds true for the relationship between the standardised ileal digestibility of individual or total amino acids in pigs and the faecal digestibility of individual or total amino acids in poultry (Figures 2 and 3).

There are various explanations for the lack of a strong relationship between protein digestibility of feedstuffs in pigs and poultry. The test conditions as plan of feeding, feed composition and feed texture were not the same for pigs and poultry, which could have affected protein digestibility (Wondra *et al.*, 1985; Haydon *et al.*, 1984; Karasov, 1993). Perhaps more importantly the digestive tract in pigs differs from that in poultry, so that the process of protein digestion is not comparable.

References

Anonymous, 1998a. The Dutch Feed Value Table (In Dutch). Centraal Veevoederbureau, Produktschap voor Veevoeder, The Hague.

Anonymous, 1998b. Statistix for Windows, Version 2.0. Analytical Software, Tallahasse.

Anonymous, 1987. J. Wiseman (ed. & transl.) Feeding of non-ruminant livestock. Institut National de la Recherche Agronomique, INRA, Paris, pp. 135–188.

Bayley, H.S., C.Y. Cho & J.H.G. Holmes, 1974. Examination of amino acids in ileal digesta as a measure of protein digestion. *Federation Proceedings* 33: 94–99.

Darragh, A.J., P.J. Moughan & W.C. Smith, 1990. The effect of amino acid and peptide alimentation on the determination of endogenous amino acid flow at the terminal ileum of the rat. *Journal of the Science of Food and Agriculture* 51: 47–56.

Grala, W., A.J.M. Jansman, J. Huisman, S. Tamminga, P. Van Leeuwen & J. Wasilewko, 1995. Effect of endogenous protein secretion on nitrogen utilization in young pigs. In: P. Van Leeuwen, A.F. Nunes, A.V. Portugal, J.P. Costa, J.R. Ribeiro (Eds.), Protein Metabolism and Nutrition. Vale de Santarem, Portugal, pp. 105–109.

Haydon, K.D., D.A. Knabe & T.D. Tanksley, 1984. Effects of level of intake on nitrogen, amino acid and energy digestibilities measured at the end of the small intestine and over the total digestive tract of growing pigs. *Journal of Animal Science* 59: 717–724.

Just, A., H. Jørgensen & J.A. Fernandez, 1981. The digestive capacity of the caecum-colon and the value of the nitrogen absorbed from the hind gut for protein synthesis in pigs. *British Journal of Nutrition* 46: 209–219.

Karasov, W.H., 1993. Digestive adaptations in avian omnivores. In: M. Walvqvist (Ed.), Proceedings of the XVth International Congress of Nutrition. International Union of Nutritional Sciences (IUNS), Adelaide, pp. 506–509.

McNab, J.M., 1989. Digestibility of amino acids by poultry. *Feed Compounder* 9 (10): 43–47.

Moughan, P.J. & A. Donkoh, 1991. Amino acid digestibility in non-ruminants – A review. In: D.J. Farrell (Ed.), Recent Advances in Animal Nutrition in Australia. University of New England, Armidale, pp. 172–184.

Mroz, Z., A.W. Jongbloed, P.A. Kemme, H. Everts, A.M. Van Vuuren & R. Hoste, 1991. Preliminary evaluation of a new cannulation technique (steered ileo-caecal valve) for quantitative collection of digesta from the small intestine of pigs. In: M.W.A. Verstegen, J. Huisman & L.A. Den Hartog (Eds.), Digestive Physiology in Pigs, EAAP Publication 54, Pudoc, Wageningen, pp. 334–339.

Rundgren, M., S. Askbrant & S. Thomke, 1985. Nutritional evaluation of low- and high-glucosinolate rapeseed meals with pigs, laying hens and rats. *Swedish Journal of Agricultural Research* 15: 61–69.

Salter, D.N. & R.J. Fulford, 1974. The influence of the gut microflora on the digestion of dietary and en-

dogenous proteins; studies of the amino acid composition of the excreta of germ-free and conventional chicks. *British Journal of Nutrition* 32: 625–637.
Sauer, W.C. & L. Ozimek, 1986. Digestibility of amino acids in swine: results and their practical applications. A review. *Livestock Production Science* 15: 367–388.
Van Leeuwen, P., J. Huisman, M.W.A. Verstegen, M.J. Baak, D.J. Van Kleef, E.J. Van Weerden & L.A. Den Hartog, 1988. A new technique for collection of ileal chyme in pigs. In: L. Buraczewska, S. Buraczewski, B. Pastuszewska & T. Zebrowska (Eds.) Digestive physiology in the pigs, Institute of Animal Physiology and Nutrition, Jablonna, pp. 289–296.
Wondra, K.J., J.D. Hancock, K.C. Behnke & C.R. Stark, 1985. Effects of mill type and particle size uniformity on growth performance, nutrient digestibility, and stomach morphology in finishing pigs. *Journal of Animal Science* 73: 2564–2573.
Wünsche, J., U. Hennig, M. Meinl, F. Kreienbring & H.D. Bock, 1982. Absorption and utilization of amino acids infused into the caecum of growing pigs. 1. Nitrogen balance with regard to the utilization of lysine and isoleucine and the isoleucine requirement of growing pigs. *Archives of Animal Nutrition* 32 (5–6): 337–348.