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A comparison of calculated and determined apparent ileal digestibility of amino acids in cereal-soyabean diets for young pigs

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ABSTRACT

The digestibility experiment was carried out on twelve cannulated pigs between 14 and 27 kg body weight. The animals were fitted with a PVTC cannula and fed with two starter diets, A and B, differing in metabolizable energy content (13.5 and 14.5 MJ ME/kg, respectively), with no supplemented amino acids (AA), in order to measure digestibility coefficients of protein-bound AA. The diets were formulated to contain 0.6 g ileal digestible lysine/MJ ME and were calculated on the basis of AA analysis of ingredients and their tabular values of apparent ileal AA digestibilities. For both diets, differences between the calculated and determined digestibilities of the limiting essential AA were found. The determined digestibilities tended to be lower than the calculated ones. Of the essential AA, the differences were greatest for threonine (6.8 and 9.5% of calculated values for diet A and B, respectively) and lysine (4.3 and 8.3% for diet A and B, respectively); the differences for methionine and tryptophan ranged from 4.0 to 6.2%. In conclusion, the present study shows that the digestible AA supply in a diet can be predicted from total AA content determined in the individual ingredients and from average literature values recommended for their AA digestibility, however, it is necessary to accept an 8-10% error for calculated values.

KEY WORDS: ileal digestibility, amino acids, young pigs

INTRODUCTION

The nutritive value of protein in feedstuffs is not only determined by its total amino acid (AA) content, but also by AA digestibility, with particular reference to the limiting AA. For formulation of pig diets, apparent ileal AA digestibility coef-

ficients of feeds, presented as average values of many literature data, are recommended (e.g., Rademacher et al., 1999). However, considerable variations in apparent digestibility values of AA in many feeds were reported. For example, lysine digestibility in wheat samples ranged from 59 to 80% (Sauer and Ozimek, 1986; Fan et al., 2001). Large variability was also found for other feeds like barley (Sauer and Ozimek, 1986) rapeseed meal (Buraczewska et al., 1987) and soyabean meal (Fan et al., 1996). The aim of our studies was to formulate diets for piglets containing a determined level of apparent ileal digestible AA, e.g., 0.6 g digestible lysine/MJ ME. For this purpose, the chosen cereal and high-protein ingredients were analyzed for their total AA content and their levels of ileal digestible AA were calculated using the digestibility coefficients recommended by Degussa-Hüls (Rademacher et al., 1999). The objective of this study was to compare the calculated and determined content of ileal digestible AA in order to test the adequacy of tabular coefficients for diet formulation. Ileal digestibility of dietary AA was determined on cannulated pigs.

MATERIAL AND METHODS

Animals and experimental design

The experiment was carried out on twelve castrated male crossbred piglets (synthetic line 990), surgically fitted with post-valvular T-caecum cannula (PVTC) according to van Leeuwen et al. (1991). After cannulation the piglets were fed two experimental diets (6 pigs per diet) during two experimental periods at about 15 and 25 kg body weight (BW), according to the change-over design. Each period consisted of at least 7 days adjustment to the diets, followed by 3 days (12 h each) collection of ileal digesta.

Formulation of diets and feeding program

Two starter diets A and B, containing 13.5 (A) and 14.5 (B) MJ ME/kg and 0.6 g ileal digestible lysine/MJ ME were formulated on the basis of chemical analysis of dietary ingredients, including AA (Table 1), their tabular ileal digestibility coefficients (Table 2) and "ideal protein", recommended by Degussa-Hüls for pigs (Rademacher et al., 1999). Apart from digestible lysine, all other essential AA were balanced in the diets composed of seven protein-containing ingredients, as described in Urynek and Buraczewska (2001). Chromic oxide (Cr_2O_3) was used as a marker. The pigs were fed two equal portions daily at 08.00 and 20.00 h in accordance with BW (5%). The unpelleted feed was mixed with water (1:1) just before feeding. Water was supplied *ad libitum*.

TABLE 1

Chemical composition (g kg^{-1}), ME value (MJ kg^{-1}) and AA, % of dietary ingredients (as-fed)

	Wheat	Barley	Maize	Soyabean meal	Soyabean protein conc.	Ful fat soya (Soyax)	Fish meal
Dry matter	883	882	888	908	910	913	932
Crude protein	128	131	95	490	552	357	633
Ether extract	17.7	16.8	42.8	14.7	7.2	197	68
Ash	18.7	21.4	14.4	61.3	67.1	48.9	226.0
Starch	476	420	541	24.2	21.1	18.8	-
Sugar	25.2	31.8	15.8	75.0	32.5	57.3	-
Crude fibre	32.1	47.2	31.9	45.9	33.8	70.9	-
NDF	118.3	186.0	114.9	107.7	77.9	113.0	-
ADF	44.3	57.3	43.7	69.5	45.8	97.1	-
Calculated ME	13.84	12.68	14.15	13.59	14.28	16.02	14.50
Amino acids							
lysine	0.36	0.41	0.31	3.05	3.00	2.15	4.04
methionine	0.20	0.21	0.17	0.64	0.73	0.46	1.70
cystine	0.30	0.28	0.20	0.77	0.84	0.51	0.52
threonine	0.37	0.42	0.34	1.91	2.15	1.37	2.37
tryptophan	0.14	0.16	0.08	0.64	0.75	0.48	0.52

TABLE 2

Apparent ileal AA digestibility coefficients of dietary ingredients (Rademacher et al., 1999), %

Amino acids	Barley	Maize	Wheat	Soyabean meal	Soyabean protein concentrate[1]	Ful fat soya[2]	Fish meal
Lysine	67	62	75	88	93	86	88
Methionine (Met)	77	82	85	89	91	85	88
Met+Cystine	74	76	84	84	91	80	84
Threonine	65	63	72	83	90	78	86
Tryptophan	67	65	80	85	89	83	84

[1] according to Jondréville et al., 1995; [2] according to CVB, 1990

Sampling, analysis and calculations

Ileal digesta was collected using bags attached to the cannulas during the three days for 12 h per day, between 8.00 and 20.00 h. The bags were changed approximately every hour and their contents were immediately frozen in plastic containers at –20°C. After each collection, samples were thawed, pooled per animal within each experimental period, freeze-dried and ground (ϕ 0.5 mm) before chemical analysis. Cr_2O_3 in samples of feeds and freeze-dried digesta was analyzed by the method of Fenton and Fenton (1979). Dry matter, nitrogen, ether extract, crude fibre, total starch and ash were analyzed using standard methods (AOAC, 1990). The content of NDF and ADF was determined using a Fibertec System (according to the instruction).

AA were analyzed with a high-pressure amino acid analyzer, Biochrom 20, according to Llames and Fontaine (1994). Methionine and cystine were determined after oxidation with performic acid. Tryptophan was determined by reversed-phase-high-performance liquid chromatography (HPLC) following alkaline hydrolysis with barium hydroxide. The apparent ileal AA digestibilities were determined according to the relevant equations (Rademacher et al., 1999). ME of dietary ingredients was calculated from the determined chemical composition of feeds (Table 1) using a corrected equation (Hoffmann and Schiemann, 1980).

RESULTS AND DISCUSSION

Determined AA digestibility values were similar for diets A and B (Table 3). There were differences between the calculated and determined digestibilities of the limiting essential AA in both diets (Table 4). The determined digestibilities tended to be lower than the calculated ones and these differences were more pronounced in diet B than A. Of the essential AA, the differences were largest for threonine (6.8 and 9.5% for diets A and B, respectively) and lysine (4.3 and 8.3% for diets A and B, respectively). For both diets, smaller differences ranging from 4.0 to 6.2% were observed for methionine and tryptophan.

TABLE 3

Apparent ileal digestibility coefficients of basic aminoacids: means ± S.D., %

	Diet A	Diet B
Methionine	82.2 ± 2.7	81.6 ± 2.9
Cystine	77.5 ± 2.9	76.3 ± 3.5
Lysine	79.4 ± 3.0	79.1 ± 3.0
Threonine	72.7 ± 3.6	72.5 ± 3.9
Tryptophan	77.0 ± 3.0	77.0 ± 3.5

TABLE 4

Calculated and determined content of digested (apparent, ileal) amino acids in diets A and B, % as-fed

	Diet A			Diet B		
	calculated	determined	difference[1]	calculated	determined	difference[1]
Ileal digestible lysine	0.810	0.778	-4.32	0.870	0.798	-8.28
Ileal digestible methionine	0.272	0.260	-4.41	0.292	0.273	-6.16
Ileal digestible cystine	0.300	0.291	-3.00	0.291	0.295	+1.37
Ileal digestible threonine	0.561	0.523	-6.77	0.588	0.532	-9.52
Ileal digestible tryptophan	0.198	0.189	-4.55	0.201	0.193	-3.98

[1] expressed in percent of calculated values

It is commonly known that many factors, including methodological approaches, fineness of grinding, dietary AA level and AA distribution among protein fractions (e.g., in cereals), NDF content (affected by genotype and growing conditions), temperature used in feed processing, level of antinutritional factors, and content of undigested endogenous protein at the ileum, are likely responsible for the variation of AA digestibility values reported in the literature. Additionally, there may be associative effects that cause the digestible supply of AA in a mixture of feeds to differ from the sum based on the digestibilities determined in the individual ingredients. Imbeah et al. (1988) reported that there were no differences between the calculated and observed digestibilities of the essential AA in a feed mixture of barley and soyabean meal, however, there were significant differences in lysine (10.5%) and phenylalanine (5.4%) content in a mixture of barley and rapeseed meal.

In conclusion, the present study shows that the digestible AA supply in a diet can be predicted from the total AA content determined in the individual ingredients and from average literature values recommended for the particular AA digestibility, however, it is necessary to accept an 8-10% error of the calculated values.

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STRESZCZENIE

Porównanie obliczonej i oznaczonej pozornej strawności jelitowej aminokwasów u młodych świń żywionych mieszankami zbożowo-sojowymi

Doświadczenie strawnościowe przeprowadzono na 12 prosiętach o masie ciała od 14 o 27 kg. Prosiętom założono proste kaniule (PVTC), a po wyzdrowieniu karmiono 2 mieszankami starter A i B, różniącymi się zawartością energii metabolicznej, odpowiednio 13,5 i 14,5 MJ EM/kg. Zastosowano dwa okresy żywienia w układzie przemiennym. Mieszanki o zawartości 0,6 g strawnej lizyny/ MJ EM i odpowiedniej proporcji innych niezbędnych AA, przygotowano na podstawie analizy AA w składnikach mieszanek i ich tabelarycznych współczynników pozornej strawności. Dla obydwóch mieszanek stwierdzono różnice między strawnością obliczoną a oznaczoną niezbędnych AA limitujących; współczynniki strawności oznaczone były niższe niż obliczone. Wśród AA niezbędnych różnice procentowe były największe dla treoniny (6,8 i 9,5%, odpowiednio dla mieszanek A i B) oraz lizyny (4,3 i 8,3%, odpowiednio dla mieszanek A i B). Dla obydwóch mieszanek w przypadku metioniny i tryptofanu różnice wyniosły od 4,0 do 6,2%.

Podsumowując, wyniki doświadczenia wskazują, że poziom AA strawnych w mieszance może być przewidziany na podstawie oznaczonej zawartości AA w poszczególnych surowcach oraz ich średnich współczynników strawności podawanych w literaturze, należy jednak przyjąć możliwość błędu, od 8 do 10%, wyliczonych wartości.