ESTIMATES OF TRUE AMINO ACID DIGESTIBILITIES IN FEED INGREDIENTS USING PRECISION-FED, CECECTOMIZED ROOSTERS[1]

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ABSTRACT - Twenty seven cecectomized mature Single Comb White Leghorn cockerels were used to estimate true amino acid digestibilities (TAAD) coefficients for eight feedstuffs for cecectomized roosters. The objective of this paper was to evaluate alternative feed ingredients TAAD coefficients using a standard precision fed (crop-intubation) methodology. The ingredients tested were corn, wheat bran (WB), two sources of soybean meal (SBM 1 and SBM 2), cottonseed meal (CSM), poultry by-product (PBP), and two samples of meat and bone meal (MBM 1 and MBM 2). A group of three roosters was fasted 24 hours prior to each assay to allow measurement of endogenous amino acid production. True lysine digestibility (TLD) in CSM (71.8%) was significantly lower (P<.01) than in all the other feed sources. No differences (P>.01) were found for TLD among the other ingredients. Means and standard error of means for TAAD were: corn 103.03±4.30, WB 90.35±2.26, SBM 1 93.13±1.55, SBM 2 92.99±2.39, CSM 81.16±4.67, PBP 86.23±2.14, MBM 1 86.20±2.49, MBM 2 85.98±2.26. In general the averages of the coefficients for TAAD of the ingredients used are in the range of the values reported in the literature and can be used to formulate diets based on amino acid digestibility.

Index terms: poultry, feedstuffs, forced feeding, metabolism, digestion.

ESTIMATIVAS DA DIGESTIBILIDADE VERDADEIRA DE INGREDIENTES DE ALIMENTOS, OBTIDA COM GALOS CECOTOMIZADOS EM ALIMENTAÇÃO FORÇADA

RESUMO - O objetivo deste trabalho foi estimar os coeficientes de digestibilidade verdadeira dos aminoácidos de oito ingredientes alternativos para alimentação de galos cecotomizados. Vinte e sete galos Leghorne de crista inteira foram usados para estimar os coeficientes de digestibilidade verdadeira dos aminoácidos (TAAD) de oito alimentos. A alimentação precisa (forçada) foi utilizada com objetivo de obter TAAD de ingredientes alternativos. Os ingredientes estudados foram milho, farelo de trigo (WB), duas fontes de farelo de soja (SBM 1 e SBM 2), farelo de algodão (CSM) e sub-produtos do abate de aves (PBP) e duas amostras de farinha de carne e ossos (MBM 1 e MBM 2). Um grupo de três galos cecotomizados foi submetido a jejum de 24 horas antes de cada ensaio para permitir a produção endógena de aminoácidos. A digestibilidade verdadeira da lisina (TLD) no CSM (71,8%) foi significativamente menor (P < 0,01) do que em todos os outros ingredientes. Não foram observadas diferenças significativas (P > 0,01) para TLD entre os demais ingredientes. As médias e desvios padrões dos coeficientes de TAAD foram: milho 103,03±4,30, WB 90,35±2,26, SBM1 93,13±1,55, SBM2 92,99±2,39, CSM 81,16±4,67, PBP 86,23±2,14, MBM1 86,20±2,49, MBM2 85,98±2,26. Em geral as médias dos coeficientes de TAAD dos ingredientes testados estão no intervalo dos valores reportados na literatura e podem ser utilizados para formular dietas baseadas em aminoácidos digestíveis.

Termos para indexação: aves, ingredientes, alimentação forçada, metabolismo, digestão.

INTRODUCTION

Interest has increased in the determination of amino acid digestibility by fecal sampling in chicks since the publication of an early procedural paper by Bragg et al. (1969). Using that technique, Ivy et al. (1971) and Burgos et al. (1974) provided evidence that the variation in amino acid digestibility,

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among samples of soybean meal or poultry by-product, can be caused by factors such as agronomic environment, strain and processing conditions.

Likuski & Dorrell (1978) and Sibbald (1979) developed a new technique for measuring nutrient digestibility based on forced feeding of roosters and quantitative excreta collection. In this procedure the bird is given a single dose of feedstuff by crop intubation and the resulting excreta is collected. The disappearance of an amino acid is used to estimate digestibility after correction for endogenous amino acid contributions to the excreta.

Several criticisms have been advanced. One concerns the length of collection period. Parsons et al. (1981), using dehulled soybean meal and other protein feedstuffs (Parsons et al., 1982), found that there were lower values for digestibility after 48 hours of collection compared with 24 hours. This indicates that the complete passage of undigested residues through the gut requires more than 24 hours. Kessler & Thomas (1981) presented results showing that a 48 hour collection is superior to a 24-hour collection period.

Another point of criticism is related to the influence of the microflora of the hindgut. Although some workers have found negligible interference due to microbial fermentation, Parsons (1985b) found that cecectomized roosters had an average of 5% lower true amino acid digestibility than did conventional birds. In the same way, Parsons (1986) found consistently lower true amino acid digestibilities with cecectomized cockerels than with conventional birds.

The purpose of this work was to obtain digestibility coefficients data for eight feedstuffs using the precision-fed rooster assay for subsequent use in testing the utility of amino acid digestibility values in diet formulation.

MATERIAL AND METHODS

True amino acid digestibilities (TAAD) were measured for a number of ingredients using the procedure of Sibbald (1979) as modified by Parsons (1985b). The formula used in calculations was that reported by Parsons (1985a): TAAD=((AAc-AAe+AAee)/AAc)100, where AAc = amino acid consumed; AAe = amino acid voided in excreta; AAee = endogenous amino acid voided in excreta of fasted birds. Since the excreta includes urinary excretion the proper term should be metabolizability which is used here as a synonym of digestibility.

The experiment was carried out in 1988 at the poultry farm of the University of Illinois, USA. Three mature Single Comb White Leghorn cockerels per treatment were allocated to individual cages with raised wire floors. Artificial light was provided for 16 hours per day and the ambient temperature was maintained in the comfort zone. The birds were given feed and water *ad libitum* to the assay period according to National Research Council (1984) requirements. The assay was initiated by fasting the birds for 24 hours, after which they were force-fed 30 g of the test ingredient. A group of control birds was fasted during this period and the excreta were collected to allow measurement of the endogenous amino acid production. The ingredients tested were those listed in Table 1. Excreta were collected for a 48-hour period using a plastic tray placed under the cage. Excreta samples were lyophilized, weighed, ground and analyzed for dry matter and amino acids. Feathers and scale that fell in the tray were removed by blowing by mouth on the collection tray three times each day.

The digestibility values for individual amino acids in the various ingredients were compared statistically. A completely randomized design with three observations per treatment was utilized. The model used was defined as: $Y_{ij} = u + Ti + e_{ij}$, where, Y_{ij} = the j^{th} observation of the i^{th} treatment; u = general mean; Ti = effect of i^{th} treatment (i=1,...8); e_{ij} = residual random term. Statistical solution of the model was done using SAS system (SAS Institute, 1985). Fisher protected LSDs were calculated in order to compare differences between means (P<.01). Pooled standard error of the mean values are presented.

RESULTS AND DISCUSSION

The four feed grade TAAD coefficients for the feedstuffs used in the precision-fed assay are presented in Table 2 and the digestible amino acids percentages calculated using the coefficients for TAAD and the total amino acids content are presented in Table 3.

The TAAD coefficients can be compared with literature values in Table 4. True lysine digestibility in cottonseed meal (CSM) (71.82%) was significantly lower (P<.01) than in all the other feed sources. This percentage is intermediate to the ones presented by Nwokolo et al. (1976) and Heartland

TABLE 1. Chemical composition of the ingredients (as fed basis, %).

Variable	Ingredients tested[1]							
	Corn	WB	SBM 1	SBM 2	CSM	PBP	MBM 1	MBM 2
Dry matter	85.58	88.30	88.47	95.38	87.83	92.64	93.98	94.11
Crude protein[2]	7.33	16.15	47.43	50.22	37.63	63.97	47.40	50.23
ME[3]	3260	2208	3117	3360	2350	2911	2256	2259
ADF[4]	2.78	11.51	5.16	5.56	16.26	8.74	4.38	5.72
Cellulose[4]	2.06	7.81	3.75	4.69	9.86	4.78	1.40	2.11
Calcium[5]	.01	.09	.48	.51	.30	4.29	14.42	11.73
Total P[5]	.23	.83	.60	.71	1.14	2.31	5.77	4.33
Available P[6]	.07	.25	.18	.21	.34	2.31	5.77	4.33
Lysine[7]	.24	.63	2.91	2.78	2.03	3.46	2.78	2.96
Met+Cys[8]	.38	.52	1.43	1.55	1.26	1.97	1.32	1.32
Tryptophan[7]	.06	.26	.60	.59	.61	.50	.30	.32
Threonine[7]	.24	.51	1.87	1.77	1.47	2.60	1.81	2.12

[1] WB = wheat bran; SBM 1 and SBM 2 = soybean meals 1 (normal) and 2 (heat treated); CSM = cottonseed meal; PBP = poultry by-product; MBM 1 and MBM 2 = meat and bone meals from two origins.
[2] Determined as N x 6.25 using macro-Kjeldahl procedure (Association of Official Analytical Chemists. 1984).
[3] Metabolizable energy (kcal/kg), calculated values from Hubbel (1988) and Fonnesbeck et al. (1984).
[4] Acid detergent fiber (ADF) and cellulose were analyzed and calculated according to Goering & Van Soest (1970).
[5] Association of Official Analytical Chemists (1984) procedures for calcium (spectrophotometric) and phosphorus (colorimetric) determinations.
[6] Calculated as 30% of total phosphorus.
[7] Analyzed by ion exchange chromatography.
[8] Met = methionine; Cys = cystine; values from Hubbel (1988).

TABLE 2. Percentage of true amino acid digestibility (TAAD) coefficients for eight feedstuffs using the precision fed roosters assay[1].

Amino acids	Ingredients[2]									
	Corn	WB	SBM 1	SBM 2	CSM	PBP	MBM 1	MBM 2	SE[3]	LSD[4]
Lysine	95.66	85.83	92.94	91.64	71.82	84.15	85.04	85.52	2.99	12.34
Met+Cys	105.61	92.55	96.23	96.23	86.58	90.51	91.17	90.49	1.29	5.35
Threonine	109.03	90.48	91.05	89.56	81.92	84.38	84.18	85.36	4.39	18.15
Triptophan	101.8	92.54	92.28	94.52	84.33	85.86	84.39	82.53	3.74	15.44
Mean	103.03	90.35	93.13	92.99	81.16	86.23	86.20	85.98	.	.
SE[3]	4.30	2.26	1.55	2.39	4.67	2.14	2.49	2.26	.	.

[1] Values are means of three observations with one rooster per observation;
[2] WB = wheat bran; SBM 1 and SBM 2 = soybean meals 1 (normal) and 2 (heat treated); CSM = cottonseed meal; PBP = poultry by-product; MBM 1 and MBM 2 = meat and bone meals from two origins.
[3] Pooled standard error of the means.
[4] Least significant difference ($P \leq .01$).

TABLE 3. Digestible amino acids percentages calculated using the coefficients for true amino acid digestibilities shown on Table 2 and the total amino acids content presented in Table 1.

Amino acids	Corn	WB	SBM 1	SBM 2	CSM	PBP	MBM 1	MBM 2
Lysine	0.23	0.54	2.70	2.55	1.46	2.91	2.36	2.53
Met+Cys	0.40	0.48	1.38	1.49	1.09	1.78	1.20	1.19
Tryptophan	0.07	0.24	0.55	0.53	0.50	0.42	0.25	0.27
Threonine	0.24	0.47	1.73	1.67	1.24	2.23	1.53	1.75

TABLE 4. Precision-fed amino acid digestibilities in corn, cottonseed meal (CSM), and soybean meal (SBM) according to various authors.

Amino acids	References														
	1	2	3	4	7	8	5	3	4	1	6	2	4	7	8
	Corn						CSM			SBM					
Lysine	96	102.6	84.8	95.7	94.0	81.0	89.0	61.0	71.8	94	87.3	89.3	92.9	91.3	90.9
Methionine	98	93.0	94.5	105.6	93.7	91.3	93.3	80.8	86.6	94	92.9	92.8	96.2	88.3	89.4
Threonine	92	89.8	86.3	109.0	86.6	81.8	89.8	70.9	81.9	93	85.8	89.4	91.1	87.8	87.5
Tryptophan	96	.	.	101.8	89.5	89.5	.	.	84.3	96	.	.	92.3	90.9	90.9

[1] 1: Likuski & Dorrell (1978); 2: Sibbald (1986); 3: Heartland Lysine Incorporation (1988); 4: Bellaver (1989); 5: Nwokolo et al. (1976); 6: Parsons et al. (1981); 7: Albino et al. (1992); 8: Albino & Silva (1996).

Lysine Inc. (1988). It is interesting that true lysine digestibility in CSM was the lowest value reported for an ingredient by Heartland Lysine Inc. (1988). In this work it was not possible to detect any difference (P>.01) for true lysine digestibility among the ingredients tested. True digestibility for threonine and tryptophan was higher (P<.01) in corn than in the other feedstuffs. Surprisingly, except lysine the TAAD values for the amino acids in corn were over 100%. Lysine TAAD coefficient for corn is in the range found by Likuski & Dorrell (1978); Sibbald (1986) and Albino et al. (1992). Sibbald (1986) also reported values higher than 100% for several batches of corn. The same author indicated that abnormally high values may result from unidentified problems, such as: unobserved regurgitation, incomplete clearance of material, or incomplete excreta collection.

Others, Ivy et al. (1971) and Nwokolo et al. (1976), have found TAAD to be close to 100% when using the procedure of Bragg et al. (1969). Actually, this methodology does not take into consideration the caeca effect and that intake is not equalized among treatments. The result is a higher estimate of digestibility.

Results calculated for individual amino acids in soybean meal (SBM) were similar to values obtained by Parsons et al. (1981); Hung & Kermorgant (1982); Sibbald (1986), Heartland Lysine Inc. (1988) and Albino et al. (1992).

Average digestibilities for amino acids in CSM, poultry by-product (PBP) and meat and bone meal (MBM) in this work were in general higher than those listed by Heartland Lysine Inc. (1988), and lesser than those reported by Nwokolo et al. (1976) for CSM and by Burgos et al. (1974) for PBP. Data from Hung & Kermorgant (1982) and Albino & Silva (1996) for MBM provide values similar to those obtained in this work. Values for true digestibility coefficients of lysine for the PBP used in this work were very close to the ones reported by Albino & Silva (1996) and higher to those calculated by Han & Parsons (1990) using either cecectomized or conventional roosters.

CONCLUSIONS

1. True lysine digestibility coefficient in cottonseed meal is lower than in all the other feed sources tested.

2. True digestibility coefficients for threonine, tryptophan and methionine is higher in corn than in the other feedstuffs.

3. Except for lysine, true amino acid digestibilities coefficients of the other amino acids in corn are over 100%.

4 Values for amino acids true digestibility coefficients reported in this work can be used in diets formulation.

REFERENCES

ALBINO, L.F.T.; ROSTAGNO H.S.; SANTANNA R.; FONSECA, J.B. Determination of metabolizable amino acids and digestible protein feedstuffs for poultry. **Revista da Sociedade Brasileira de Zootecnia**, v.21, p.1059-1068, 1992.

ALBINO, L.F.T.; SILVA, M.A. da. Nutritive value of feedstuffs for poultry and swine determined in Brazil. In: INTERNATIONAL SYMPOSIUM ON NUTRITIONAL REQUIREMENTS OF POULTRY AND SWINE, 1996, Viçosa. **Proceedings...** Viçosa: UFV, 1996, p.1-15.

ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS (Washington, D.C.). **Official methods of analysis.** 14.ed. Washington, 1984. 1141p.

BELLAVER, C. **Estimation of amino acid digestibility and its usefulness in swine feed formulation.** Urbana-Champaign: Univ. of Illinois, 1989. 99p. Ph.D. Thesis.

BRAGG, D.B.; IVY, C.A.; STEPHENSON, E.L. Methods for determining amino acid availability of feeds. **Poultry Science**, v.48, p.2135-2137, 1969.

BURGOS, A.; FLOYD, J.I.; STEPHENSON, E.L. The amino acid content and availability of different samples of poultry by-product meal and feather meal. **Poultry Science**, v.53, p.198-203, 1974.

FONNESBECK, P.V.; LLOYD, H.; OBRAY, R.; ROMENSBURG, S. **IFI tables of feed composition.** Logan: Utah State Univ., International Feedstuffs Institute, 1984. 607p.

GOERING, H.K.; VAN SOEST, P.J. **Forage fiber analysis.** Washington, DC: USDA, Agricultural Research Service, 1970. 20p. (USDA. Agriculture Handbook, n.379).

HAN, Y.; PARSONS, C.M. Determination of available amino acids and energy in alfalfa meal, feather meal, and poultry by-product meal by various methods. **Poultry Science**, v.69, p.1544-1552, 1990.

HEARTLAND LYSINE INCORPORATION. (Chicago, IL). **True digestibility of essential amino acids for poultry-1989.** Chicago, 1988. 2p.

HUBBEL, C.H. Feedstuffs analysis table. **Feedstuffs**, v.15, p.20, 1988.

HUNG, N.T.; KERMORGANT, J. Pepsin digestibility and true amino acid availability of plant and animal protein feedstuffs. In: MARYLAND NUTRITION CONFERENCE FOR FEED MANUFACTURES, 1982, College Park. **Proceedings...** College Park: Univ. of Maryland, 1982. p.5-10.

IVY, C.A.; BRAGG, D.B.; STEPHENSON, E.L. The availability of amino acids from soybean for growing chick. **Poultry Science**, v.50, p.408-410, 1971.

KESSLER, J.W.; THOMAS, O.P. The effect of cecectomy and extension of the collection period on the true metabolizable energy values of soybean meal, feather meal, fish meal and blood meal. **Poultry Science**, v.60, p.2639-2647, 1981.

NATIONAL RESEARCH COUNCIL. Committee on Animal Nutrition. Subcommittee on Poultry Nutrition. (Washington, EUA). **Nutrient requirements of poultry.** 8.ed. Washington: National Academy of Sciences, 1984. 71p.

LIKUSKI, H.J.A.; DORRELL, H.G. A bioassay for rapid determinations of amino acid availability values. **Poultry Science**, v.57, p.1658-1660, 1978.

NWOKOLO, E.N.; BRAGG, D.B.; KITTS, W.D. The availability of amino acids from palm kernel, soybean, cottonseed and rapeseed meal for the growing chick. **Poultry Science**, v.55, p.2300-2304, 1976.

PARSONS, C.M. Amino acid availability in feedstuffs for poultry and swine. In: BAKER, D.H.; PARSONS, C.M. (Eds.). **Recent advances in amino acid nutrition.** Tokyo: Ajinomoto Co., 1985a. p.35-47.

PARSONS, C.M. Influence of caececotomy on the digestibility of amino acids by roosters fed distillers' dried grains with solubles. **Journal of Agricultural Science**, v.104, p.469-472, 1985b.

PARSONS, C.M. Determination of digestible and bioavailable amino acids in meat meal using conventional and cecectomized cockerels or chick growth assay. **British Journal of Nutrition**, v.56, p.227-240, 1986.

PARSONS, C.M.; POTTER, L.M.; BROWN JUNIOR, R.D. True metabolizable energy and amino acid digestibility of dehulled soybean meal. **Poultry Science**, v.60, p.2687-2696, 1981.

PARSONS, C.M.; POTTER, L.M.; BROWN JUNIOR, R.D. Effects of dietary protein and intestinal microflora on excretion of amino acids in poultry. **Poultry Science**, v.61, p.939-946, 1982.

SAS INSTITUTE. (Cary, NC). **SAS user's guide**: statistics. Cary, NC, 1985. 955p.

SIBBALD, I.R. A bioassay for available amino acids and true metabolizable energy in feedingstuffs. **Poultry Science**, v.58, p.668-673, 1979.

SIBBALD, I.R. **The TME system of feed evaluation:** methodology, feed composition data and bibliography. Ottawa: Agriculture Canada. Research Branch, 1986. 114p.